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CONTENTS

MECHANICAL BEHAVIOUR OF ROASTED AND UNROASTED OIL PALM KERNELS UNDER COMPRESSION LOADING
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MECHANICKÉ CHOVÁNÍ PRAŽENÝCH A NEPRAŽENÝCHOLEJOVÝCH PALMOVÝCHJADER POD TLAKOVÝM ZATÍŽENÍM

Asst. Prof. Ph.D. Eng. Kabutey A.*[1)], Prof. Ph.D. Eng. Herák D.[1)], Lect. Ph.D. Eng. Dajbych O.[1)], Ph.D. Stud. Eng.Akangbe O.L.[1)], Lect. Ph.D.Eng.Napitupulu R.[2)], Lect. Ph.D. Pandiangan S.[3)]
[1)] Czech University of Life Sciences Prague, Faculty of Engineering / Czech Republic;
[2)] University of HKBP Nommensen, Faculty of Engineering / Indonesia;
[3)] University of HKBP Nommensen, Faculty of Agriculture / Indonesia
Tel: +420 775 661 481, E-mail: kabutey@tf.czu.cz

Keywords: *compressive force, speed, deformation, energy, serration effect*

ABSTRACT

This article follows the previously published study on the mechanical behaviour of oil palm kernels under compression loading. A slight change in deformation of the heat-treated kernels was observed at force 100 kN and speed 60 mm/min. Therefore, a greater force was required to produce higher percentage kernel oil.In this present study, however, both roasted and unroasted kernels were compressed in a vessel with diameter of60 mmat varying forces from 150, 200, 250 and 300 kN and speed 10 mm/min aimed at determining the optimal pressing force without serration effect on the force-deformation curve.

ABSTRAKT

Tento článek navazuje na předchozí zveřejněnou studii o mechanickém chování olejových palmovýchjader pod tlakovým zatížením. Aplikování maximální síly 100 kN při rychlosti 60 mm/min ukázalo mírné změny deformace. Proto byla potřebná větší síla k získání vyššího podílu jádrového oleje. Avšak v tomto experimentu bylajak pražená,tak nepražená olejová palmová jádra stlačována v lisovací nádobě o průměru 60 mm při různých siláchod150, 200, 250 a 300 kN při rychlosti 10 mm/mins cílem stanovit optimální lisovací sílu bez efektu zoubkování na deformační křivce.

INTRODUCTION

The oil palm (*Elaesis guineensis*) is a perennial monoecious crop originated from the tropical climates with high rainfall, which belongs to the family Palmae (*Ozumba and Obiakor, 2011*).The tree starts to produce fruits four to five years after planting and the fruits bunch weighs between 10 and 75 kgdependingon the varieties(*Kabutey et al., 2013; Owolarafe et al., 2007*).

The processing of the fresh fruit bunch to yield red palm oil gives the shelled palm nut which is cracked to produce the palm kernel nut and the shell. The shells are used as energy and road construction whiles the palm kernel nut is processed to yield palm kernel oil and cake. The palm kernel oil is 81% saturated and is obtained a white to yellowish vegetable oil similar to coconut oil beingsemi-solid at normal temperature while the palm mesocarp oil is 41% saturated and it is red due to the presence of carotenoids(*Akinoso et al., 2009*;*Akinoso and Raji, 2011*;*Keshvadi et al*., 2011).

Palm oil is used in packaged edible products including cooking oils,margarine, mayonnaise, ice cream, cookies and chocolates; and non-edible products such as soaps, detergents and cosmetics.It is also used as a biodiesel through thetransesterification process and also used in the metal and leather industries(*Morrison and Heijndermans, 2013*). Palm kernel oil is used in commercial cooking because of its relatively low cost and longer storage period. It can also be used for the manufacture of soaps and washing powders. The meal is used as a fertilizer and livestock feed.

The processing of the fruits and nuts for the edible oils especially in the developing countries is labour intensive and time consuming.The mechanical extraction process is suitable for oil extraction in both small and large-scale operations by the application of pressure. However, the relevance of optimal pressure in mechanical oil expression has been rapidly mentioned (*Oriaku et al., 2013*).

Technological improvement of the oil processing requires accurate knowledge on both the physical and mechanical properties of the oil palm fruit, nut and kernel.These properties include among others moisture content, sphericity, porosity, pressing force, deformation and energy balance (*Akinoso et al., 2009*;*Akinoso and Raji, 2011*).In the literature, such informations are limited. Therefore, in this present study, the mechanical properties of unroasted and roasted oil palm kernels were mainly investigated under compression loading.

MATERIAL AND METHOD

The unroasted and roasted oil palm kernels procured from New Tafo, Eastern Region, Ghana were used for the compression test. The moisture content of unroasted and roasted oil palm kernels was determined to be 9.67±0.196 and 3.33±0.191 using the standard oven method with a temperature setting of 105 ºC and a drying time of 17 h (*Kabutey et al., 2014*).

A compression device (ZDM 50, Czech Republic) was used at speed 10 mm/min for varying forces between 150 kN and 300 kN. The kernels were measured at the initial pressing height of 60 mm in a pressing vessel of 60 mm diameter. After the initial test,the kernels were again pressed to ensure permanent deformation which was observed at pressing heights 55 mm and 50 mm respectively. However, the test was stopped for kernel pressing height of 50 mm at force 300 kN as a result of the ejection of kernel cake through the holes beneath the pressing vessel.

RESULTS

The results of the compression test are presented in table 1. Percentage oil yield and energy increased with increasing pressing force for both unroasted and roasted kernels at speed 10 mm/min.Unroasted kernels produced higher percentage oil yield compared to roasted kernels. Hence, energy demand was higher.

The coefficients of determination (R^2) of oil yield for both unroasted and roasted kernels were approximately 72% (Fig. 1). On the other hand, that of energywas72% and 47% respectively (Fig. 2). The 72% explainthe significant effect of compressive force on oil yield and energy whiles the 47% suggestpartly effect. The decrease in percentage oil yield of roasted kernels compared to unroasted kernels could be attributed to the change in the physical, mechanical and chemical structure during the heat-treatment process.

Traditionally, the roasting of the kernels is to aid oil extraction. However, due to the energy intensive process of the traditional oil processing of the roasted kernels(drying of nuts, cracking of nuts, sieving of cracked nuts, separation of kernels, sun-drying of kernels, winnowing of kernels, removal of undesired materials, roasting of kernels, milling of roasted kernels into paste and cooking and collection of oil), direct compressionof the unroasted kernels would be more convenient and environmentally friendly.

Although, the kernels required repeated pressing for complete deformation to achieve maximum oilrecovery at optimal pressing force of 250kN, there is still need to examinethe variation offorces, moisture content, heat-treatment duration, pressing vessel diameters and speeds in relation to oil yield and energy requirement of both the unroasted and roasted oil palm kernels under compression loading.

Table 1

Energy (kJ) and oil yield (%) of oil palm kernels at speed 10 mm/min

Pressing force [kN]	Pressing height [mm]	Unroasted kernels		Roasted kernels	
		Energy [kJ]	Oil yield [%]	Energy [kJ]	Oil yield [%]
150	*60	0.907	22.09	0.824	14.50
	55	0.699	10.50	0.490	7.82
	50	0.588	6.20	0.341	4.44
	Sum	2.194	38.79	1.655	26.76
200	60	1.045	22.75	1.091	18.38
	55	0.654	10.50	0.707	9.22
	50	0.783	7.30	0.985	6.73
	Sum	2.482	40.55	2.782	34.33

250	60 55 50	1.226 0.717 0.958	25.27 12.38 7.40	1.225 0.742 0.543	18.19 7.44 6.29
	Sum	2.901	45.05	2.510	31.92
300	60 55 **50	1.536 0.929 -	31.06 14.00 -	1.339 0.869 -	20.54 8.21 -
	Sum	2.465	45.06	2.208	28.75

* Initial pressingheight of kernels; ** Compression was ceased due to the ejection process.

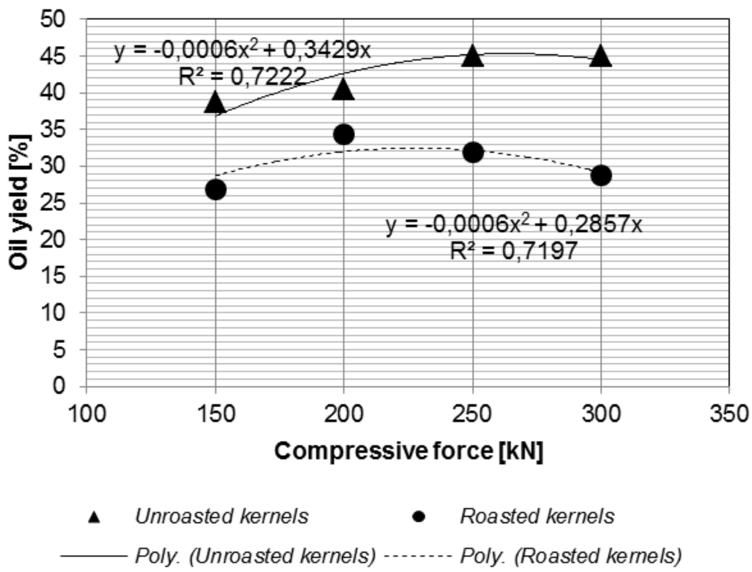

Fig. 1 - Relationship between oil yield (%) and compressive force (kN) of unroasted and roasted oil palm kernels at speed 10 mm/min

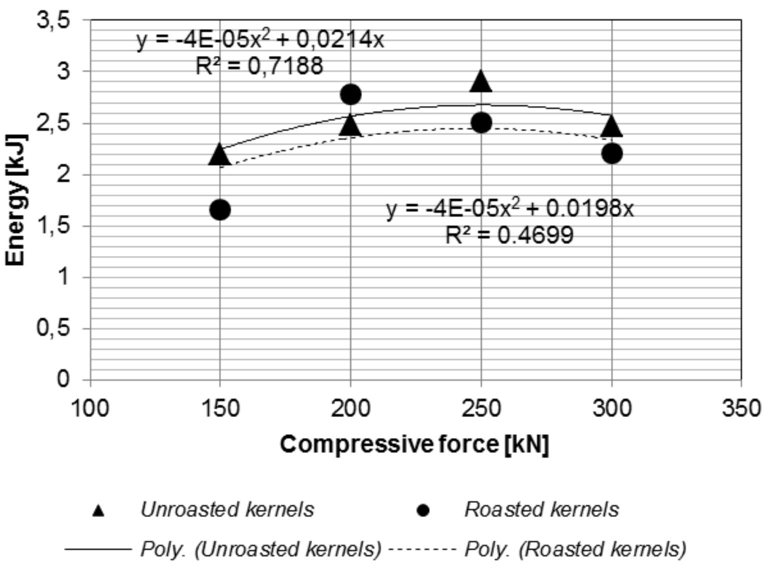

Fig. 2 - Relationship between energy (kJ) and compressive force (kN) of unroasted and roasted oil palm kernels at speed 10 mm/min

CONCLUSIONS

Knowledge of the mechanical properties of bulk oilseeds or kernels isessential in determining the energy requirement for obtaining higher percentage oil. The study findings include the following:

- Optimal pressing force without serration effect on the force-deformation curve was observed at 250 kN. However, the kernels were not permanently deformed.
- Serration effect was noticed at force 300 kN and pressing height of 50 mm. Compression was ceased here as a result of the ejection of the crashed kernels through the holes beneath the pressing vessel.
- Oil yield and energy requirement of unroasted kernels were higher in comparison with roasted kernels.

It is necessary to consider the variation of compressive forces, moisture content, heat-treatment temperatures, pressing vessel diameters and speeds to adequately understand the mechanical behaviour of oil palm kernels under compression loading.

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TECHNOLOGY AND POLICY PATHWAYS FOR RECLAMATION OF SALT AFFECTED LANDS IN INDO-GANGETIC PLAIN

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INDO-GANGA MAIDAN MEIN NAMAKGRAST BHOOMI SUDHAR: PRAUDYOGIKEE AUR NITI PATH

Ph.D. Eng. Tyagi, N. K.* [1], **Ph.D. Agri. Econ. Joshi, P. K.** [2]
[1] Central Soil Salinity Research Institute Karnal, India, [2] International Food Policy Research Institute-South Asia, New Delhi, India
Tel: +91-9818911253; E-mail: nktyagi1947@gmail.com

KEYWORDS: *salinization, reclamation, drainage, technology, policies*

ABSTRACT

Salinization of irrigated lands is a major issue in India having serious implications on food security and environment. Appropriate technology packages-one for reclaiming water logged saline soils underlain by brackish water aquifers; and the other for sodic soils, mostly underlain by good quality groundwater, have been evolved. The evolution and out-scaling of these agro-technologies with supporting policies and institutions, is presented. The restoration of sodic lands was achieved through integrated management of rainwater (in farm pond and rice paddies) , chemical amendment for neutralization of alkalinity, shallow tube wells for irrigation and drainage and land surface modifications to improve salt leaching and irrigation efficiency. The technology for reclamation of saline soils, evolved from multi-location field experimentation, with focus on shallow horizontal subsurface drainage system for monsoonal climate. The system required minimal pumping, and offered opportunity for practicing controlled drainage to reduce irrigation requirements in post reclamation years. The monitored data indicated favourable changes in hydrology, subsoil water quality (in case of saline water logged lands), land productivity, farm income and employment. The assessment of out-scaled land restoration programme revealed that, public policies in respect of energy for energizing tube wells, subsidy on chemical amendments and farm credit, accelerated the pace of technology adoption. The institutional arrangements –research institutions, land reclamation corporations and international organizations with strong linkages at country level; and the users' associations, self help groups and cooperatives at village level, very effectively supported the land reclamation, leading to transformative socio-economic changes.

ABSTRACT

Sinchit bhoomi ka salinization Bhaarat mein khaadya aur paryaavaran suraksha ke liye ek pramukh mudda hain. Es gambeer hoti ja rarhi samssyya ko theek karney ke liye upayukt praudyogikee sankul viksit kiya gaya. Yeh praudyogikee sankul mukhyataya jalgrast namkeen bhoomi, jiske neeche namkeen pani ke jalbhret hote hain; aur sodic bhoomi, jinkee neeche mukhyateh mithae jalbhret hote hain, unke sudhar ke liae viksit kiya. Eskey saathhe praudyogikiyon ke prasar ke vaste samarthak neetiyan prestavit ke hain. Sodic bhoomi sudhar kee praudyogikee mein mukhyateh sanyojit varsa jal prabhandh(khet taalaab aur dhan ke khet mein), sodicity nivaran ke liae raasaayanik sudharak, sinchaee aur jal nikaasee ke liae uthlae nalkoop, namak leeching aur sinchaee dkhshta ke liae bhommi satah samtalan, aur dhan ke kheti samlit hain I Maanasoonee jalavaayu kchetra mein jalakarant namkeen bhoomi suddhaar kee praudyogikee, bahu esthaan kshetrya prayogon se vikasit kee gai hain. Es praudyogikee mein uthale kshaitij upasatah jal nikaasee vyavastha par dhyaan dene ke saath niyojit jal niskasan par jor rehta hein. Yeh pranali sunischit karti hain kee jal niskasan kam se kam rahe, aur niyantrit jal nikaasee ho, jisse bhoomi sudhar ke paschat sinchaee aavashyakataon ko kam karane ka avasar milta hein. Jootayae huae ankron ke adhar par yeh jankari praptt hue, kee bhoomi hydrology, jal kee gunavatta (in namkeen jalakrant bhoomi), bhoomi kee utpaadakata, krishi amdani, aur rojagaar avsaron mein anukool parivartan aayyaen hein. Bade paimane par bhoomi sudhar ke karyakram ke anklan ne yeh sanket diya hein kee raasaayanik sanshodhak, krishi loan, avam bijlee aadi par sabsidee aur twarit gati se praudyogikee graham sambandhi saarvajanik neetiyon ka bahoot prabhabh hua hain. Sansthaagat vyavasthayan, jaise krishi anusandhan sansthaan, bhoomi sudhaar nigam, antarrastrya sehyog, aur desh ke estar par majboot sehkari sansthain, svayam sevi sahaayata samooh; aur graam istar par sahakaaree samitiyon aadi ne bahut prabhaavee dhang se bhoomi sudhaar karyyakram to vistar diya, aur karntikari saamaajik-aarthik parivartan lanne mein prabhabshali bhoomika nebhai.

INTRODUCTION

Soil salinity in irrigated lands, which is of common occurrence in India, has two main manifestations-saline soils with high concentration of soluble salts within the root zone due to occurrence of high water table in areas underlain by brackish water; and the alkali soils having high concentration of sodium and magnesium in exchangeable form. According to recent estimates salt affected soil are spread over 6.73 Mha, with serious implications on Indian economy (CSSRI, 2010, Joshi and Jha, 1992).Salinity and water logging which reduces land productivity and make land uncultivable, in case of high salt concentration, can be reclaimed for crop production mainly through improved drainage. Globally, horizontal subsurface drainage (HSSD) has been found to be quite effective and eco-friendly technology in areas with poor quality groundwater. In India, experimentation with HSSD began in 1873, when stone and tile drains were laid out to reclaim the lands in the Northwest. In the first quarter of 20th century, four major studies - one at Manjri (Maharashtra), Baramati (Maharashtra) Chalkanwali (now in Pakistan), Nissang (Haryana), were conducted (INDP, 2002). The significant observation from these studies was that though the installed system failed to keep water table below the desired levels during critical periods, yet it provided significant benefits in terms of increased crop yield over the un-drained cropland. The technology development for reclamation of waterlogged saline lands, which can be named as shallow horizontal subsurface drainage (SHSSD) described in subsequent sections has drawn support from these seminal studies.

MATERIAL AND METHOD

Like saline soils, alkali soils also have been a major concern as reflected in Reh* Committee Report of 1879 and the scheme for experimentation recommended by this committee, as reported in Tyagi and Minhas(1998), were documented by Leather (1906,1911).Leather , on the basis of experimentation on alkali soils in United Province and Punjab, reported that “The only methods feasible are good cultivation practices-- and application of gypsum”. Unfamiliarity with the cation exchange phenomena and lack of government support for chemical amendment, reclamation of alkali soils did not make much headway. But researches initiated by Leather and subsequently by Indian researchers as reported in Tyagi and Minhas (1998) provided basis for currently evolved reclamation technologies. Alkali land reclamation technology has been out-scaled in large area covering more than a million ha of degraded land.

Experience with technology adoption in the past had shown that capital intensive natural resources management technologies do not go very far without supportive policy environment by way of mainstreaming them in development programmes. Faced with the challenge of ensuring food security with declining land resources and growing population, institutional restructuring and policy initiatives were undertaken to promote salty land reclamation (INDP, 2002; Tyagi and Singh, 2009,Joshi and Jha,1994). This paper aims at presenting the current status of technology which has been developed and refined though multi-location field experimentation and its out scaling with supportive policies, public sector institutions and grass root organizations.

RESULTS

Technology for reclamation of alkali land

Major advancements in salinity research are due to US Salinity Research Laboratory, Riverside California; Institute of Soils, Hungary, and Central Soil Salinity Research Institute (CSSRI), Karnal, India (Szabolcs, 1977; Tyagi and Minhas, 1998; Wallender and Tanji, 2011). The researches at CSSRI and at several state agricultural universities in India have led to problem specific technology development in the last 40 years (Agarwal et al, 1982; Abrol et al, 1988; Tyagi and Minhas, 1998; and CSSRI, 2004). The solution of alkalinity/sodicity revolves mainly around application of chemical amendments along with use of appropriate crops and varieties and good agronomic practices. The current emphasis for reclaiming salt-affected soils is on harnessing the synergy of built-in plant salt tolerance and the chemical amendments (Singh et al, 2004)

Innovations in sodic land reclamation technology and constraints

It is true that application of chemical amendments, which was mostly gypsum or in some cases pyrites, but Indian researches on alkali land reclamation made a number of innovations leading to reduction in cost and improvement in efficiency of water use.

Reduced requirement of chemical amendments

A major advancement in technology of alkali land reclamation was the field tested recommendation on the reduction in doses of chemical amendment- a major item in reclamation cost. But field experiments conclusively established that gypsum requirement could be reduced by 50 percent of what was required for complete neutralization of exchangeable sodium, without any appreciable loss of crop productivity over a time span of 3-5 years (Abrol et al, 1988). Once initiated, the reclamation goes in auto mode taking advantage of calcium carbonate present in calcareous soils occurring in northern India. Advantage of salt tolerant crop varieties to reduce the requirements of chemical amendments was successfully tested and out-scaled (Singh et al, 2004, Tyagi and Singh, 2009).

Land shaping and irrigation application system design

Standards for land levelling, grading and design of surface irrigation application methods for rice-wheat, which is the most prevalent cropping pattern, were evolved and propagated (Tyagi, 2007). It was established that light and frequent application of irrigation water was possible, if the levelling index (departure from the required surface elevation across the irrigation unit) was within limits (Tyagi, 1884). A major issue in design of surface water application was the conflicting water management demands of rice, which required uniform water depth of standing water across the rice paddies, as against the requirement of zero submergence in case of wheat to avoid aeration stress. The problem was resolved by adopting mildly sloping border check basins for wheat, which were compartmentalized into 2-3 check basins along the length, and were equipped with an overflow device on the earthen bunds across the width at desired elevation (Pandey et al, 1977).

Farm drainage system

A three tier system of drainage, for taking care of surface water stagnation ;involving storage of rainwater within rice paddies ,storing part of the surplus rainfall in on-farm reservoirs ,which also served as source of irrigation water, and channelizing the remaining runoff into regional drains, was conceived and implemented. The permeability of alkali soils being extremely low, provision of horizontal sub surface drainage (HSSD) system for lowering the sub soil water level was not a very cost effective option. An innovative solution of this problem was found in shallow tube wells for every 2-3 hectare land, which served the dual purpose of providing vertical drainage, and of serving as dependable source of irrigation water. Recently another innovation has been introduced in the form of dugout ponds in water logged alkali lands, which collects subsoil water from the surrounding area resulting in lowering of water table, which in turn serves as source of irrigation water (CSSRI, 2010). Earth from dugout ponds is put on embankments, which are used for raising commercial crops and this has raised the benefit cost ratio of the reclamation technology.

Technology for reclamation of waterlogged saline land

In India the need for provision of drainage and development of appropriate technology for reclamation of waterlogged saline lands in irrigated areas, has been emphasized as early as 1928(Royal Commission,1928) ;and has been subsequently emphasised by several other commissions (Irrigation Commssion,1972; National Commission on Agriculture,1976), the real attempts to had to wait till 1982. These efforts initiated by Central Soil Salinity Research Institute (Rao et al,1986),got further strength from Dutch collaboration in the form of Indo-Dutch project Pilot Area Drainage Research(INDP,2002),Haryana Operational Pilot Project (HOPP,2001),Rajasthan Agricultural Drainage Project(RAJAD,1995

Intensive monitoring of soil salinity, water table, sedimentation in drains, effluent quality and its reuse, and crop yields was undertaken for periods ranging from 3 to 12 years. These efforts, which are documented in several technical bulletins and research publications cited in Ambast et al (2004) and Gupta (2014), led to evolution of appropriate technology for reclamation of irrigated water logged saline lands in arid regions. The emphasis in these efforts was to keep focus on economic and environmental aspects, unlike the drainage in humid regions, where technical design criteria was given importance. The philosophy and innovations are briefly discussed.

Technology innovations and constraints

The technology innovations for reclamation of waterlogged lands are based on the premise that in arid regions which are water scarce, and where water logging is the result of water percolating into the sub soil over the years, the aim of drainage should not be removal of large quantities of water of water in short time. The reduced drainage will lead to reduced irrigation requirements due to increased use of sub-soil water.

HSSD with shallow depth and wider spacing

The drainage system for large scale implementation should aim at minimization of cost rather than maximizing crop yield with faster water table drawdown. Experience with operation of drainage system over a period of 12 years at Sampla in Haryana has shown that under the agro-climatic conditions prevailing in Northern India, close to 70 % of the root salt was leached after 5 years resulting in insignificant difference in yield of wheat crop in plots with drain spacing ranging from 25m to 75m after 5 years (Fig1). Further, for field crops like wheat, maize, cotton etc, it did not make much sense to install HSSD at deeper depths, as this would increase cost without any commensurate gains in salinity profile of the crop root zone or crop yields. Therefore, for light textured soils of arid regions of Rajasthan, from economic and environmental considerations, the recommended depth and spacing of HSSD system were placed at 1.1 m, and 100-150 m. The corresponding values of these parameters for medium textured soils of semi-arid regions of Haryana were 50-100 m (INDP, 2002).

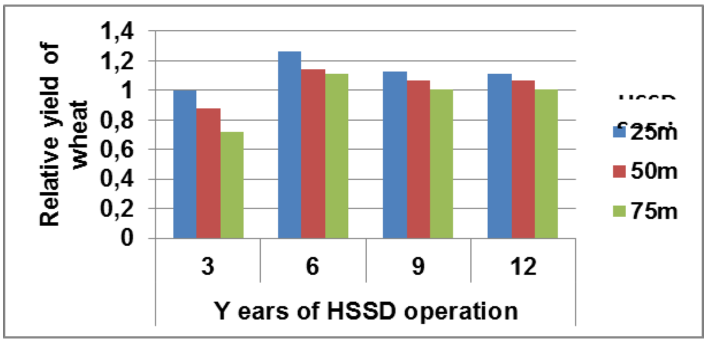

Fig.1 - Change in relative yield of wheat under different drain spacing in post installation years(Data: INDP, 2002)

Salinization and desalinization in monsoonal climate and greater reuse of drainage effluents

The salinity of drainage effluents from horizontal subsurface drained lands decreased with time and this increased the crop productivity and reduced the need for disposal of effluents. Monsoonal rains play a crucial role in desalinization cycle and in regulation of seasonal salt balance in the root zone. The opportunity of continuous leaching and prevalence of higher moisture regime in the crop root zone in HSSD drained land resulted in higher crop productivity (Tyagi, 2011). Of course, distribution of monsoon rainfall, seasonal root zone salinity variation and long term aquifer salinity balance remain important considerations.

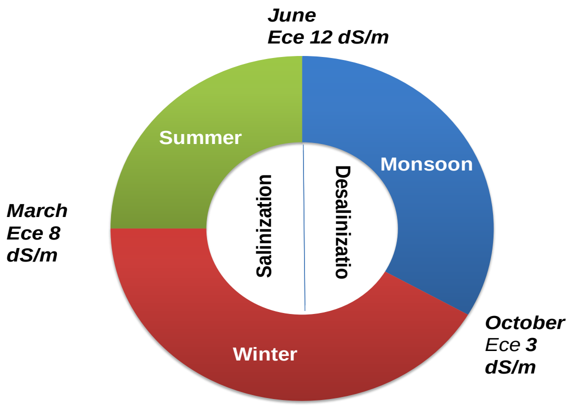

Fig.2-Soil salinization and desalinization cycle in monsoon climate

Disposal of saline effluents during monsoon season

Salt laden drainage effluents often create environmental issues in disposal sites. This problem was effectively solved by organizing pumping for water table control mostly during rainy season (June-September) when rivers are in high flows. For example, the flow in River Yamuna, which drains a large part of the waterlogged in Haryana, the flow varies from June-September which effects huge dilution, with practically no adverse environmental effects. On the other hand, flow during winter months (December – March), when river flow is only the disposal of effluents is only through reuse in irrigation, which is favoured by the desalinized post monsoon soil profile and the low evaporative demands during the winter season.

Socio-economic impacts of land reclamation

One of the major benefits of land reclamation has been the generation of additional income and employment. Intensification and expansion of cultivated land were the major routes through which income of the order of US $ 297/ha/yr (Tyagi and Singh,2009) and additional employment of about 165 man-days ha^{-1}in the first year of alkali land reclamation (Joshi,1994). The incidence of poverty saw a sharp decline of the order of 40 percent. The transfer of land ownership right to the cultivators; and its consolidation encouraged farmers to make investment in land improvement; and in the long run it saw several fold increase in land value. The increased participation of women through self help groups improved their self confidence and made them the agents of change.

Evolution of institutions and policies for out-scaling technologies

The technologies need the wings of appropriate policies, institutions and the long term funding to travel from labs to land at faster speed; and the case of land reclamation technologies was no different. The major components of alkali land technology were established in 1960s, but application had to wait, till the evolution of public policies, institutions and funding support. The major institutions and policy initiatives are briefly discussed.

Establishment of land reclamation corporations

Institutionalized arrangement for implementation of reclamation programme was a significant departure from the past. The adoption of land reclamation technologies by the farmers began with demonstrations on farmers' fields and their success persuaded the state governments to establish land reclamation corporations with the mandate to establish infrastructure for soil testing, land levelling, and supply of inputs at government controlled prices. Establishment of command area development authority (CADAS) as early as 1974 with the mandate to improve irrigation water utilization through micro level infrastructure development and efficient farm water management played an important role. For example, the reclamation of water logged saline lands in the state of Rajasthan in black soils region of Kota was undertaken by Chambal Command Area Authority with Canadian International Development Agency(CIDA) (RAJAD,1995).

Community based organizations

In the state of Uttar Pradesh, the sodic soil reclamation projects were implemented in a participatory mode based on the principles of: transparency, equity, accountability, decentralized decision making, and human and institutional building (World Bank,2008). A management structure among the farmers was created to promote participation and share responsibilities. Water Users Groups, Land Drainage Associations, Self Help Groups, which were established in different projects played very crucial role (Tyagi and Singh, 2009). The nongovernmental organizations (NGOs) also assisted in spread of technology by increasing the awareness amongst the farming community.

Subsidy and credit policies

Land reclamation is a capital intensive activity, which small and marginal farmers could not have taken without government support. The subsidy on chemical amendments, land shaping and, electricity etc; and the credit for installation of tube wells were the major policy instruments which supported land reclamation. The policy of extending credit for agricultural inputs at nominal interest rates proved very helpful (Tripathi et al, 2004). The rural electrification programme that facilitated development of farmers' owned shallow tube wells for irrigation, took care of high water table. As a flagship programme of the salinity affected states, the land reclamation was mainstreamed into development programmes of the governments for large scale implementation. The impact of credit, subsidy and extension had very significant effect on technology adoption(Sharma,1997)

Public investment in land reclamation

The government of India launched a number of special schemes for reclamation of salt affected land under which budget provisions for technology adoptions were made. To support these programmes National Bank for Agriculture and Rural Development (NABARD) provided refinance assistance for reclamation of saline soils, under land development activity. A very crucial role was played by international lending agency like the World Bank and bilateral project assistance by the European Commission for up-scaling land reclamation in sizeable proportion (Tyagi and Singh, 2009).

Research and development organization

A number of public funded research organizations, such ICAR Salinity Research Institute at Karnal, and Agricultural Universities in the states, which were responsible for technology development also assisted in human capacity development and technical backstopping. The capacity building exercise covered village and district panchyats (local self government organization), non government organizations (NGOs), line departments and support agencies etc. Several international organizations including, World Bank, FAO-UNDP, and ILRI-ALTERA of Netherlands were partners in refinement and up-scaling of the reclamation technology.

CONCLUSIONS

The sustained research efforts over several decades have led to development of appropriate technologies for rehabilitation of salt affected waterlogged lands in the Indo-Gangetic Plain. The technologies are technically robust, economically viable and environment friendly. Large scale technology adoption has led to change from subsistence type of farming to more profitable agriculture. The favourable policy and institution regimes that were put in place have enabled the technology to make remarkably favourable impacts on capital formation, factor productivity, crop yield. These changes ultimately led to positive socio-economic transformation in the society. The immense environmental benefits in the form of reduced floods in alkali watershed, removal of water logging and improved sub soil water quality in saline land, have made the development and implementation of land reclamation technology a win-win proposition.

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ASSESSMENT OF POULTRY DRESSING TABLE LAYOUT WITH RESPECT TO WORKSPACE ENVELOPE

Tanbir Ahmad*[1], Nilesh Nivrutti Gaikwad[2], Yogesh Kumar[1], Rahul Kumar Anurag[1]
[1]Central Institute of Post-Harvest Engineering and Technology, Ludhiana141004, Punjab, India-
[2]National Research Centre on Pomegranate, Solapur 413 255, Maharashtra, India
Tel: +60172189116; E-mail: tanbirvet05@rediffmail.com

Keywords: *Poultry; Poultry dressing table; Workspace envelope; Poultry dressing, Ergonomics*

ABSTRACT

A survey study of thirty poultry butchers shops was carried out for assessment of positions of different components of poultry dressing tables from the central axis of the body in the live bird markets of state of Punjab, India. Ten representative samples were selected randomly. The workspace envelope was drawn by using the average height of northern Indian male workers which is 1685 mm. Segment lengths expressed as ratio of stature were used for the development of workspace envelope. The locations of different components of poultry tables surveyed were superimposed on the prepared two dimensional template of workspace envelope in both the planes and their locations were compared with respect to developed workspace envelope. Dicing boards were placed in the workspace envelope in all poultry dressing tables but did not fall in the optimum work area for tables G, H, I, and J. Weighing balances and washing buckets were out of workspace envelope in all the poultry dressing tables. Except for G, all the dustbins were out of workspace. All the meat holding bowls were out of workspace envelope with the exception of table G. Weighing balance was inside the horizontal workspace envelope in tables D, F, G, and I and outside the vertical workspace envelope in all the cases. The results clearly indicated the poultry butchers have to adopt uncomfortable postures and stretch their limits to reach at the different components while dressing the poultry birds.

INTRODUCTION

Traditional manual poultry dressing accounts for roughly 95% (Ministry of Food Processing Industries, Govt. of India, 2012) to 98% (*Landes et al., 2004*) of all the poultry meat consumed in India. Indian poultry processing sector operates almost completely as a live-bird market where live-birds are slaughtered at the time of sale. The poultry dressing in these live markets are characterized by poorly designed dressing tables, floor dressing, non-separation of clean and unclean area, improper carcass washing. Mostly poultry dressing is carried out in standing posture by the butchers and sometimes in sitting posture. A standing posture allows greater flexibility to exert force (*Department of Occupational safety and Health, Malaysia, 2002*). The highest risk industries, with respect to work related musculoskeletal disorders (WMSDs) were meat and poultry processing (*Yassi et al., 1996*). The physical work place factors associated with an increased risk of WMSDs are repetition, posture and force (*Bernard, 1997*). This industry implies a high risk of musculoskeletal disorders in the neck and upper limbs (*Viikari Juntura, 1983; Frost et al., 1998, 2002; Van Rijn et al., 2009*). *McGorry et al. (2000)* investigated a poultry processing operation and found a significant effect of elbow height and work surface height on the power requirement of the cutting operation. Interventions should in general aim at improving all these factors (*Westgaard and Winkel, 1996*). The improper design of a standing workstation would make the task more difficult, strenuous, fatiguing, boring, unacceptable and uncomfortable for the operators, which will have an effect on quality of work, productivity and safety and health of the employees (*Department of Occupational Safety and Health, Malaysia, 2002*).

The working posture and task should be designed to avoid strain and damage to any part of the body such as the tendons, muscles, ligaments, and especially the back. During work, employees subconsciously tend to accept and adapt to unsatisfactory standing working conditions. They may not realize that their body is under strain until they feel actual pain and even then they may not understand the causes (*Department of Occupational Safety and Health, Malaysia, 2002*). Ideally all work activity should permit employees to adopt several different, equally healthy and safe postures without reducing the capability to do the work. The employees should be able to maintain an upright and forward facing posture. The work should be arranged so that it may be done either in the seated or standing position (*Department of Occupational Safety and Health, Malaysia, 2002*).

The present study was carried out to assess the locations of the different components or to compare the locations of the different components poultry dressing tables surveyed in live poultry markets with respect to developed workspace envelope for an average north Indian population. Anthropometric dimensions of average north Indian male farm workers were used to develop workspace envelope and different components were placed in horizontal and vertical plane of workspace envelope.

MATERIAL AND METHOD

A survey study was carried out for assessment of positions of different components of poultry dressing tables in the live bird markets of state of Punjab, India. Poultry butchers were using different components viz. dustbin for bleeding the birds and keeping by-products waste, washing bucket to wash the poultry carcasses after bleeding, dicing board to cut the poultry carcasses into different parts, weighing balance to weigh the meat and meat holding bowl to temporarily store the unsold meat. In this study dustbin, washing bucket, dicing board, weighing balance, and meat holding bowl are referred as different components of poultry dressing table. The survey was conducted to assess the locations of the different components of poultry dressing table from the central axis of the body. The standing position of butcher is considered by leaving 10 cm of clearance from the inner edge of the table. The measurements were taken for the comparative evaluation in relation to the developed workspace envelope in horizontal and vertical planes of an average height of male farm worker in northern region of India. The poultry shops of thirty butchers were visited. Ten representative samples were selected randomly out of 30 sampling units (Table 1 and 2).

Table 1

Dimensions of different poultry dressing tables (cm).

Poultry dressing table	A	B	C	D	E	F	G	H	I	J	Mean
Height (cm)	82	79	73	70	78	98	86	88	65	68	78.7 (±10.18)
Length (cm)	140	127	220	45	178	153	106	153	255	270	164.7 (±68.76)
Width (cm)	80	74	87	70	100	92	67	112	85	95	86.2 (±14.09)

Values in parenthesis are standard

Table 2

Distance and height of different components of poultry dressing table from central axis of the body.

Poultry dressing table	Distance of dicing board (cm)	Height of dicing board (cm)	Distance of weighing balance (cm)	Height of weighing balance (cm)	Distance of washing bucket (cm)	Height of washing bucket (cm)	Distance of meat holding bowl (cm)	Height of meat holding bowl (cm)	Distance of dustbin (cm)	Height of dustbin (cm)
A	42	94	90	97	68	55	60	82	70	59
B	47	98	87	94	130	42	84	79	71	40
C	40	88	80	88	95	43	88	73	80	44
D	46	80	70	85	85	43	87	70	60	40
E	44	89	98	93	96	43	65	78	95	70
F	44	115	80	113	70	45	90	98	80	52
G	60	98	70	101	16	44	40	86	40	76
H	50	98	96	103	75	43	63	88	70	56
I	50	85	75	90	100	45	68	65	65	54
J	55	90	80	83	90	44	70	68	68	50
Mean	47.8 (±5.81)	93.5 (±9.16)	82.6 (±9.41)	94.7 (±8.66)	82.5 (±27.94)	44.7 (±3.55)	71.5 (±15.04)	78.7 (±9.66)	69.9 (±13.61)	54.1 (±11.31)

Values in parenthesis are standard deviation from mean.

Workspace envelope template

A workspace envelope was drawn by using the average height of northern Indian male workers which is 1685 mm (Gupta et al., 1983). The anthropometric survey conducted by Gupta et al. (1983) on Indian farm workers established that there was a linear relationship between the standing height and other body dimensions and therefore other dimensions could be predicted from the standing height. Segment lengths expressed as ratio of stature by Roebuck et al. (1975) were used to arrive at the anthropometric dimensions of body parts (Fig. 1). These body dimensions were used for the development of workspace envelopes. Workspace envelope should ideally be designed for the 5th percentile or 95th percentile population. In present case however this will result in too little common space for placement of different utilities however use of 50th percentile is considered to be more appropriate to accommodate (Kumar et al., 2009) majority of meat workers population.

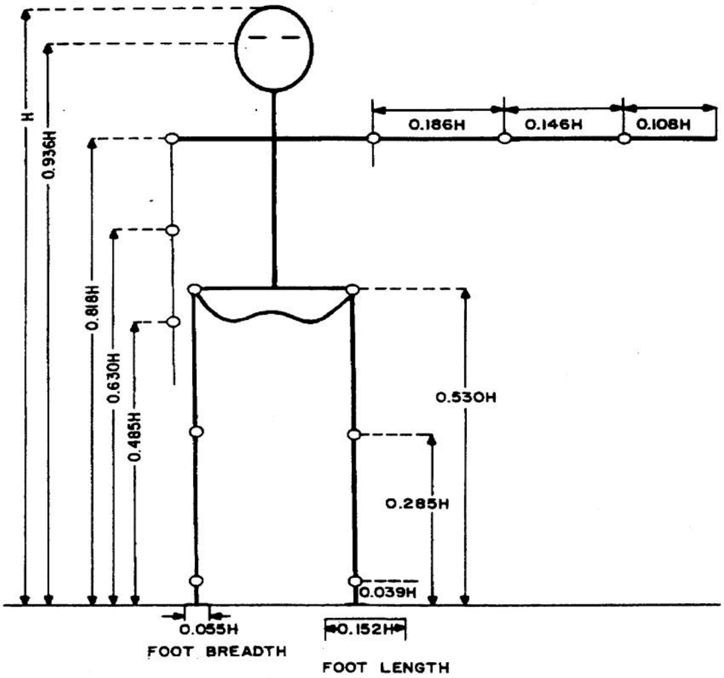


Fig. 1 - Segment lengths expressed as ratio of stature (Roebuck et.al, 1975)

The maximum reach for a male north Indian was 741.4 mm from the centre of the shoulder joint of the body (Fig. 1). Two arcs were drawn with radius of 741.4 mm each centred at the centre of the right and left shoulder joints (Fig. 2).

The elbow height from ground is 0.63 times the total height of the person (Fig. 1). Thus the average elbow height for north Indian farm worker will be 1060 mm. OSHA (2004) envisages that for the heavy work like meat cutting, the workstation should be below elbow height and Magnusson and Örtengren (1987) arrived at the conclusion that a table height of 17 to 22 cm below elbow height resulted in low loadings on both the low back and the shoulders. Helander (1995) further specified that the standard height of work station in vertical plane for working in standing position for long duration should be 15 cm below the elbow height. Thus the ideal height of workstation or dicing board in case of poultry dressing in horizontal plane has to be 910 mm.

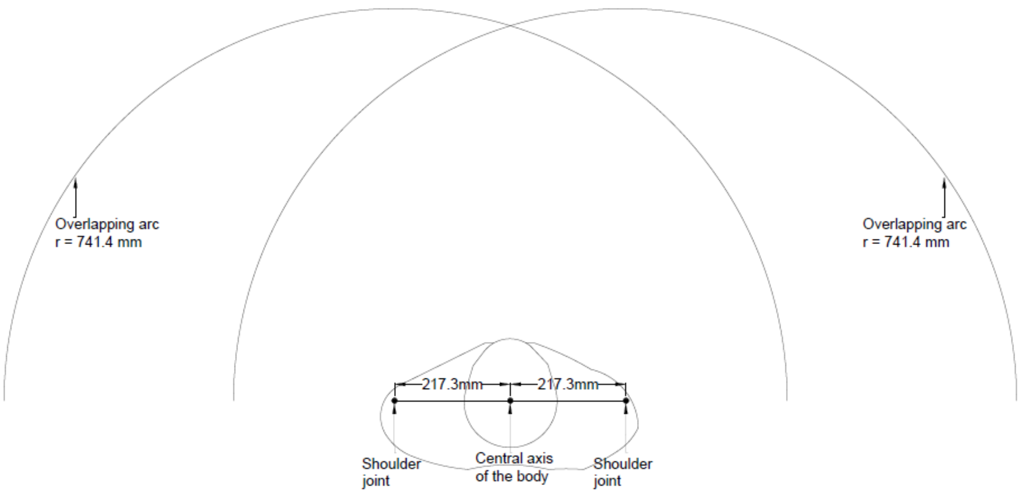


Fig. 2---Development of workspace envelope for an average north Indian population in horizontal plane.

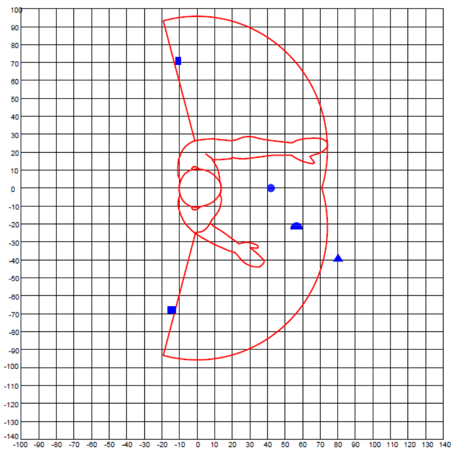
A two-dimensional template in 1:5 scale was drawn in plan and elevation following the method used by Zander (1972). The reach of north Indian farm worker (Fig 2) was used for drawing the workspace envelope in this template. The locations of different components of poultry tables surveyed were superimposed on the already prepared two dimensional template of workspace envelope in both plan and elevation.

Comparison of locations of different components on different poultry dressing tables

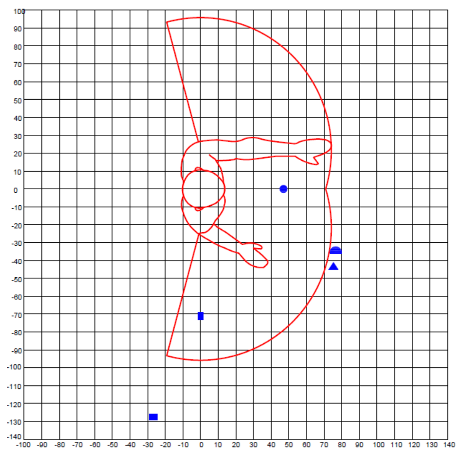
The components of poultry dressing tables surveyed were arranged spatially in both horizontal and vertical planes and their locations were compared with respect to developed workspace envelope. Meat cutting is categorized as the heavy task (*McGorrya et al., 2003; Wang and Shanmugam, 2009; OSHA, 2004*) and therefore in the developed workspace envelope, the dicing board should be kept in most efficient work area *i.e.* in front of the worker's central axis of the body and with outer edge of square measuring 250 x 250 mm overlapping at center of outer edge of the reach (*Department of Occupational Safety and Health, Malaysia, 2002*).

RESULTS

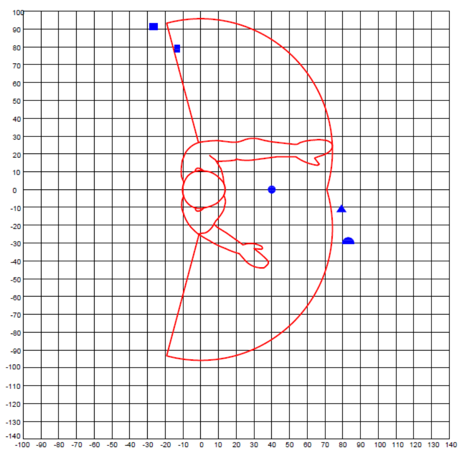
Different components of different poultry dressing tables were superimposed on the developed workspace envelope in both horizontal (Fig. 3) and vertical planes (Fig. 4). The locations of different components with respect to workspace envelope in horizontal and vertical planes were combined and shown in Fig. 5 (a) and Fig. 5 (b), respectively. The components were classified as located within the workspace envelope and outside the workspace envelope with respect to particular plane. The components were also classified as inside workspace envelope in both horizontal and vertical planes and outside workspace envelope in either or both horizontal and vertical planes (Table 3).



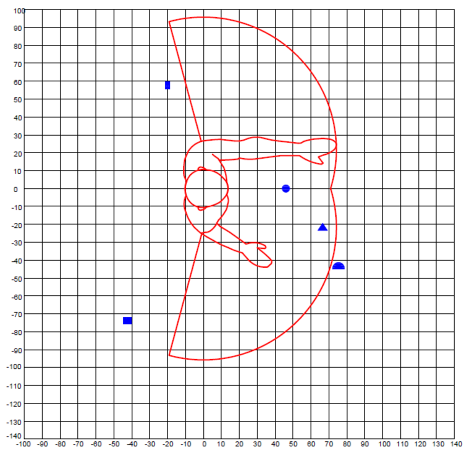
Poultry Dressing Table A



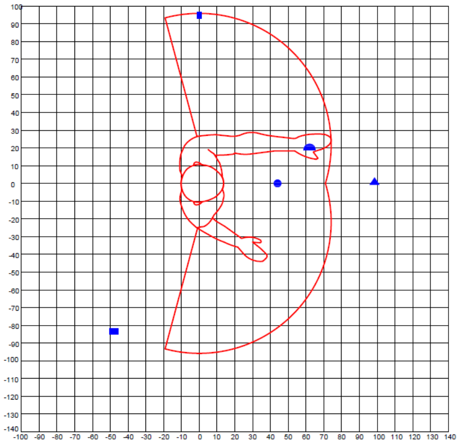
Poultry Dressing Table B



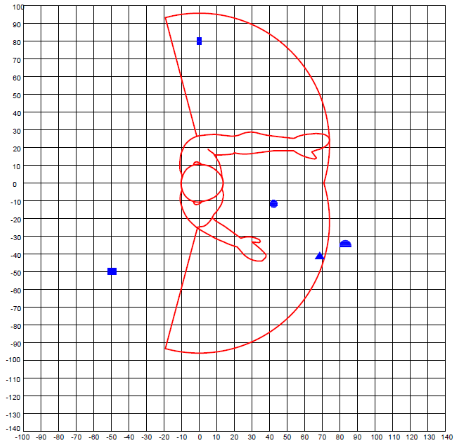
Poultry Dressing Table C



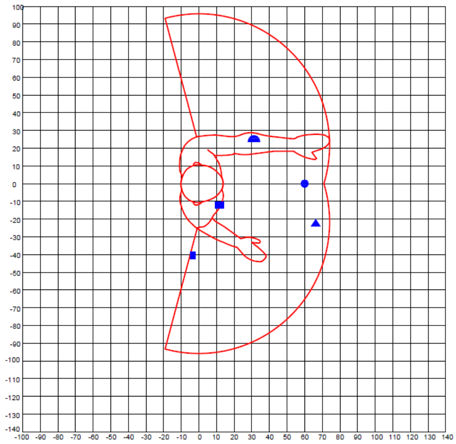
Poultry Dressing Table D



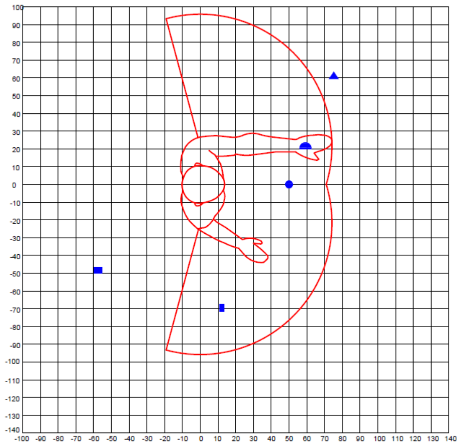
Poultry Dressing Table E



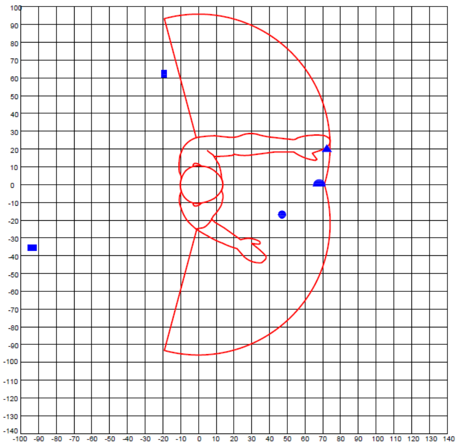
Poultry Dressing Table F



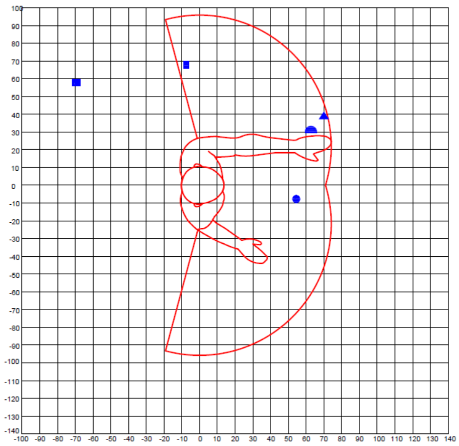
Poultry Dressing Table G



Poultry Dressing Table H



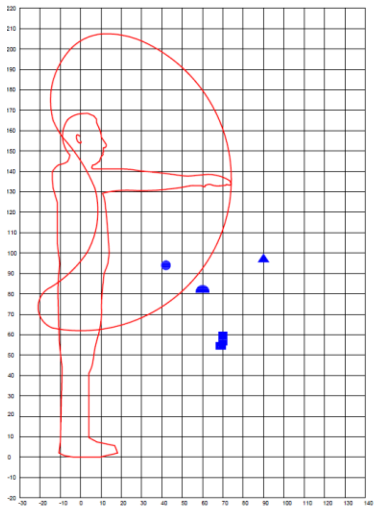
Poultry Dressing Table I



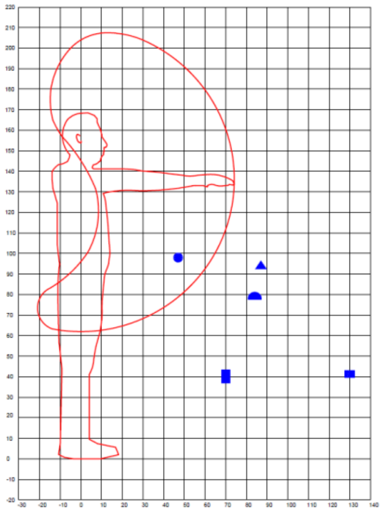
Poultry Dressing Table J

Fig. 3---Location of different components of poultry dressing table with respect to workspace envelopes in horizontal plane (A- J)

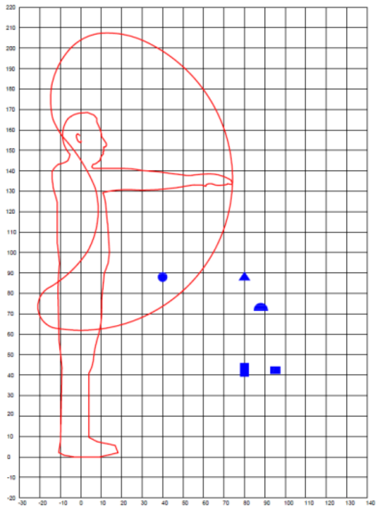
=Dicing board, =Weighing balance, =Washing bucket, =Dustbin, =Meat Holding Bowl



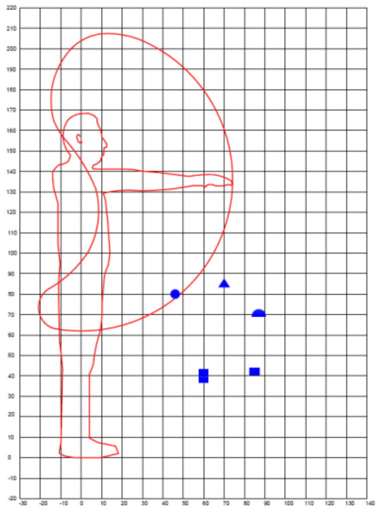
Poultry Dressing Table A



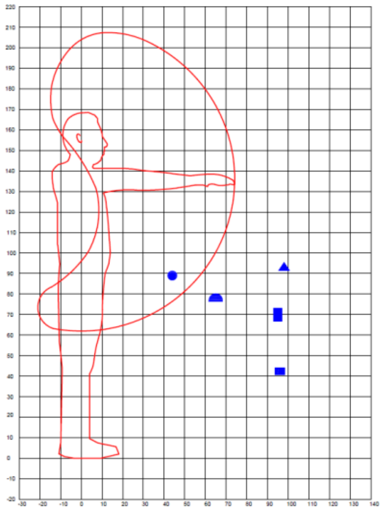
Poultry Dressing Table B



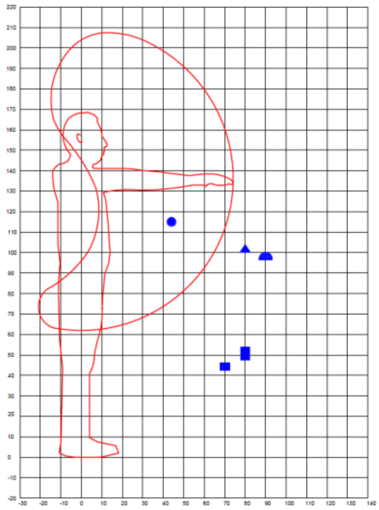
Poultry Dressing Table C



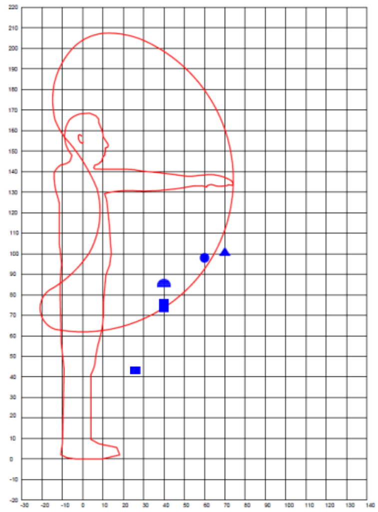
Poultry Dressing Table D



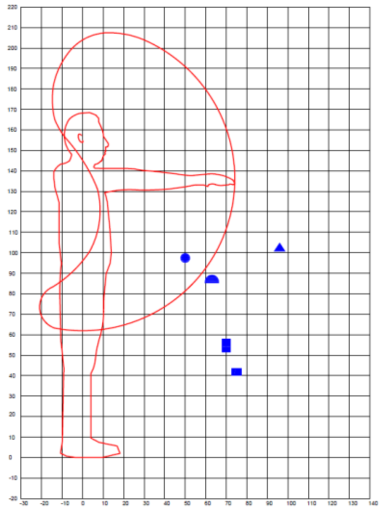
Poultry Dressing Table E



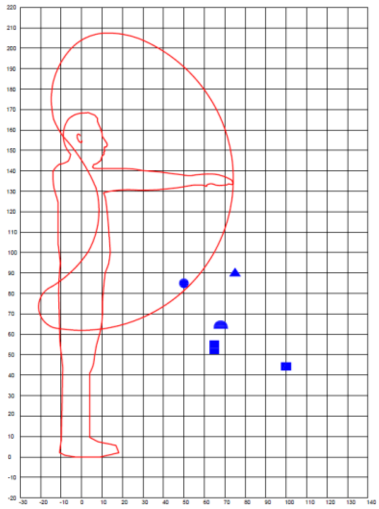
Poultry Dressing Table F



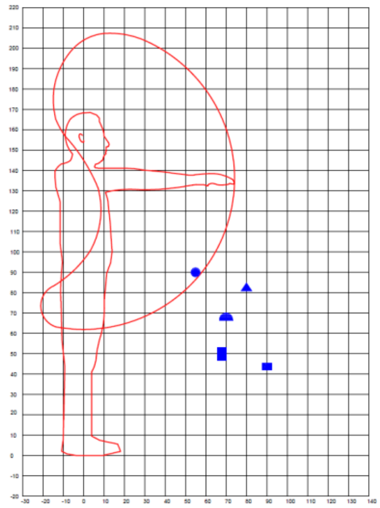
Poultry Dressing Table G



Poultry Dressing Table H



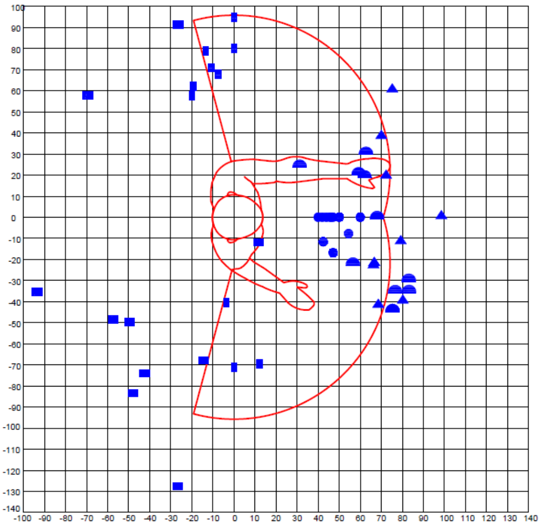
Poultry Dressing Table I



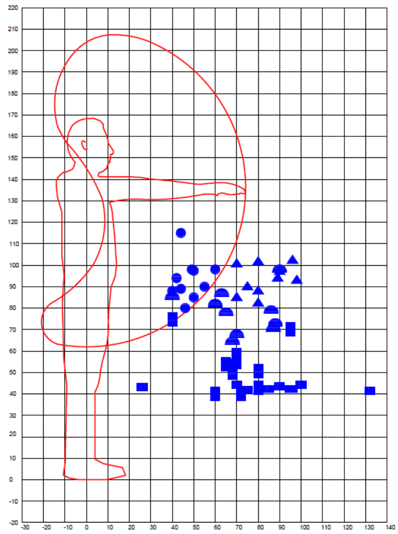
Poultry Dressing Table J

Fig. 4---Location of different components of poultry dressing table with respect to workspace envelope in vertical plane (A- J)

=Dicing board, =Weighing balance, =Washing bucket, =Dustbin, =Meat Holding Bowl



a



b

Fig. 5---Location of different components of different poultry dressing table with respect to workspace envelopes in horizontal plane (a) and vertical plane (b) (poultry dressing tables A- J)

Where, =Dicing board, =Weighing balance, =Washing bucket, =Dustbin, =Meat Holding Bowl

Table 3

Location of poultry dressing table components with respect to workspace envelope.

Poultry Dressing Table	Plane	Dicing board	Weighing Balance	Washing bucket	Dustbin	Meat Holding Bowl
A	Horizontal	I	O	O	I	I
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
B	Horizontal	I	O	O	I	O
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
C	Horizontal	I	O	O	I	O
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
D	Horizontal	I	I	O	O	O
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
E	Horizontal	I	O	O	I	I
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
F	Horizontal	I	I	O	I	O
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
G	Horizontal	I	I	I	I	I
	Vertical	I	O	O	I	I
	Location	#	X	X	#	#
H	Horizontal	I	O	O	I	I
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
I	Horizontal	I	I	O	O	I
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X
J	Horizontal	I	I	O	I	I
	Vertical	I	O	O	O	O
	Location	#	X	X	X	X

Where, I = inside workspace envelope

O = outside workspace envelope

 # = inside workspace envelope in both horizontal and vertical plane

X = outside workspace envelope in either or both horizontal and vertical plan.

Dicing board

Dicing boards were placed in the workspace envelope in both horizontal and vertical planes in all poultry dressing tables (Table 3) but did not fall in the optimum workspace area for table G, H, I, and J.

Weighing balance

Weighing balances were located outside the workspace envelope in either or both the planes in all poultry dressing tables (Table 3). It was inside the horizontal workspace envelope in table D, F, G, I, J and outside the vertical workspace envelope in all the poultry dressing table.

Washing bucket

Washing buckets were out of workspace envelope in both the plane in all poultry dressing tables (Table 3) except in table G where it was inside the horizontal workspace envelope.

Meat holding bowl

Except for G where it fell inside the workspace envelope in both horizontal and vertical planes, all other meat holding bowls were out of workspace envelope in either or both the planes in all poultry dressing tables (Table 3). In tables B, C, D and F, meat holding bowls were situated outside the workspace envelope in both the planes and in tables A, E, H, I, and J it was outside the vertical plane.

Dustbin

All the dustbins were out of workspace envelope in either or both the planes in all poultry dressing tables (Table 3) except in table G where dustbin was inside the workspace envelope in both horizontal and vertical planes. Sparing table G, dustbins were outside the vertical workspace envelope in all the tables. In table D and I, dustbins were located outside the workspace envelope in both the planes.

Discussion

The results clearly indicated that the most of the components of poultry dressing tables fell outside the workspace envelope. Therefore, the poultry butchers have to adopt uncomfortable postures and stretch their limits to reach at the different components while dressing the poultry birds. Mean duration of work per day and average number of working days per week among meat cutters (butchers) in West Bengal, India was reported to be 10.4±2.1 hrs and 6 days respectively in unorganized sector (*Gangopadhyay et al., 2003*). So they face awkward bending, stretching and forceful exertion for a long duration of time. This causes unnecessary stress to them and may lead to musculoskeletal disorders (MSDs). Gangopadhyay et al. (2003) while studying the upper extremity cumulative trauma disorders (CTD) in different unorganized sectors also found out that about 72 % of meat cutters were engaged in their profession since more than 10 years and 80% responded in affirmation about discomfort feeling (pain-75%, numbness-40%, swelling-40% and stiffness-55%). They further concluded that in case of meat cutting activity which is highly repetitive activity-non-neural wrist posture, flexion, extension, forceful exertion with heavy tools used for long periods were the main causes of upper extremity CTD.

The heights of the tables do not match with the developed ideal height of the table which is 910 mm for north Indian farm workers. Table F height is 980 mm which is higher and all other tables height were lower than the recommended height of the table. Therefore, the poultry workers bent their backs and waist while performing the different tasks of poultry dressing exerting undue stress on their different body parts. The tables were of varied shape which did not confirm with the arc shape of the workspace envelope in horizontal plane.

Dicing boards of tables G, H, I, and J being away from the optimum workspace area force the butcher to adopt awkward posture every time to perform the task. They bent forward to reach the dicing board and this leads to unnecessary stress on their back.

Poultry butchers using the tables A, B, C, E, and H have to stretch their arms to reach at the weighing balance while weighing the meat. This resulted in the exertion on waist and shoulder joints as also reported by *Tichauer (1973).* Lying of weighing balance below the vertical plane would lead to bending and stress on back, waist and shoulder joints.

Washing buckets were kept on the floor of the shop. Their average height was 447 mm from the ground so to wash the poultry carcasses, butchers have to bend excessively. Keeping washing buckets out of the workspace envelope in both the planes causes bending and stretching of different body parts causing musculoskeletal disorders.

Meat holding bowls of tables B, C, D and F were outside the horizontal plane of workspace envelope requiring the butchers to extend their limits. In all the tables except G, the meat holding bowls were outside (below) the vertical plane although they were kept on the tables. Outside the vertical plane meant that the meat workers stretched their limits to reach the component.

Dustbins in all the cases except in the case of table G were below the vertical workspace envelope (Fig 3.3). All the dustbins were kept on the floor and average height of the dustbins was 541 mm from the ground. This implies that while using dustbins meat workers have to bend compromising their posture thus deviating from the normal posture.

CONCLUSIONS

The location of components of poultry dressing table mostly fell outside the workspace envelope for an average north Indian farm population. Dicing boards were placed in the workspace envelope in all poultry dressing tables but did not fall in the optimum work area for heavy task in tables G, H, I, and J. Weighing balances and washing buckets were out of workspace envelope in all the poultry dressing tables. All the meat holding bowls were out of workspace envelope with the exception of table G. In case of tables B, C, D and F, meat holding bowls were outside the horizontal plane of workspace envelope but it was in the optimum work area in table G. Except for G, all the dustbins were out of workspace.

Most of the washing buckets, dustbins and meat holding bowls were placed below the workspace envelope in vertical plane and this will force the butchers to bend every time to perform the task requiring undue effort leading to physical disorders. Meat cutting is categorized as heavy work. That is why the dicing board should be kept in the most efficient work area. There should be provision of washing carcass on the table itself. A meat holding bowl with provision to store the unsold meat temporarily should also be provided on the table top. For work requiring heavy force (e.g., some cutting or deboning), the table should be below elbow height.

Proper workstation height minimizes excessive forward trunk bending and lifting of the arms while dressing poultry. Therefore, the components of poultry dressing table should be kept on the table top to reduce drudgery to the poultry meat butchers. Efforts should be made to design and develop a poultry dressing table where all the components should fall within the optimum reach of workspace envelope of a person or at least within the maximum reach of workspace envelope.

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MEANS OF MICRO TURBINE USE IN AGRICULTURE
/
ВАРИАНТЫ ИСПОЛЬЗОВАНИЯ МИКРО ГАЗОТУРБИННЫХ УСТАНОВОК В СЕЛЬСКОМ ХОЗЯЙСТВЕ

Kulagin I.V.
The All-Russian Scientific-Research Institute for Electrification of Agriculture
(The ARIEA), Moscow, Russia.
Tel. +79689660946: E-mail; koulajin@gmail.com

Keywords: *agriculture, electric energy, thermal energy, micro turbine plants*

ABSTRACT
Micro turbine plants have a wide range of applications in agriculture. But for many farmers these technologies are still closed, mostly because of their high costs. The ARIEA made the first experimental plant which is intended for small agricultural manufacturers and characterized by small capital investments, easy maintenance and several ways of use. In this article are shown the most profitable ways of using such plants.

ABSTRACT
Микро газотурбинные установки имеют широкий спектр применения в сельском хозяйстве. Но для многих фермеров эти технологии все еще закрыты, в основном из-за их высоких цен. В ВИЭСХ создана первая экспериментальная установка, которая предназначена для небольших сельскохозяйственных производителей и характеризуется небольшими капитальными вложениями, простотой в обслуживании и несколькими способами ее примененения. В этой статье приведены наиболее выгодные способы использования таких установок.

INTRODUCTION
Farmers cannot always use advanced technologies and facilities for crop and livestock productions due to their high costs. Therefore, farmers often use outdated machines, which cannot fully perform high quality manufacturing operations and, accordingly, cannot withstand the whole production technology of a particular culture.

To provide farmers portable micro gas turbine power plants with a wide range of applications, the ARIEA has created a new technology for manufacturing micro gas turbine power plants (MTP).

The first experimental MTP is intended for small agricultural manufacturers and characterized by small capital investments, easy maintenance and several ways of use.

MATERIAL AND METHOD
MTP for biogas productions. Since farms are often located in remote areas, it is more profitable to produce and use biofuels for their own use.

Since biogas contains harmful components such as sulfur, ammonia, and sometimes silica, as well as their compounds, the possibility of its use is limited. These components can cause rapid deterioration and corrosion of internal combustion engines, so that gaseous content must not exceed the established norms. Moreover, the exhaust gases cannot be cooled to a temperature below 140 - 150° C, otherwise, acidic condensate will be deposited in the heat exchanger and the bottom of the channel system for exhaust gases. So reciprocating generators are difficult to operate on biogas (*Kulagin I.V.,2013).*

In gas turbine engines such phenomenon does not occur, because the burning of the fuel in the combustion chamber is made by an open burning. Thus, own power supply of manufacturers, which produce biofuels, is most available with MTP.

For small and medium farms exists a need for production wastes utilization. The perspective solution for these households is the union of a biogas plant and MTP. Since MTP can produce its own heat and the power supply for the automatic mixing system, consolidation into a single complex will completely eliminate needs of the bioreactor heating and the electricity supply.

MTP for grain dryers. The share of costs associated with a properly organized and technically supported post-harvest treatment is not more than 5-10% of crop production costs. Unresolved issues at this stage can lead to losses of a significant part of already invested 90-95% due to the reduction or quality loss of produced crops *(Aniskin V.I., Zyulin A.N., 2002)*.

Mobile grain dryers can run on diesel fuels, natural gases, methane, propane gas, including liquefied. Operating plants without electricity supply do not exist for today. To start a workflow requires electrical power of 16 to 90 kW, depending on the plant performance.

The use of mobile dryers on diesel fuels or fuel oil is not an environmentally friendly process; moreover, it is not economically profitable. For hot air production is necessary to carry out two processes: fuel burning and a heated air blowing, wherein a portion of the fuel goes into the electricity production for its own needs. This process organization gives an overall machine efficiency of 65% (*Sorochinsky V.F., 2011*).

The overall efficiency of modern cogeneration gas turbines comes today to 85% (*Polishchuk I.Z., Tsirelman N.M., 2003*), MTP creates a high-temperature gas flow, which allows a drying mode, similar to standard grain dryer modes. Thus, grain dryers based on MTP can replace mobile dryers and in areas with no centralized power supply would not have analogues.

MTP for the autonomous heat and power supply. The traditional heating method of village buildings is a wood-burning furnace with maximum efficiency of 98%. Usually, 10-15 kg of wood is enough for the house heating during a whole day. Like the Russian furnace, instead of which a wall with a heat conductor is arranged, MTP can be used as the primary source of heat and electrical energy.MTP will provide the heating and electricity in an automatic mode. MTP efficiency may reach 90 percent in such systems. The operating of MTP with thermal capacity of 12-15 kW will be approximately 2.5 - 3 hours per day. The warmed up wall will store heat, while charged batteries provide lighting and appliances from several hours to several days (fig. 1).

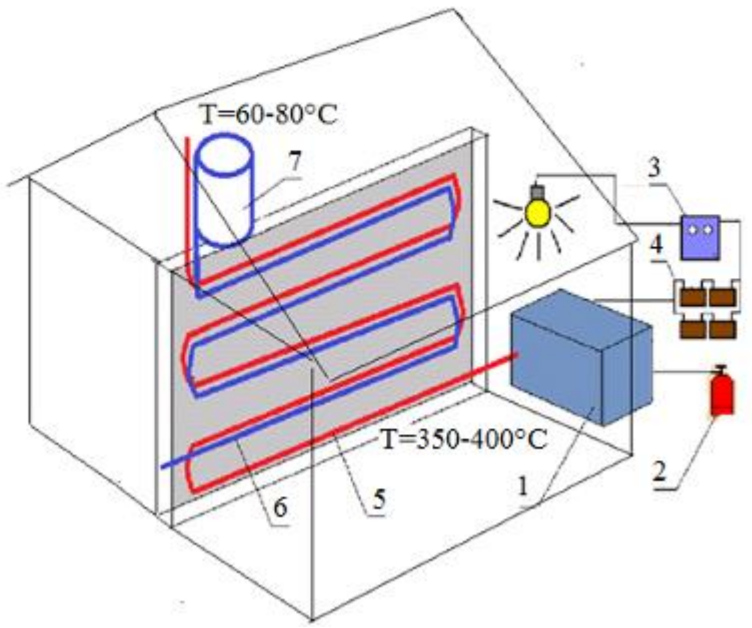

Fig.1 - Cogeneration plant based on MTP with the wall part including the heat gas passageway and power supply systems.

1- MTP; 2- gas cylinder; 3- inverter; 4 rechargeable batteries; 5 hot gas outlet; 6- water; 7 water tank

In just a few hours, at morning and evening times, MTP can recharge batteries, warm the house and the water tank till the next recharge.

MTP for irrigation systems. Farmer independent irrigation systems are expensive due to the fact that pumping systems are necessary to establish in fields and there is a need to provide the electricity or other mechanical energy of the pump. In this case, the heating of raised from depths or taken from open reservoirs water is usually not carried out.

In such works may be used MTP. The electrical component can go for a water lifting and water supply, while another goes on the heating. For example, water heated by 5-8 degrees above environment temperature significantly increases crop yields. Therefore, the concept of an autonomous mobile operating irrigation system on the basis of MTP can be applied to any crops.

MTP for greenhouses. An actual MTP use case is their use as heat- electric stations for greenhouses. In addition to electrical and heat energy, the exhaust from the micro turbines can be used to feed plants, because it contains large amounts of carbon dioxide without or with minimal harmful impurities.

The atmosphere contains on average 0.03% of $C0_2$. With the increase of CO_2 concentration to 0.2-0.6% the photosynthesis process is accelerated, that leads to an increase in a plant yield by 12-16% and in some cases up to 100% with a ripening acceleration for 7-12 days (*Bogdanov, K.B., Uskov E.I., 2004*).

There are a few CO_2 sources: the gasification by cylinders, solid carbon dioxides (dry ice), burners for of the gas combustion and special charcoal furnaces. For a standard greenhouse area of 1000 m^2 is necessary up to 60-80 kg of CO_2 in cylinders or in the form of dry ice (10-20 g per 1 m^3 of a greenhouse volume).

Thus, MTP can provide required CO_2 amounts during the operating time and replace the standard carbon dioxide production equipment.

RESULTS

According to the proposed technology, the first experimental plant MTP 5-30 was developed with using of the turbocharger from automotive industry and internal combustion engines. The use of serial turbochargers allows reducing costs and simplifying of the technology and production.

MTP 5-30 passed state tests in the test center of FGBU "Podolsk government machine testing station ". The test procedure is based on Standard Test P 52782-2007 for open cycle gas turbine engines using combustion chambers in which fuel gas is supplied.

Emission of harmful NOx emissions from the experimental plant is 0.2 ppm, which is significantly lower than today's systems and meets the latest sanitary and ecological requirements.

Carried out field measurements of plant power are 3 kW of electrical power using a 5.5 kW generator. The fixed thermal power is 56.1 kW.

Fig. 2 - The first experimental MTP.

1- the air starter; 2 – the compressor of turbocharger; 3 – the combustion chamber; 4 –the turbine of turbocharger; 5 - the nozzle apparatus of the power turbine; 6- the power turbine; 7 - belting; 8 –the generator; 9- control systems.

According to obtained test data, the testing center made a conclusion that MTP 5-30 substantially corresponds to the requirements of normative documents.

Table 1

Technical data of laboratory tests *(Podolsk government machine testing station, 2015),*

Parameters	The value of indicators for test data
Date and place of tests	from 01.10.14 to 31.12.14 ARIEA
Mode	Continuous, automatic
Power Supply, V	28
Maximum current on-board network, A	8
The gas temperature at the turbine inlet, °C	565
The gas temperature in front of the power turbine, °C	460
Exhaust gas temperature, °C	370
Noise level - distance 10м, dB	105
CO_2 production, kg	23,76
Time to nominal mode	Less than 1 minute
Weight without batteries, kg	87
Dimensions, mm	400x1115x650
Type of fuel	Methane, propane-butane

CONCLUSIONS

Based on these characteristics, the developed experimental MTP is most effective in greenhouses, as produces three types of products: electricity for lighting and the extension of daylight, drive mechanisms, heat energy for central heating greenhouse areas of up to 1000 m^2, CO_2 for a plant growth supply.

Serial production of micro gas turbines by the proposed method is expedient, because the cost of 1 kW of installed capacity should be twice cheaper on the market than costs of micro gas turbines with similar technical parameters. The cost reduction is achieved by use of commercially available automotive industry components.

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EFFECT OF DIFFERENT SUBSOILING APPLICATIONS ON SOIL SURFACE ROUGHNESS
/
FARKLI DİPKAZAN UYGULAMALARININ TOPRAK YÜZEY PÜRÜZLÜLÜĞÜNE ETKİSİ

Assoc.Prof.Ph.D. Korucu, T[1]., Asst. Prof.Ph.D. SELVİ, K.Ç*[2]., Eng. İnce, İ[1].
[1]Dept. of Biosystem Engineering, Agricultural Faculty, Sütçü İmam University, Kahramanmaraş, Turkey
[2]Dept. of Agricultural Machinery and Technologies Engineering, Agricultural Faculty, Ondokuz Mayıs University, Samsun, Turkey
Tel: +90362 3121919/1259; E-mail: kcselvi@omu.edu.tr

Keywords: *soil surface roughness, different subsoiling applications.*

ABSTRACT

The soil surface roughness (SSR) is strongly influenced by soil tillage implements, together with soil condition, properties and climate. In this study, effects of two different operating conditions were established: subsoiler with blade coulter (SBC) and subsoiler without blade coulter (SWBC) at three different working depths (0.25, 0.30 and 0.35 m), and with either a vibratory (V) or non-vibratory (NV) operation. The maximal SSR in both applications to the direction of tillage was obtained at the subsoiling without blade coulter-non-vibratory (SWBC-NV) (34.66 %) application at 0.35 m depth. Minimal SSR with perpendicular direction of tillage was occurred at subsoiling with blade coulter-vibratory (SBC-V) application at 0.30 m tillage depth.

ÖZET

Toprak yüzey pürüzlülüğü (TYP), toprak özellikleri, toprağın içinde bulunduğu koşular ve iklim ile beraber, toprak işleme uygulamalarından kuvvetli şekilde etkilenmektedir. Bu çalışmada, bıçak keski aparatı olan ve olmayan iki farklı dipkazan uygulamasının titreşimli ve titreşimsiz koşullarda ve farklı derinliklerde (0.25, 0.30 and 0.35 m) çalıştırılmasının TYP üzerine etkileri araştırılmıştır. Her iki uygulamada da en yüksek TYP değerine 0.35 m işleme derinliğinde, ilerleme yönüne dik, titreşimsiz, bıçak keskisiz dipkazan uygulamasında (34.66 %) ulaşılmıştır. Minimum değer ise titreşimli, bıçak keskili dipkazan uygulamasında ve 0.30 m çalışma derinliğinde elde edilmiştir.

INTRODUCTION

Tillage is one of the basic applications in agricultural soils. The main target of tillage is to create suitable physical conditions for crop growth and production. The one of those conditions is the creation of a desired soil surface shape to be carried out the best way to planting, irrigation, drainage and harvesting operations. Suitable soil surface shape is directly related to degree of soil surface roughness. *Hauer et al. (2001)* is defined soil surface roughness (SSR) as a dynamic soil property that influences many processes occurring at the soil surface. In other definitions related to this issue it is defined as the standard deviation of elevation readings (*Guillobez and Arnaud, 1998; Vannier et al., 2006; Moreno et al., 2008*). In many studies about the soil surface roughness related to effect of predict water infiltration and runoff (*Linden and Van Doren,1986; Dong et al., 1999; Kamphorst et al., 2000*.) while others interested in the effect of soil tillage implements on soil surface roughness (*Boydaş, 2007*; *Moreno et al., 2008*; *Tekgüler and Selvi, 2011*).

Measurement techniques of soil surface roughness can be classified by measurement dimension and sensing type. The former one includes two dimensional (2D) profile measurements and three dimensional (3D) measurements (usually elevation points in a regular raster). 2D measurements facilitate quick data acquisition with simple means like a roller chain (*Jester and Klik, 2005*). One of the two-dimensional measurements is chain method to measure both random and oriented roughness proposed by Saleh (1993). The chain method is based on the principle that as a chain of given length is placed across a surface, the horizontal distance covered by the chain will decrease as surface roughness increases. Reductions in chain length caused by soil surface roughness are described in following equation. The roughness (R) can be calculated from:

$$R = \left(1 - \frac{L_2}{L_1}\right) \times 100 \qquad (1)$$

Where: R is soil surface roughness (%). L_1 is the length of chain (cm) required to span roughness element(s) for a horizontal distance L_2 cm. Chain method is as a relatively simple, fast, and inexpensive technique for determining surface roughness (*Gilley and Kottwitz, 1995*).

The evaluation of surface roughness due to tillage and the quantification of roughness related properties, such as surface storage, require the use of a parameter, capable of describing quantitatively surface disturbance or irregularities (*Römkens and Wang,* 1986)

Each type of tillage tool generates a kind of roughness on soil surface. *Boydaş (2007)* has tried to determine the effects of different soil tillage implements and working speeds on soil surface roughness in a soil with a loamy texture in Eastern Anatolia Region. In this study, conventional moldboard plow (KP), slatted moldboard plow (IP), disk plow (DP) and chisel plow (CP) were used with the combination of rotary harrow at 1.25, 1.50, 1.75 m/s speeds respectively. Finally, application of conventional moldboard plow was reported to have the highest surface soil roughness at 1.25 m/s working speed according to the others. Similarly, *Tekgüler and Selvi (2011)* compared the effects of some soil tillage implements on soil surface roughness. They reported that while the maximal soil surface roughness was obtained at the moldboard application, minimal was obtained moldboard plough+(2×discharrow+2×rotarytiller) with parallel direction of tillage and the perpendicular in chisel plough+(2×discharrow+2×rotary tiller) combination.

In this study, the effect of different subsoiling applications (subsoiling with blade coulter (SBC) and without blade coulter (SWBC)) on soil surface roughness at three different working depths (25, 30 and 35 cm), and with either a vibratory (V) or non-vibratory (NV) operation at 1 m/s speed was investigated.

MATERIAL AND METHOD

The field experiments were conducted at the research fields of the Kahramanmaraş Sütçü İmam University in 2014. The experimental fields have an approximately 10% slope in a south-north direction (Figure 1).

Fig.1 - Experimental field

A Massey Ferguson 285S® tractor was used for the tillage applications. The tillage system included a subsoiler unit and a blade coulter with a working depth that was lower than the subsoiler (Figure 2). Some specifications belonging to this implement are given Table 1.

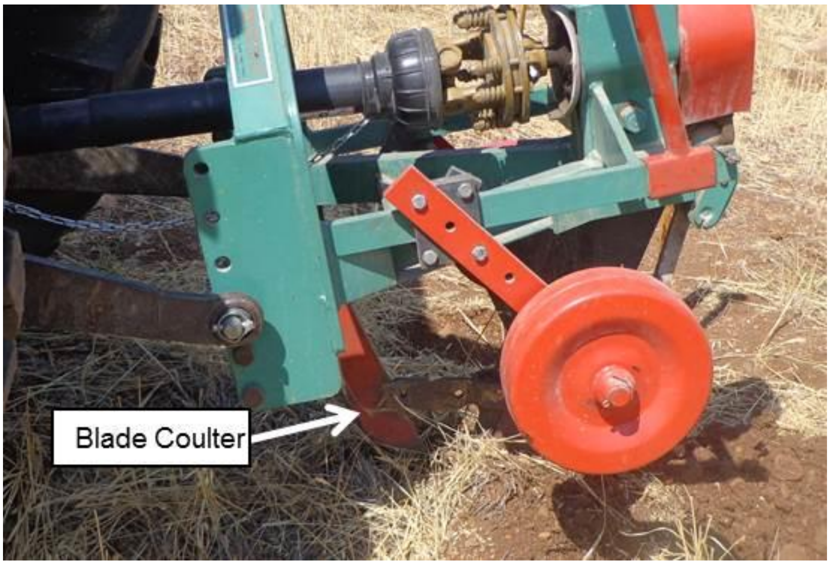

Fig.2 - Subsoiler unit and a blade coulter

Table 1

Some specifications of subsoiler

Type and hitches	T-TD 115, three-point hitch
Power requirement (BG)	40
Pto revs per minute	540
Number of legs	1
Base frame width (mm)	1.00
Weight (kN)	2.54
Working depth (m)	Adjustable and max. 0.60

In the experiment a chain having 1800 mm total length and 18 mm pitch is used (Figure 3).

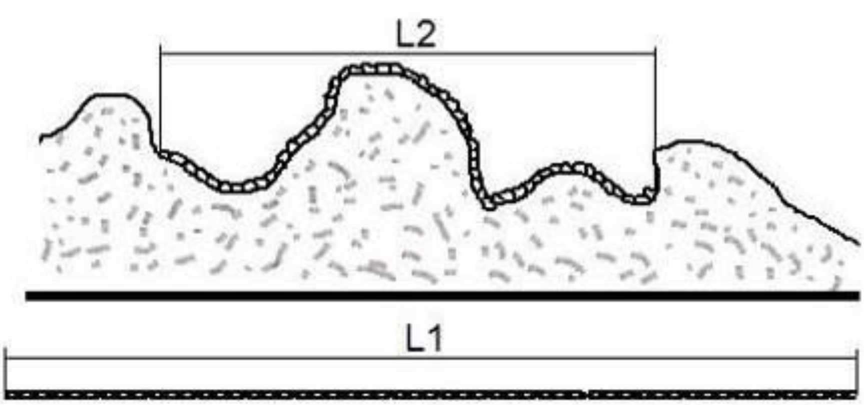

Fig.3 - Determining the soil surface roughness with chain method

The size of experimental field was 0.18 ha and the experimental plots were 4x50 m. The soil texture of experimental site is classified as a calceric vegosol according to the FAO soil classification (FAO/ISRIC, 2006). Some soil properties of experimental field are summarized in Table 2.

Table 2

Some soil properties of the experimental field.

Soil properties	Soil depth (0-20 cm)
Clay (%)	11.65
Silt (%)	44.89
Sand (%)	43.46
Organic matter content (%)	2.48
pH (1:1)	7.28

Two different operating conditions were established: subsoiler with blade coulter (SBC) and subsoiler without blade coulter (SWBC). At each experimental site, the subsoilers were operated applied with or without blade coulters, at three different working depths (25, 30 and 35 cm), and with either a vibratory (V) or non-vibratory (NV) operation.

Data analysis was performed via ANOVA according to 2x2x3 factorial design with the factors of apparatus, vibration and depth. Suitability of the data for analysis of variance was tested with Kolmogorov-Smirnov one sample test for normality and Levene test for homoscedasticity. Results showed that data was normally distributed (P>0.05) and variances were homogeneous (P>0.05). In this case use of ANOVA for this data was appropriate method.

Chain method developed by Saleh was used to determine soil surface roughness in an experimental field as perpendicularly to the direction of tillage as it is given in formula 1.

The chain method is based on the principle that as a chain of a given length (cm), L_1, is placed across a surface, the horizontal distance covered L_2 (cm), will decrease as the roughness increases (Saleh A, 1993).

RESULTS

Descriptive statistics of soil surface roughness at two different operating conditions around 1 ms^{-1} forward velocity at three different working depths obtained as perpendicularly to the direction of tillage are given in Table 3.

Table 3

Descriptive statistics of soil surface roughness

Apparatus	Vibration	Depth (cm)	SSR (%)
SBC	NV	25	20.99 ± 2.42b
		30	19.68 ± 1.74b
		35	16.43 ± 1.69b
	V	25	19.71 ± 2.13b
		30	16.87 ± 1.82b
		35	18.93 ± 1.76b
SWBC	NV	25	30.26 ± 2.99a
		30	28.39 ± 2.04a
		35	34.66 ± 2.57a
	V	25	33.40 ± 2.26a
		30	29.23 ± 1.76a
		35	30.86 ± 0.61a
Sig.			<0.001
Sig. For Levene			0.057
Sig. For Normality			0.745

SSR: soil surface roughness; SBC: subsoiler with blade coulter; SWBC: subsoiler without blade coulter; NV:non-vibratory; V:vibratory

When the results are examined, values of SSR belonging to SWBC were found greater than values of SBC in general. Soil surfaces roughness (%) is changed between from 16.43 (%) to 34.66 (%) in all applications. The maximal soil surface roughness in both applications to the direction of tillage has been obtained at the SWBC-NV (34.66 %) application at 0.35 m depth. Minimal soil surface roughness was occurred at SBC-NV application at 0.35 m tillage depth. SWC application showed a decreasing trend in the magnitude of the SSR according to SWBC.

All interaction effects among factors were found statistically insignificant (P>0.05). When the main effects were examined, only the factor of blade coulter apparatus was found statistically significant (P<0.001) on soil surface roughness. Other two factors (vibration and tillage depths) were found insignificant (P>0.05) on soil surface roughness.

Römkens and Wang were investigated the effect of soil tillage on soil surface roughness. They were studied: chisel, chisel+disking, and chisel+disking+harrowing. They reported that the chisel tillage showed an increasing effect on soil surface roughness.

Tekgüler and Selvi, 2011 were obtained minimal soil surface roughness (19.12 %) with perpendicular direction of tillage in chisel plough+(2×discharrow+2×rotary tiller) application. In our study minimal value was similar with their research. These results may cause by the similarity effects of both chisel and subsoiler tools on soil tillage. On the other hand, blade coulter showed reducing effect on soil surface roughness. The mean values of SSR belonging to SBC and SWBC applications were found 18.76 and 31.13 respectively. These values showed that soil roughness was approximately two times lower after using blade coulter than without blade coulter. This trend is a consequence of the occurrence of smaller clod sizes with blade coulter. Because, larger clods increase the microrelief index and reduce the peak frequency per unit transect length.

Surface conditions may be affected by cutting soil in front of subsoiler with blade coulter. Thus, soil strength which may cause more soil surface roughness is reduced with using the blade coulter and surface variations due to cloudiness may be decreased.

On the other hand, Subsoiler is a soil tillage implement working in deep soil profile. Avoiding the excessive deeper tillage with subsoiler to obtain a smooth surface roughness can provide energy savings. This study also showed that it is not need to deeper tillage application to obtain suitable surface roughness.

To obtain desirable soil surface roughness to tillage SBC-V at 0.30 m application may be preferable.

CONCLUSIONS

In this study, the effect of different subsoiling applications (subsoiling with blade coulter (SBC) and without blade coulter (SWBC)) on soil surface roughness at three different working depths (25, 30 and 35 cm), and with either a vibratory (V) or non-vibratory (NV) operation at 1 m/s speed was investigated.

All interaction effects among factors were found statistically insignificant (P>0.05). Only the factor of blade coulter apparatus was found statistically significant (P<>0.001). Also, the effect of vibration and soil depth on soil surface roughness in perpendicular direction was not found statistically significant. Only the factor of blade coulter apparatus was found statistically significant (P>0.001).

It is clear that blade apparatus showed an effect of reducing the surface roughness. To obtain desirable soil surface roughness to tillage SBC-V application at 0.30 m can suggest in practice.

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YIELD COMPONENTS OF MAIZE (ZEA MAYS L.) UNDER DIFFERENT CONSERVATION TILLAGE SYSTEMS IN WEST MEDITERRANEAN IN TURKEY (PART 1)

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BATI AKDENİZ BÖLGESİNDE (TÜRKİYE) FARKLI KORUYUCU TOPRAK İŞLEME SİSTEMLERİNİN MISIR BİTKİSİ VERİM PARAMETRELERİNE ETKİSİ(KISIM 1)

Asst. Prof.Dr. KABAŞ Ö[1].,Asst. Prof.Dr. SELVİ, K.Ç*[2]
[1]Akdeniz University, Vocational School of Technical Science, Antalya, Turkey
[2]Dept. of Agricultural Machinery and Technologies Engineering, Agricultural Faculty, OndokuzMayıs University, Samsun, Turkey
Tel: +90362 3121919/1259; E-mail: kcselvi@omu.edu.tr

Keywords: *conservation tillage, maize.*

ABSTRACT

*The study was conducted during two summer seasons (2012 and 2013) under Mediterranean area conditions (South of Turkey) to determine the effect of four tillage system (conventional tillage (T1) "Plough+discharrowing+float+pneumaticseeding machine", reduced tillage I;(T2) "rotovator +float+pneumatic seeding machine", reduced tillage II (T3) "rotary tiller combination+pneumatic seeding machine" and no tillage(T4) "seeding by direct seedingmachine") on the yield components of Maize in the area. The soil of the experimental parcel was classified as silty. Results indicate that conventional tillage system (T1) was the greatest plant yield of maize (*10031 kg/ha) *under four different tillage methods.*

ÖZET

Bu çalışma, 2012 ve 2013 yıllarıyazüretimsezonunda, dörtfarklıtoprakişlemesisteminin; (Gelenekseltoprakişleme; "Pulluk+diskaro+merdane+pnömatikekim makinası (T1)", indirgenmiştoprakişleme I; "Rotovatör+merdane+pnömatikekim makinası (T2), indirgenmiştoprakişleme II; "Rototiller+ pnömatikekim makinası (T3) vetoprakişlemesizsistem (T4)) Akdenizbölgesikoşullarında (Türkiye'ninGüneyBatısı) mısırbitkisininverim paramatreleri üzerineetkisinibelirlemekamacıylaplanlanmıştır.Yapılançalışmasonuçlarınagöre,dörtfarklıtoprakişlemesistemii çerisindeenyüksekürünverimine (T1) toprakişlemesisteminde (10031 kg/ha) ulaşılmıştır.

INTRODUCTION

Maize (*Zea mays L*.) is one of the most important cereal crops of Turkey and it is becoming more popular product among Turkish farmers with product support program and the increasing availability of irrigation in recent years. The area harvested with maize in Turkey in 2015 was 688,169 ha *(TSI Statistical Databases, 2016)*. The rank is third in cultivated area and production after wheat and barley. Many factors can affect maize production in Turkey such as climatic conditions, intended purpose, little or inadequate use of chemical fertilizers, poor weed and pest controls, and inappropriate tillage operations. In general, farmers perform tillage operations without being aware of the effect of these operations on soil physical properties and crop responses *(Aikins et al., 2012)*. Hence, understanding operations of soil tillage under agricultural system is an essential requirement for any future farming concepts. In traditional agriculture (It started with simple roman plow), the aim of tillage can be summarized as to create a suitable seedbed, kill weeds, for reducing competition and conserving water and remove restrictions to infiltration, drainage and root growth within the root zone *(De Vitaand Bandyopadhyay, 2013)*. On the other hand results of various investigations from almost all world agricultural zones suggest that conventional tillage often reveals common soil-related problems such as soil compaction *(Hakansson and Reeder, 1994),* soil erosion*(Lal, 1984)*, deteriorated water percolation, high energy and time requirements *(Öztürk et al., 2006; De Vita et al, 2007)*,nutrient leaching *(Selvi, 2012)*. In response to this, conservation tillage leaves some part of crop residues on the soil surface, thus affecting chemical, biological, and physical properties of soil *(Sessiz et al, 2010)*. The principle of conservation tillage involves maintenance of surface soil cover through retention of crop residues achievable by practising zero tillage and minimal mechanical soil disturbance. Also, moving away from plowing could lead to a reduction of approximately 50-70% in power and energy used (*Köller, 1989;Kosutic et al, 2005*). Although,both effect of conventional and conservation tillage practices on maize yield*(Korucu et al. 2005; Karaağaç and Barut, 2009)*and soil properties (*Çetin et al, 2005;Sağlam et al, 2012)* have been reported in TURKEY, there are relatively few studies that have been conducted on the soils of West Mediterranean part in TURKEY.

The objective of this work was to evaluate the effects of different tillage methods on seedling emergence and yield components of maize (*Zea mays* L.) in West Mediterranean part in TURKEY.

MATERIAL AND METHOD

Work area and soil

This experiment was conducted at the West Mediterranean Agricultural Research Institute, Antalya, Turkey, during two summer seasons (2012 and 2013). The soil in the experiment field was a silty with pH of 7.5 and organic matter content of 1.8%. The results of soil analyses are given Table 1.

Table 1

The result of soil analyses

pH (1:2.5)	7.5
Lime (%)	19.6
EC micromhos/cm (25°C)	195
Sand (%)	21
Clay (%)	33
Silty (%)	46
Organic matter (%)	1.8
P ppm	16
K ppm	250
Ca ppm	4585
Mg ppm	409

The average weather conditions during growing seasons such as annual temperatures and rainfall etc. are shown in Table 2.

Table 2

Average climate dates on a long-term at the site of experimentation(30 years)

	May	June	July	August	Sept.	October
Temperature (°C)	20.4	25.4	28.4	28.1	24.7	19.8
The highest Temperature (°C)	25.9	31.3	34.4	34.3	31.3	26.7
The lowest Temperature (°C)	14.8	19.4	22.5	22.4	19.1	14.9
Sunshine duration (hour)	9.5	11.4	11.5	11.3	9.5	8.0
Number of rainy days	5.0	2.4	0.7	0.5	1.7	5.4
Rainfall (kg/m^2)	29.3	7.1	3.3	1.6	11.0	74.8

The experiment, which was begun in June 2012 and finished 2014 compared four tillage systems for maize(Zea mays L.) production following a wheat-maize rotation.Seeds of maize (Zea mays saccharata Sturt.) were used in this study. The standard cultural practices (such as pest and weed controls) recommended by West Mediterranean Agricultural Research Institute; other than treatments, were followed throughout the growing seasons. Plant sampling was done at final crop harvest

The experiment was established as a randomized block design with four replications. Plots were 5 m wide (four rows) and 25 m long with an inter row spacing of 0.7 m distance.After the field had been selected and before the application of the treatments, the land was freed from weeds and crop residues except the no-tilled plots. The experimental procedures were the same for the both seasons.

Soil tillage systems

Tillage systems are shown in Table 3 and the specifications of tools used in the experiment are given Table 4.

Table 3

Soil tillage methods utilized in experiments

Tillage systems	Tillage operations
T1 (conventional tillage)	Plough(25-30 cm) + disc harrowing + float + pneumatic seeding machine
T2 (reduced tillage I)	Rotovator + float + pneumatic seeding machine
T3 (reduced tillage II)	Rotary tiller combination + pneumatic seeding machine
T4 (no tillage)	Seeding by direct seeding machine

For the conventional tillage method, the soil was first ploughed with five bottom moldboard ploughs. After plowing, the field was harrowed with disc harrow andleveled with float. In the reduced tillage method I, soil was prepared for seeding with only one pass of soil tillage, float and pneumatic seeding machine. In the reduced tillage method II, soil was prepared for seeding with only one pass of soil tillage with rotary tiller combination and then pneumatic seeding machine. For the direct seeding application,seeding was applied without tillage. Massey Ferguson 5400 (Engine Power 105 HP) tractor was used in the experiments.

Table 4

The specifications of the tools used in experiments

Tools	Average speed (km h^{-1})	Working depth (mm)	Working width (mm)
Plough	5.5	300	1500
Disc harrowing	6.5	150	2200
Rotovator	6	220	2000
Rotary tiller combination	2.8	200	2500
Float	7	-	3000
Seeding machine	6.3	40-50	2800
Direct seeding machine	5.6	40-50	2800

Investigations and data collection

For crop yield determination, the mature corn plants were harvested and threshed by hand, adjusting to 14-15 % moisture the seed yield. At harvesting time, some plant agronomic properties such as mean plant height, stalk thickness, cob yield were measured in samples taken from 3.5 m^2area in two middle rows for each plots *(Yalcin and Cakir, 2006; Samarajeewa et al., 2006 ; DeVita et al., 2007; Sessiz et al, 2010)*.

For each plot, emerged seedling on the 2 rows with 5 m length were counted 3 times at 3 days in intervals during emergence, calculating the rate of emerged seedling (ES) through the following formula (*Bilbro and Wanjura, 1982; Bayhan et al., 2006*): ES=(Total emerged seeds/m)/(Number of planted seeds/m)x100.

RESULTS

Some agronomic properties of corn as affected by tillage methods are given Table 5. The year effect was found statistically insignificant for all examined properties($P>0.05$), so the year factor was removed from the model. The cob yield (Cy), height of the plants (Ph), stalk thickness (St), 1000 seed weight (Sw), and seedling emergence rate (Ser) for each tillage practice are shown in Table 5. Over the course of the study, analysis of variance showed no significant difference in plant properties except plant yield between the different tillage operations. These results are similar to that of *Aikins et al.,* 2012.

Table 5

Descriptive statistics of some plant agronomic properties of maizeunder different tillage methods

Sap	T1	T2	T3	T4
Cy (kg/ha)	10031±107.1a	9252±248.2c	9439±212.7b	9038±342.7c
Ph(mm)	2600.81±3.41	2570.05±6.31	2560.23±8.03	2560.95±4.73
St (mm)	19.82±0.57	19.16±0.39	18.37±0.12	17.96±1.42
Sw (g)	365.54±5.1	368.21±6.2	365.21±5.9	363.40±7.4
Ser(%)	95	93	90	92

Sap: Some agronomic properties; Cy: Cob yield; Ph: Plant height (mm); St: Stalk thickness (mm); Sw: 1000 seed weight (g); Ser: Seedling emergence rates (%)

Results showed that only the Cy was found statistically significant ($P<0.05$). Max. Cy was found in T1 application and min. was in T4. Higher maize yields in conventional tillage systems compared to no-tillage or minimum tillage systems are widely documented in other similar studies, both when crop rotation was applied, or with continuous maize production (*Pederson and Lauer 2003, Kosutic et all, 2005*). This is partly due to the fact that no-tillage environments are more likely to exhibit non-uniform germination, emergence and early growth and development (*Videnovic et al, 2011; Javeed et al,* 2013). On the other hand differences of grain yield among different tillage treatments might be due to differences in number of plant per hectare and also, enhanced seed-soil contact and suppressing weed growth (*Rashidi and Keshavarzpour,* 2007)

CONCLUSION

This study examined the effect of four different tillage practices on maize performance under different conservation tillage systems in West Mediterranean in Turkey. We concluded that under the agro-climatic conditions of Antalya, Turkey, the conventional tillage practice (T1: Plough + disc harrowing + float) with pneumatic seeding machine treatment performed best for grain yield than the other tillage practices. In future studies, we also recommend to determine the fuel consumption by comparing four different tillage systems in terms of the required item.

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ECOLOGICAL NICHES AND SPATIAL DISTRIBUTION OF SOIL MESOFAUNA IN SODDY-LITHOGENIC SOILS ON LOESSIAL SANDY LOAMS: CASE OF NIKOPOL MANGANESE ORE BASIN
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ЭКОЛОГИЧЕСКИЕ НИШИ И ПРОСТРАНСТВЕННОЕ РАСПРЕДЕЛЕНИЕ ПОЧВЕННОЙ МЕЗОФАУНЫ В ДЕРНОВО-ЛИТОГЕННЫХ ПОЧВАХ НА ЛЕССОВИДНЫХ СУГЛИНКАХ

Andrusevych K., Benselhoub A.*
Department of Ecology and Environment Protection, Dnipropetrovsk State Agrarian and Economic University.
E-mail: benselhoub@yahoo.fr

Keywords:*ecomorphs, reclamation, soil mesofauna, ecological niches.*

ABSTRACT

The paper presents the spatial distribution and quantitative characteristics of ecological niches soil mesofauna of soddy-lithogenic soils on loess land reclamation of Nikopol manganese ore basin. It was established that edaphic characteristics of soddy-lithogenic soils on loess loam and vegetation characteristics (ecomorphs and using phytoindication scale) describe 87.71% of the variation of the spatial distribution of soil animals. With RLQ-analysis revealed two axes of differentiation of animal populations that are integral evaluation of the entire set of environmental factors. Axis 1 describes 62.81%, and the axis 2 - 18.90% of the spatial variability of distribution mesofauna. There was a statistically significant marginal 3 species (O. sabulosum, A. rosea, A. trapezoides) of 21, which speaks of the non-random choice of habitat preference of these species-specific conditions for life. The functional groups of soil animals, marked by a cluster analysis on the basis of the relationship of ecomorphs structure and environmental factors reflect the differentiation of ecological niches of individual groups of species which are sensitive to hardness, soil temperature and projective cover plants. Reflection axes RLQ-analysis in the geographic space show that the study of the landfill is not uniform for soil animal.

АННОТАЦИЯ

В статье представлены пространственное распределение и количественные характеристики экологических ниш почвенной мезофауны дерново-литогенных почв на лессовых суглинках Никопольского марганцеворудного бассейна. Было установлено, что эдафические харатеристики дерново-литогенных почв на лессовидных суглинках и характеристики растительного покрова (экоморфическая и с помощью фитоиндикационных шкалы) описывают 87.71 % вариации пространственного распределения почвенных животных. С помощью RLQ-анализа выделены две оси дифференциации животного населения, которые являются интегральными оценками всей совокупности факторов внешней среды. Ось 1 описывает 62.81 %, а ось 2 – 18.90 % пространственной изменчивости распределения мезофауны. Зафиксирована статистически достоверная маргинальность для 3 видов (O. sabulosum, A. rosea, A. trapezoides) из 21, которая говорит о неслучайном выборе мест обитаний, предпочтении данными видами конкретных условий для жизнедеятельности. Функциональные группы почвенных животных, выделенные с помощью кластерного анализа на основе взаимосвязи экоморфической структуры и факторов внешней среды, отражают дифференциацию экологических ниш отдельных группировок видов, которые чувствительны к твердости, температуре почвы и проективному покрытию растений.Отражение осей RLQ-анализа в географическом пространстве показывают, что изученный полигон не является однородным для мезопедобионтов.

INTRODUCTION

The soil mesofauna is a faunistic complex consisting of large invertebrates. The importance of studying populations of soil invertebrates is due to their enormous role in the life of soil, where they not only live, but also actively form the structure of soil horizons. Soil's representatives of mesofauna are involved in many of soil formation processes and are essential of ecosystem engineers (Lavelle *et al.*, 1997).Uneven spatial distributions of the soil fauna is one of the most important characteristics of their reactions to environment factors (Pokarzhevsky, 2007). It is so-called "environmental standard" according to (Gilyarov, 1965) - the needs of each species in a certain complex environmental conditions. The environmental factors influence the species distribution, usually the space is structured and therefore societies have also the spatial structure (Dray *et al.,* 2006). Habitat is characterized by the presence in certain areas of resources and conditions necessary to species to survive, reproduce and successfully and competitively fight.(Hall *et al.,* 1997).

Zoological diagnosis of soils is the establishment of conformity and data communication between the typological units of soil cover and emergent properties of soils animal population (Zhukov, 2009). Soil-zoological studies allow to use soil animals for the characterization of soil conditions and their changes from technogenic or economic impacts. Zoological technozems diagnostics is promising and represents a relevant issue in the use of recultivated soils (Gilyarov, 1965; Zhukov, 2009). The study of spatial distribution of soil mesofauna in the soddy-lithogenic soils allows diagnosing soil data, evaluating the impact of various environmental factors, and revealing interrelations of vital activity soil animals and modes of soil processes.

The purpose of the present work was to quantify the ecological niches of the soil fauna landfill on soddy lithogenic soils formed on the loess loams on the basis of RLQ- and OMI-analyses.

MATERIAL AND METHOD

Material is selected on the reclamation site of Dnepropetrovsk State Agrarian University of Nikopol manganese ore basin(see Fig.1) (Dnipropetrovsk region, the city of Ordzhonikidze) in April-May 2012. Samples were collected in a soddy-lithogenic soils formed on loessial sandy loams. Material is selected at a regular grid - 7 transect at 15 of samples each, a total of 105 samples. The lag between transects and samples is of 3 m. At each point were made soil-zoological samples for collecting a soil mesofauna, carried out the measurement temperature, conductivity and hardness of the soil, litter thickness and height of herbage (R-table). Soil-zoological samples had a size of 25 × 25 cm. Hardness measurement of soils performed in the field conditions using manual penetrometer Eijkelkamp on depth to 50 cm at an interval of 5 cm. The average error of measurement results of the instrument is ± 8%. The measurements were carried out with a cone sectional dimension 2 cm^2 within each measurement point of hardness of soil were carried out in triplicate. To make measurement of soil electrical conductivity was used in situ a sensor HI 76305 (Hanna Instruments, Woodsocket, RI). This sensor operates in conjunction with a portable device HI 993310. Tester assesses the overall electric conductivity of the soil, i.e. integrating the soil air, water and particles. The measurement results are presented in units of the device of the soil saturation with salts solution of - g / l. Comparison of the results measurements with HI 76305 with laboratory data allowed us to estimate the conversion factor units as 1 dC / m = 155 mg / l (Pennisi and Iersel, 2002).

Fig.1-Map of the study area location

The soil temperature was measured from 13 to 14 hours of digital thermometers WT-1 (PJSC "Steklopribor», http://bit.steklopribor.com, precision – 0.1 ° C) at a depth of 5-7 cm. Measurements of electrical conductivity and temperature made in triplicate at each test point. Aggregate soil composition was determined by dry sieving by Savinov (Dospehov, 1979). Soil samples were selected from the top layer 0-10 cm. The physiognomic types of flora are highlighted on the basis of spectral reflectivity of digital images surfaces vegetation cover, which can be conditionally be characterized as: 1 - Poáceae; 2 - Umbellíferae; 3 - Asteraceae; 4 - Fabáceae; 5 - deadwood; 6 - soil.). Phytoindication scales of vegetation are presented by (Tsyganov D.N., 1983). Characteristic of ecomorphs plants shown by (Belegarde A.L., 1971; Tarasov V.V., 2005), Q-table is presented ecomorphs of soil animals (Zhukov, 2009).

RESULTS

Edaphic characteristics can be considered as determinants of ecological space communities of soil mesofauna (Table. 1).

Table 1

Determinants of ecological space of the soil mesofauna

Medium parameters	Average	Confidence interval – 95 %	Confidence interval + 95 %	CV, %	RLQ axis 1	RLQ axis 2
Soil structure, size fraction,%						
>10 mm	7.30	6.31	8.29	69.91	0.09	–0.03
7–10 mm	6.04	5.65	6.43	33.37	–0.01	–0.21
5–7 mm	9.48	8.01	10.94	80.06	0.16	–0.22
3–5 mm	19.06	17.93	20.19	30.63	–0.06	–0.14
2–3 mm	40.67	38.83	42.50	23.30	–0.17	0.11
1–2 mm	5.24	4.66	5.81	56.46	0.01	0.13
0.5–1 mm	6.51	5.87	7.16	51.37	0.00	0.24
0.25–0.5 mm	5.71	5.15	6.26	50.18	0.09	0.28
<0.25 mm	7.30	6.31	8.29	69.91	0.09	–0.03
Hardness at depth soil, MPa						
0–5 cm	4.08	3.71	4.45	46.70	0.27	–0.39
5–10 cm	6.18	5.68	6.67	41.71	0.38	–0.65
10–15 cm	7.17	6.67	7.67	36.21	0.33	–0.72
15–20 cm	7.84	7.28	8.41	37.05	0.38	–0.73
20–25 cm	8.54	7.91	9.16	37.67	0.38	–0.76
25–30 cm	9.01	8.31	9.72	40.28	0.40	–0.71
30–35 cm	9.23	8.41	10.05	45.80	0.37	–0.73
35–40 cm	9.55	8.67	10.43	47.70	0.40	–0.66
40–45 cm	10.04	9.05	11.02	50.79	0.42	–0.62
45–50 cm	10.44	9.37	11.52	53.11	0.41	–0.60
Physical properties and humus content						
Electrical conductivity, S /m	0.51	0.48	0.54	29.41	0.20	0.28
Temperature 03.05.12	17.22	17.05	17.39	5.12	–0.54	–0.16
– 20.06.12	3435	33.78	34.92	8.54	–0.12	–0.50
Physiognomic vegetation types						
Type_1	0.09	0.08	0.10	46.00	0.34	–0.05
Type_2	0.17	0.16	0.19	42.67	–0.20	–0.46
Type_3	0.13	0.12	0.14	47.99	0.44	–0.25
Type_4	0.06	0.05	0.07	70.34	–0.20	0.02
Type_5	0.12	0.11	0.12	26.06	0.37	–0.06
Type_6	0.43	0.40	0.46	35.83	–0.19	0.33
TsyganovPhytoindication assessments						
Tm	9.24	9.18	9.30	3.20	–0.35	–0.45
Kn	9.24	9.18	9.30	3.20	0.78	0.64

Om	9.21	9.15	9.27	3.22	–0.78	–0.62
Cr	8.71	8.65	8.77	3.51	0.77	0.64
Hd	7.61	7.53	7.68	5.04	–0.77	–0.49
Tr	10.27	10.06	10.47	10.28	0.84	0.56
Nt	5.59	5.49	5.68	8.82	0.79	0.57
Rc	8.83	8.79	8.86	2.06	0.16	–0.23
Lc	2.21	2.17	2.25	9.40	–0.81	–0.62
A.L Belgard Ecomorphs						
Hygr	2.13	2.11	2.14	3.56	–0.31	0.02
Troph	2.88	2.86	2.90	3.10	0.18	–0.19
St	0.72	0.71	0.73	6.80	–0.74	–0.55
Pr	0.04	0.03	0.04	58.92	–0.13	–0.30
Hel	3.26	3.22	3.31	7.16	–0.85	–0.50

Corresponding to the analysis of obtained data, the predominant fraction is aggregates of 2-3, 3-5 mm. Other fractions are characterized by participation in the aggregate structure at 4.08-10.44%. The average value of hardness regularly increases with depth. At the toplayer of a depth of 5 cm hardness is at a level of 4.08 MPa. According to literature data (Bathke et al., 1992), growth of plant roots stops at resistance of 0.8-5 MPa. Penetrometer Readings higher than 5 MPa, indicates a compacted soil which counteracts the root growth (Faechner *et al*., 1999). From a depth of 5 to 50 cm hardness gradually increased from 6.18 to 10.44 MPa. It was recorded that the average value of electrical conductivity is 0.51 S / cm. The average temperature of sod-lithogenic soils on red-brown clays at time of measurement in 03.05.2012 was 17.22 ºC. On 20.06.2012, the average temperature is equal to 34.35 ºC. According to Phytoindication scales the thermo-climate investigated ecotopenemoral (46.1 kcal / cm * cm * year), Continental - mainland; ombro-climate - sub-humid (P-E = - 305 mm / year, P - precipitation mm / year, E - evaporation mm / year); crio-climate - mild winters / mild winters; humidity - Average steppe type; common mode of soil salinity and trophic - rich / saline soils; nitrogen nutrition - poor soil nitrogen; soil acidity - slightly acidic / neutral soils; light conditions - open / semi-open spaces. The ecomorphic analysis of vegetation in coenomorphes aspect is characterized by a predominance of steppe (72%).

Ecological optimum hygromorphes (Matveev, 2003) is 2.13 - fresh type of the regime trophomorphes - 2.88 and also corresponds to moderately fertile soils, and geliomorph - 2.21, which shows in the penumbral regime type. According to analysis results shown in Table RLQ 2 and Figure 3, it was established that 81.71% of the variation (of total inertia) describe the first two axes RLQ (62.81 and 18.90%, respectively). Rand test procedure has confirmed the significance of the results RLQ-analysis at the p-level of 0.01. Axis RLQ – it is integral estimates interrelation between environmental factors (Kunakh *et al.,* 2013). In this case, we take into account the structure, hardness, conductivity and temperature of the soil as well as of vegetation structure using physiognomic types Phytoindication scale by Tsyganov and ecomorphes structures according to Belegarde. Axis RLQ-analysis –is the integrated assessment of interrelation of two matrices: the first shows the sampling points (spatial component, taking into account the fact that the coordinates of sampling points were recorded), the second - the location types of the soil mesofauna, and the third - the significance level of environmental factors and the level of significance of ecomorphes characteristics of mesofauna (Fig. 2). Environmental factors which structure the community, have a complicated integral nature and reflected through measurable characteristics. Complexes related characteristics in multivariate techniques allocate according to various criteria, since the number of factor solutions is infinite. Maximize described dispersion and correlation factors are the target criteria in multivariate factor analysis and principal component analysis. It is obvious that such criterion has a general character and does not reflect the specificity of environmental problems. Maximization of criterion in RLQ-analysis is the solution which best describes relationship between different environmental phenomena - the environment, the community and its formal environmental properties (*Kunakhet al*., 2013).

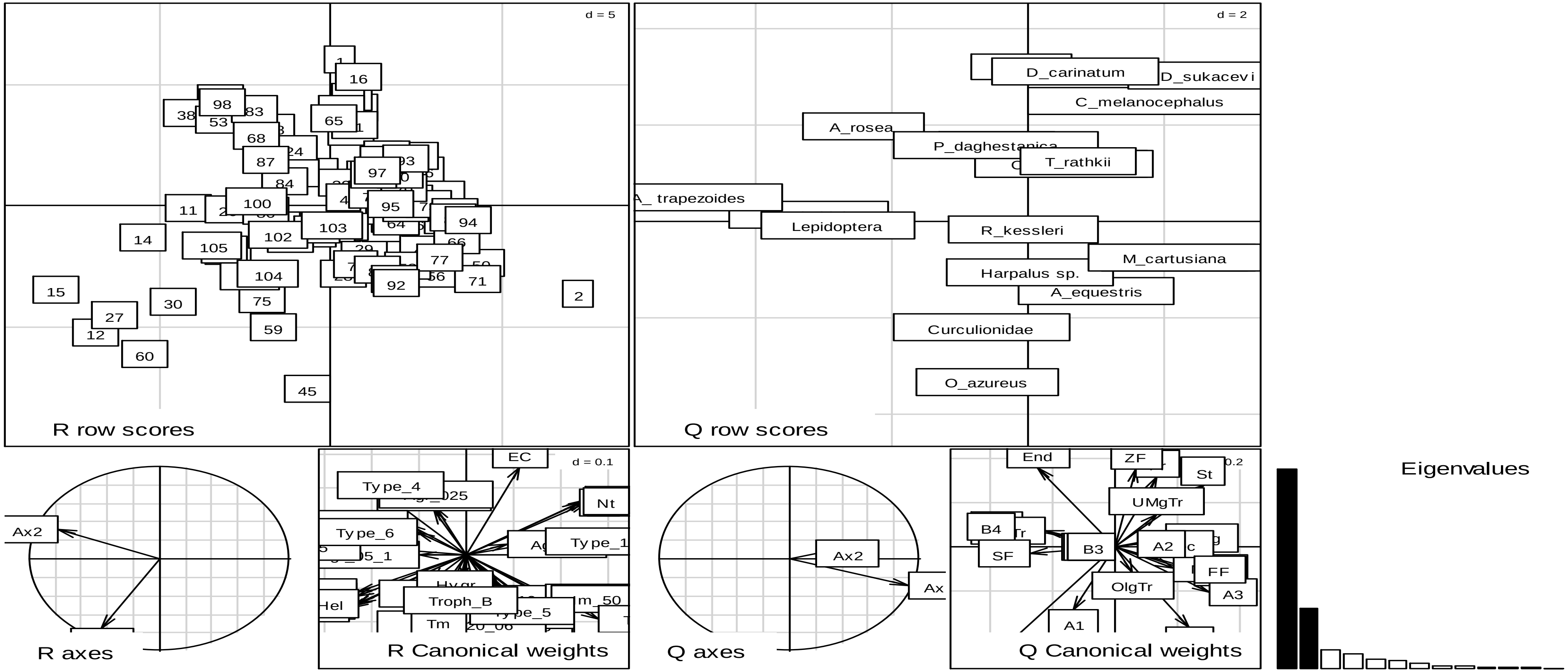

Fig. 2 - The results of the analysis of RLQ

x-axis - RLQ-1 axis, y-axis - RLQ-axis 2; A - weight of sampling points (R-matrix) for RLQ-axes; B - weight species (Q-matrix) by RLQ-axes; C - correlation of principal components 1 and 2 are derived from factor analysis of environment variables and RLQ-axes; D - correlation of environment variables and RLQ-axes; E - correlation of principal components 1 and 2 are derived from factor analysis and ecomorphs RLQ-axes; F - correlation ecomorphs and RLQ-axes; G - histogram of eigenvalues.

Axis 1 highlighted RLQ-analysis, characterized by positive correlation with the hardness of soil on the entire depth. This axis is negatively correlated with soil temperature at the time of collecting zoological soil samples - 03.05.12. There is a weakly significant positive correlation with the electric conductivity of the soil. It is observed a close relationship between the axis 1 and the projective cover of both living and dying plants. Axis 2, in contrast to the axis 1, is negatively correlated with the hardness of all studied depths,as well is negatively correlated with soil temperature at 20.06.2012. From electric conductivity axis is poorly correlated. Correlation with physiognomic vegetation types reflects a positive impact of absence projective cover. A joint measurement of edaphic and plant characteristics and structure of animal populations allowed us to estimate the properties of ecological niche of soil mesofauna (Table. 2).

Table 2

Analysis of the types of marginality communities of the mesofauna

Types	Reduction	Inertia	OMI	omi	tol	rtol	p-level
Amara equestris	A_equestris	52.1	7.1	13.7	9.9	76.4	0.04
Amphimallon solstitiale	A_solstitiale	24.7	9.4	38.1	0.8	61.1	0.35
Anoxia pilosa	A_pilosa	63.3	11.0	17.4	12.6	70.0	0.13
Aporrectodea rosea	A_rosea	43.9	1.5	3.5	25.2	71.3	0.00
Aporrectodea trapezoides	A_.trapezoides	49.1	1.9	4.0	23.2	72.7	0.00
Aranea sp.	Aranea	43.8	5.6	12.9	16.1	71.0	0.03
Brephulopsis cylindrica	B_cylindrica	41.3	0.1	0.2	10.0	89.9	0.54
Calathus melanocephalus	C_melanocephalus	48.8	6.7	13.9	5.7	80.4	0.33
Curculionidae sp.	Curculionidae	50.1	15.5	31.0	11.8	57.2	0.02
Dendarus punctatus	D_punctatus	77.9	23.0	29.6	9.9	60.5	0.01
Diphyonyx sukacevi	D_sukacevi	32.6	2.6	8.1	5.1	86.8	0.94
Dorcadion carinatum	D_carinatum	31.7	15.0	47.4	1.7	50.9	0.06
Harpalussp.	Harpalus.sp.	55.7	9.2	16.5	23.0	60.4	0.13
Helix lucorum	H_lucorum	43.3	0.7	1.8	7.8	90.4	0.46
Lepidoptera	Lepidoptera	50.4	14.0	27.8	12.2	60.0	0.08
Monacha cartusiana	M_cartusiana	39.9	0.2	0.6	14.7	84.7	0.06
Opatrum sabulosum	O_sabulosum	45.1	5.7	12.7	24.7	62.6	0.00
Ophonus azureus	O_azureus	30.4	8.9	29.4	11.4	59.3	0.56
Podonta daghestanica	P_daghestanica	35.9	4.1	11.6	25.4	63.0	0.24
Rossiulus kessleri	R_kessleri	42.2	0.7	1.6	10.30	88.1	0.65
Trachelipus rathkii	T_rathkii	26.9	3.2	11.9	7.0	81.1	0.67
OMI		6.9	–	–	–	–	0.00

Legend: OMI - index of the average distance (marginal) for each species; Tol - tolerance, Rtol - residual tolerance; italics index data presented in % of total variability; p-level using the Monte Carlo method after 25 iterations. The total inertia, which can be calculated as a result of OMI-analysis is proportional to the average marginality species community and is a quantitative assessment of the impact of environmental factors on the species separation (Kunakh *et al.,* 2013). Marginality - is the displacement degree of centroid ecological niche of the species at typical conditions represented by a polygon.

The analysis revealed that the total inertia, which can be calculated in the analysis result of OMI,is proportional to the average marginality of community species and represents a quantitative assessment of the impact of environmental factors on the separation of species. The analysis determined that the total inertia is 1.99. The first axis, obtained from OMI-analysis describes 41.93%, and the second - 22.54% of inertia. So the first two axes describe 64.47% of inertia which is quite enough, in order to differentiate the description of ecological niches of mesofauna in the studied polygon in the space to carry out the first two

axes. For the average value marginalized communities (OMI = 6.99) the significance level is p = 0.00, which indicates the importance of the selected environment variables for the structuring of the soil mesofauna community. The marginalitywhich was significantly different from the random alternatives characteristic of 3 types out of 21, for which carried out the OMI-analysis (Table. 3).Thus, for most species of the studied landfill typically edaphic conditions are identical with the centroid of their ecological niche.
Configuration of ecological niches is presented in Figure 3.

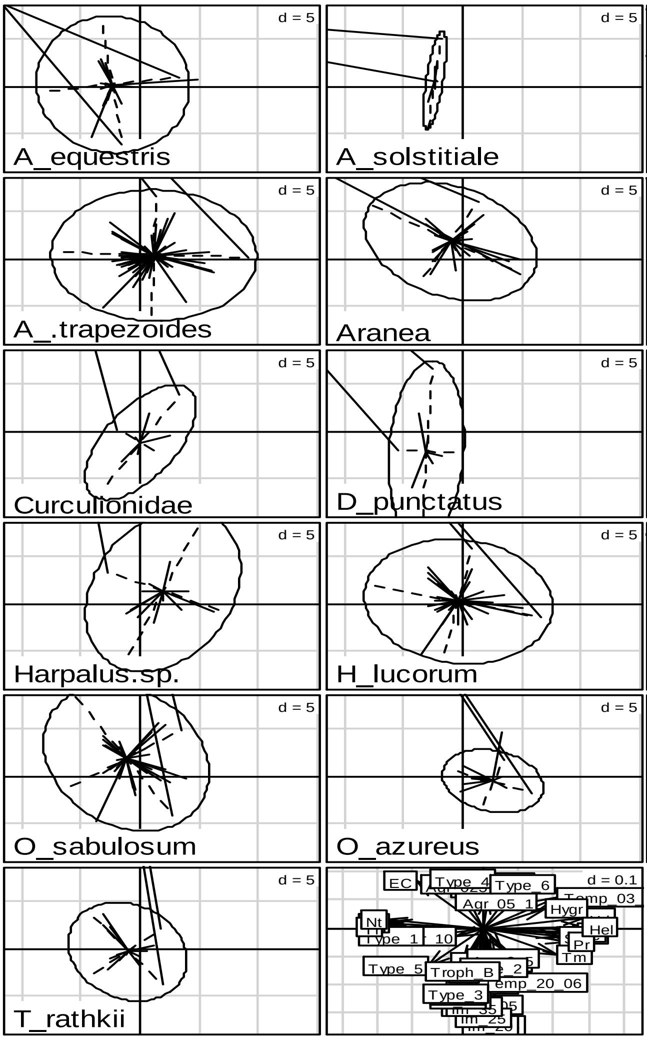

Fig. 3 -The ecological niches of species of soil macrofauna

The coordinate axes are specified with components of marginality; origin - zero marginal. The ellipse represents the inertia of ecological niche. Rays associated with the centroid ecological niche sites meeting the form in the space of marginalized communities. In the lower right corner of the normalized weight of environmental -

RLQ-analysis allows us to classify animals according to the nature of their ecological structure and due to environmental factors. The cluster analysis allowed identifying four complexes species that form the functional groups A, B, C and D (Fig. 4).

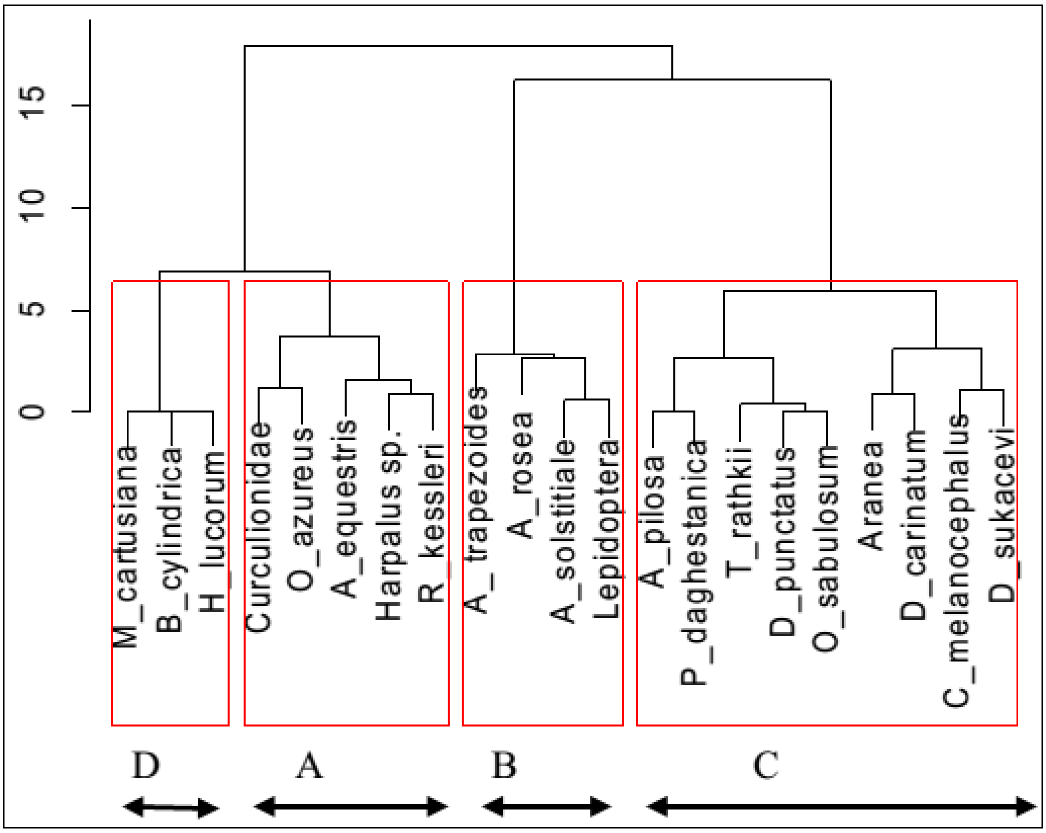

Fig. 4- The cluster analysis of the structure of the animal population of the soil

The location of these functional groups in space RLQ axes are shown in Fig. 5. A functional group includes most consists of xerophilic steppe species (eg O. azureus, A. equestris, R. kessleri).

This functional group is sensitive to the vertical differentiation of the soil profile (marker - axis 2). The functional group is represented in xerophilic steppe species (Lepidoptera sp. Larvae), mesophilic steppe species (A. rosea), hygrophilic meadow species (A. trapezoides) and hygrophilic forest species (A. solstitiale). The main axis is determined by the appearance of communities 1. The third functional group C is mainly composed of xerophilicStepanov (egOpatrumsabulosum, Podontadaghestanica). Group C is sensitive to vertical differentiation of the soil profile (marker - axis 2). The fourth functional group D are terrestrial snails (Mollusca, Gastropoda), which hygromorphes and coenomorphes aspects are mesophilic. Group D is sensitive to the 1 axis.

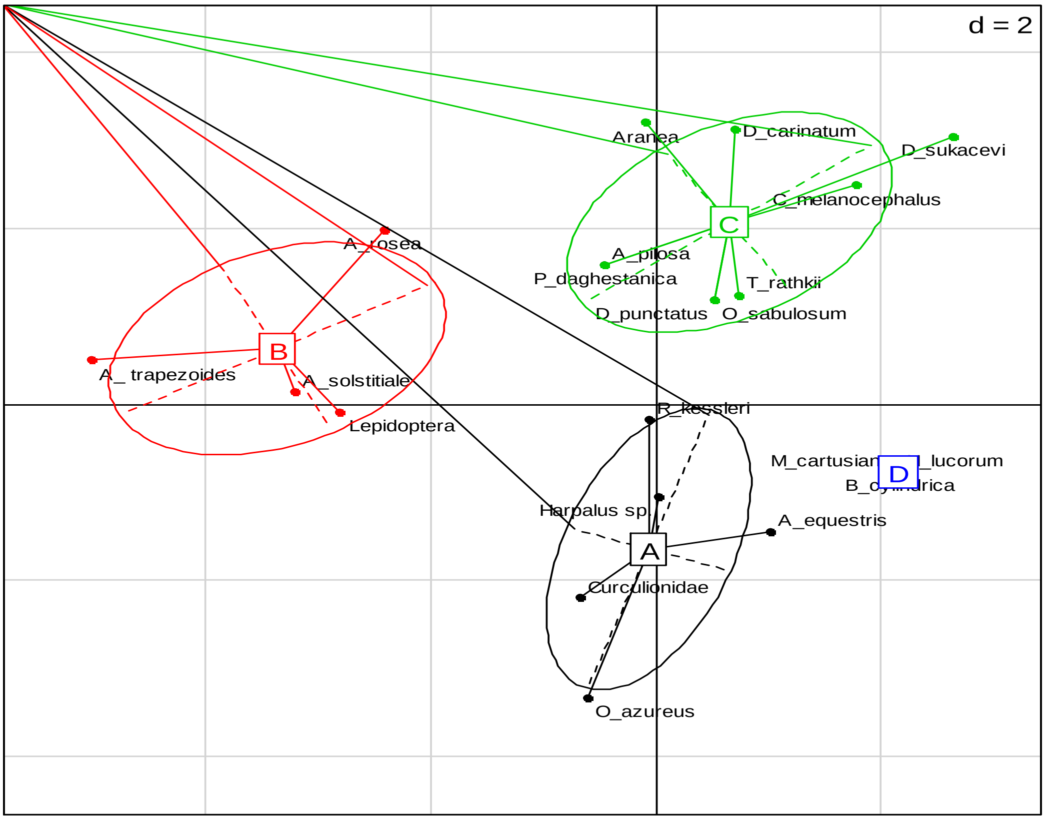

Fig. 5 - Location of the functional groups in the space of RLQ-axes

Ecological specialization is the adaptation of an organism or group of organisms to the narrow conditions of existence. Ecological specialization within the context of concrete conditions takes the form of functional groups. Ecomorphs structure analysis of the animal population allows determining the nature of the functional groups obtained in terms of the provisions of this habitat (Fig. 5). An important tool for describing the ecological structure of the animal population is its reflection in geographic space. Spatial variability RLQ-axis is shown in Fig. 6.

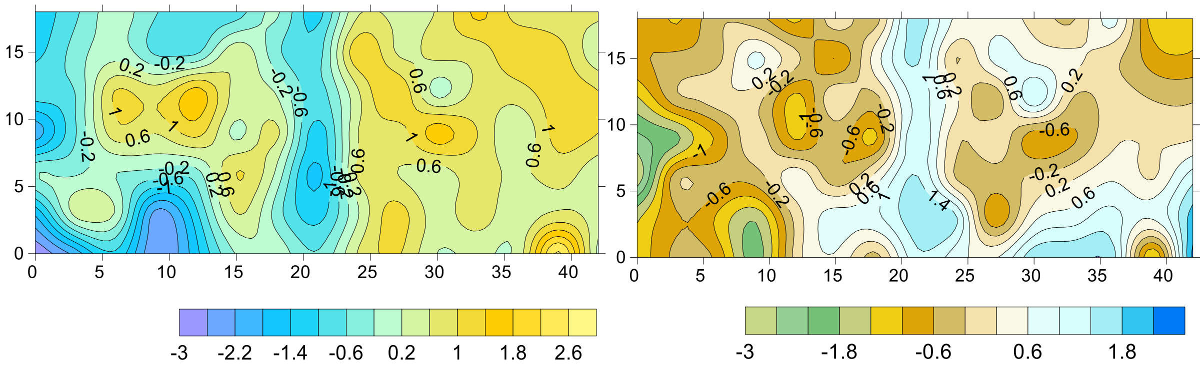

Fig. 6 - Spatial variability RLQ-axes

Figure 6 shows the trends of relatively independent of the spatial variability of the animal population of soddy-lithogenic soils on loessial sandy loams. Figure 6 demonstrates the spatial distribution of soil animals relative to the axis 1: the high values indicate a high density of functional groups of representatives, on the other hand, the low values - functional group B. The functional group A is relatively tolerant to the axis 1.

Figure 6illustrates the spatial distribution of soil animals relative to the axis 2. The area with a high density of representatives of functional groups B and C are fragmentary and alternated with areas where there is a high density of members of the group A.

CONCLUSIONS

According to the analysis and interpretation of results obtained in the present research the following points should be emphasized:

1. It is established that edaphic characteristics sod-lithogenic soils on loessial sandy loams and vegetation cover characteristics (ecomorphs and using phytoindication scale) describe the 87.71% of the variation spatial distribution of soil animals.
2. Using the RLQ-analysis, the two axes of differentiation of animal populations that are integral evaluation of the entire set of environmental factors. Axis 1 describes 62.81%, and the axis 2 - 18.90% of spatial variability distribution of mesofauna.
3. Was noted statistically significant marginality of 3 species (O. sabulosum, A. rosea, A. trapezoides) of 21, which indicates non-random choice of habitat preference of these types of specific conditions for life.
4. The functional groups of soil animals derived by using cluster analysis on the basis of interrelation ecomorphs structure and environmental factors that reflect the differentiation of ecological niches of individual groups of species which are sensitive to hardness of, soil temperature and projective cover plants.
5. 5. The mapping axes RLQ-analysis in geographic space shows that the study polygon is not uniform for soil anmal.

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COMPARATIVE ANALYSIS OF MISCANTHUS PRODUCTIVITY PARAMETERS UNDER THE FOREST – STEPPE AND STEPPE ZONES CONDITIONS OF UKRAINE
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ПОРІВНЯЛЬНИЙ АНАЛІЗ ПРОДУКТИВНИХ ПАРАМЕТРІВ МІСКАНТУСУ В УМОВАХ ЛІСО-СТЕПОВОЇ ТА СТЕПОВОЇ ЗОН УКРАЇНИ

Prof. Ph.D. Kharytonov M.*[1)], Dr. Ph.D. Martynova N.[2)], Dr. Ph.D. Opanasenko V. [2)], Dr. Ph.D. Gumentyk M. [3)], Dr. Ph.D. Kvak V. [3)], Ph.D. Stud. Zamoysky O. [2)], Ph.D. Stud. Katelevsky V. [3)]
[1)]Dnepropetrovsk State Agrarian and Economic University, Dnepropetrovsk, Ukraine
[2)]Oles Gonchar Dnepropetrovsk National University, Dnepropetrovsk, Ukraine
[3)]Institute of energy crops and sugar beet, Kyiv, Ukraine
Tel: 380973456227;E-mail: envteam@ukr.net

Keywords: *weather conditions, Miscanthus species, productivity parameters, biomass yield, soluble sugars*

ABSTRACT
The comparative analysis of the main biological productivity parameters of Miscanthus various species was carried out in the forest-steppe and steppe zone of Ukraine. The yield of Miscanthus increases due to rhizomes planting in the early stages. Optimum planting depth is 8...10 cm. It has been revealed that such morphological features as the number of leaves per stem, width and length of lamina have small variability and are determined mainly by the plant genotype. Biomass components, such as canopy height, stem number per plant and stem diameter, are more dependent on environment influence and the crop age. For the first 3 years of cultivations Miscanthus can grow up to 189 (M. sacchariflorus) – 198 cm tall (M. sinensis) under insufficient water supply. Comparison of the stem number per plant for the 2-year plants has shown the least values for M. sacchariflorus, and the largest for M. sinensis and M. oligostachyus. Plant aboveground biomass productivity increases with age. Productivity of M. sacchariflorus and M. sinensis is almost the same. At the same time, the biomass productivity of 1-year plants M. × giganteus is only 30% less than 2-years plants aforementioned species. The maximum biomass yield have been registered for 15-year plantation of M. sinensis and amounted to 41.5 t/ha.

ТЕЗИ
В умовах лісо - степової та степової зон України проведений порівняльний аналіз головних параметрів біологічної продуктивності різних сортів Міскантусу. Урожайність міскантусу збільшується завдяки садінню ризомів у ранні строки, оптимальною глибиною садіння є 8…10 см..Виявлено, що такі морфологічні ознаки, як кількість листків на стеблі, ширина і довжина пластинки мають малу мінливість і визначаються в основному генотипом рослин. Такі компоненти біомаси, як височина листвяного покриву, чисельність та діаметр стебел знаходяться в більшій залежності від умов навколишнього середовища та віку рослини. Протягом перших 3 років культивації Міскантус може зрости до 189 (M. sacchariflorus) – 198 см заввишки (M. sinensis) при недостатній забезпеченості вологою. Порівняння кількості стебел на рослині для 2-річних рослин показал найменше значення у M. sacchariflorus, а найбільше – у M. та M. sinensis oligostachyus. Рослина надземна підвищує продуктивність біомаси з віком. Продуктивність M. sacchariflorus і M. sinensis практично однакова. У той же час, продуктивність біомаси 1-річних рослин M. x giganteus булла на 30% менше ніж 2-річних рослин вищевказаних видів. Максимальний врожай біомаси був зареєстрований для 15-річних плантацій M. sinensis і склав 41,5 ц/га.

INTRODUCTION
Miscanthus is a perennial grass with the C_4 photosynthesis type. According to current taxonomy data there are 16 species (*Plant list, 2013*) in the genus *Miscanthus* Anderss. Only 8-9 of these can grow in the temperate climatic zone. They all have origin in East Asia.

Miscanthus was first cultivated in Europe in 1930s. At first, it was used as ornamental plant in landscape architecture. With the laps of time researchers have become interested in this plant as a promising source of cellulose containing biomass for chemical industry and bioenergy production (*Karp and Sheid, 2008, Dohleman et al., 2009, Brosse et al., 2012*). First of all, it concerns *Miscanthus × giganteus* J.M.Greef et Deuter ex Hodk. et Renvoize. – spontaneous sterile hybrid cross between *Miscanthus sacchariflorus* (Maxim.) Hack. and *Miscanthus sinensis* Anderss. The first, its trial plots were established in Europe in 1983. Now this species takes a large industrial area along with other energy crops

(*Lewandowski et al., 2000*). *M. × giganteus* is being intensively cultivated in the United States as well (*Heaton et al., 2004, Anderson et al., 2011, Planting and Managing, 2011*). The first plantations of *M. × giganteus* have been established in Ukrainian forest-steppe region and Polesye recently (*Pidlisnyuk et al, 2012; Rakhmetov et al, 2015*). Studies of *M. sacchariflorus* and *M. sinensis* are still at the stage of scientific development (*Christian et al., 2005, Shumny et al, 2010, Bonin et al, 2014, Yu et al, 2015*). The potential of other Miscanthus species has not been studied at all. At the same time, the possibility of using them as an energy crop is extensive enough. The above ground biomass can be used as renewable raw materials for the production of solid (pellets, briquettes), liquid or gaseous (ethanol, butanol, ethylene) types of fuels (*Hodgson et al., 2010, Han et al., 2011*).

Recent researches (*Heaton et al., 2004, Lewandowski and Schmidt, 2005, Zub and Brancourt-Hulmel, 2010, Arnoult and Brancourt-Hulmel, 2015*) have shown that many different factors can influence Miscanthus efficiency (geographical location of the cultivation area, climate conditions, water supply, crop management, mineral element availability, genotypic variability). Therefore, thoroughly studying productivity parameters under introduction conditions will allow to determine the potential and prospects of this crop cultivation

MATERIAL AND METHOD

Seedlings were planted in three sites. First site is in Borschyvsky district of Ternopol region in the north-western part of Ukraine. Second site is in Botanic garden of Dnipropetrovsk National University. Third site is in land reclamation station of Dnipropetrovsk State Agrarian and Economic University. Both sites are situated in Dnipropetrovsk region in the south - eastern part of Ukraine.

The long-term average values of air temperature and precipitation in Ternopol region are given in table. 1.

Table 1

The average long-term values of air temperature and precipitation in Ternopol region

Month	Air temperature, C^0					Precipitation, mm				
	Year				average	Year				average
	2009	2010	2011	2012		2009	2010	2011	2012	
Jan	-3	-7.9	-2.3	-3.5	-5.5	34.5	9.4	23.7	15	33.0
Feb	-1.3	-3.1	-3.9	-9.5	-4.2	26.4	89.7	25.6	40.1	31.0
March	1.7	2.1	2.0	3.3	0.7	34.8	16.4	15.4	14.0	40.0
Apr	11.1	9.4	10.4	10.3	7.2	3.4	26.3	37.5	83.0	50.0
May	14.5	15.3	14.9	16.0	14.1	41.0	108.6	21.2	21.5	75.0
June	17.3	17.9	18.4	19.3	16.8	81.3	143.9	92.4	105.5	94.0
July	20.9	20.3	19.7	23.0	18.4	27.3	122.9	66.0	82.2	94.0
Aug	19.7	21.1	19.3	19.1	18.0	49.9	42.1	63.0	77.5	80.0
Sept	16.0	12.8	17.2	15.1	13.6	3.8	134.8	13.3	19.0	55.0
Oct	8.7	5.2	7.6	9.6	8.1	67.9	43.2	13.4	41.7	50.0
Nov	5.3	7.2	7.6	9.6	8.1	32.0	24.8	2.6	23.2	43.0
Dec	-1.6	-5	1.1	-5.4	-0.9	0	55.5	16.8	77.6	34.0
Sum						402.3	817.6	390.9	600.3	679.0

The climatic conditions were typical for the Forest - Steppe zone as the average values of indicators and the degree of deviation from the long - term average in some years.

First experiment goal: to establish the timing of planting and planting depth rhizomes. Factor A – planting dates: 1) the I-II decade of April; 2) II-III decade of April; 3) I decade of May. Factor B – drilling depth: 1) 6 cm; 2) 8 cm; 3) 10 cm; 4) 12 cm. The repetition – fourfold. The soil is podzolic, soil pH is 6.0.

Dnepropetrovsk region is situated in steppe zone at 48°N, 34°E. Climate is moderately continental. Over the course of a year, the temperature typically varies from -8°C to +31°C. The cold season lasts from December to March with an average daily temperature of -3.1°C. In the winter air temperature can sometimes fall till -20-25°C. The warm season lasts from May to September 15 with an average daily temperature above +24°C. Often, the average daily temperature in summer reaches +30-34°C, maximum +37-40°C. Total annual precipitation averages are of 500-540 mm During the warm season precipitation occur most often in the form of thunderstorms (63%), light rain (31%), and moderate rain (6%). The rainfall varies significantly over the course of the warm season. For example, 106 mm of precipitation were fallen in March 2015, which made a record 247% of normal, while in July were 29 mm (54% of normal), and in September was only 1 mm (2% of normal). At the same time the average daily temperature of September has exceeded the norm on 4.4°C (Fig.1).

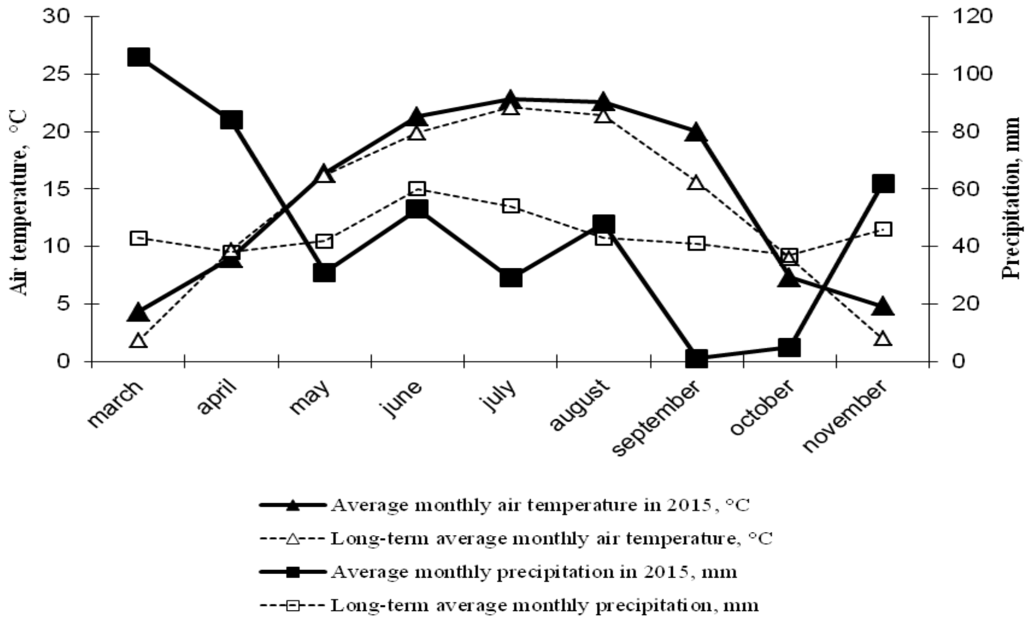

Fig.1 - Climate data (rainfall and air temperature) of Dnepropetrovsk region

There is an insufficient water supply during the growing season. The experimental data on physical constants of chernozeom (black soil) and pedozeom (mix of red-brown clay and loamy like loess) are shown in Figure 2.

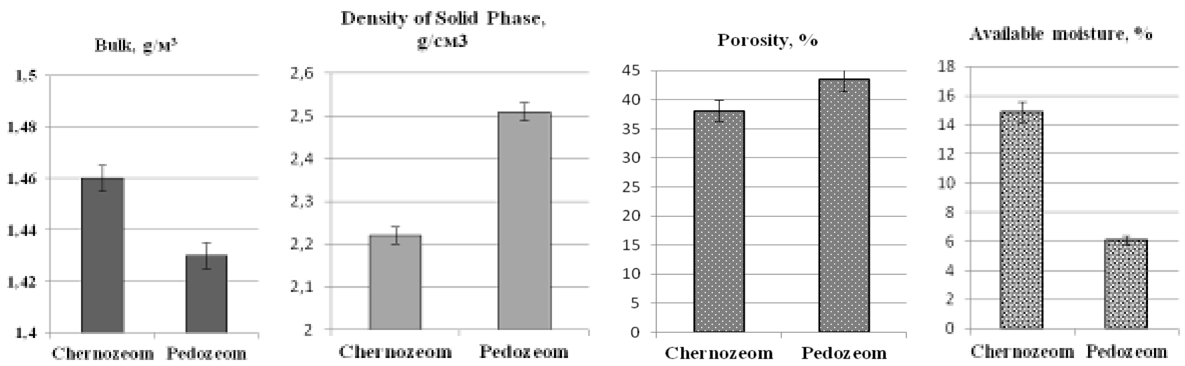

Fig.2 - Physical constants of chernozeom and pedozeom

Due to differences in soil texture, the moisture content in pedozeome was 2. 5 times less than in the black soil.

As part of this work, four species *(M. sacchariflorus, M.* × *giganteus, M. oligostachyus* Stapf., *M. sinensis* and *M. s. cv. Gracillimus)* from collection of Dnepropetrovsk National University Botanic Garden were studied: As a mother plant have been selected 3-year-old and 4-year-old plants. One mother plant produced 23 to 35 seedlings or harvestable rhizomes (for *M. sacchariflorus* and *M.* × *giganteus*). Each seedling had 3 to 5 shoots and each rhizome had minimum of two to three buds. The optimum time for planting is the middle of April.

Subject of studying were the following parameters related to biomass efficiency and biomass composition: above ground biomass productivity, canopy height, stem number per plant, stem diameter, the number of leaves per stem, width and length of lamina, soluble carbohydrates content. Above ground biomass yield was assessed for the late autumn harvest; other morphological traits were obtained at the end of growing season.

The soluble carbohydrates were estimated by photometric methods (*Naiem and Abdelatif, 2001*). Samples were quantified photometrically by measuring the change in wave length at 660 nm. The amount of soluble carbohydrates was calculated with the help of standard curve obtained by using different concentration of standard glucose solution. The amount of sucrose was estimated as difference between total sugar content and reducing sugar content and multiplied with coefficient 0.95.All the data are processed with statistical methods using the software package StatGraphics Plus5.

RESULTS

The timing and depth impact of planting rhizomes on the yield of Miscanthus are shown in the table 2.

Table 2

Yield of biomass of Miscanthus depending on the timing and depth of planting rhizomes

Planting time	Year				
	2009	**2010**	**2011**	**2012**	**Average**
			Planting depth - 6cm		
I	2.2	3.7	1.8	3.2	2.7
II	2.1	3.1	1.5	2.5	2.3
III	1.7	2.8	1.3	2.1	2.0
			Planting depth - 8cm		
I	2.8	3.7	1.9	3.3	2.9
II	2.1	3.2	1.7	2.6	2.4
III	1.7	2.8	1.4	2.3	2.0
			Planting depth - 10cm		
I	2.9	3.9	2.2	3.6	3.2
II	2.2	3.5	1.9	2.6	2.5
III	1.8	2.9	1.4	2.4	2.1
			Planting depth - 12cm		
I	2.9	3.9	2.0	3.1	3.0
II	2.1	3.5	1.8	2.3	2.4
III	1.7	2.8	1.3	2.1	2.0
LSD_{05}	0.4	0.4	0.3	0.3	

Weather conditions had a significant effect on the Miscanthus biomass yield. The yield of Miscanthus in the favorable weather conditions of 2010 and 2012 years was 2 times higher compared to 2009 and 2011. The early stages (first and second) planting helped to increase yields from 19 to 45% compared to the third planting time. It is established that the yield of Miscanthus biomass increases with the increase in depth of planting rhizomes.

According to long-term phenological observations in the steppe zone of Ukraine, spring growth Miscanthus begins mainly at the end of April. In some years it starts in early May. Growing season continues until the third decade of October. Miscanthus plants reach the greatest height in a flowering stage, which comes in August-September (Fig.3).

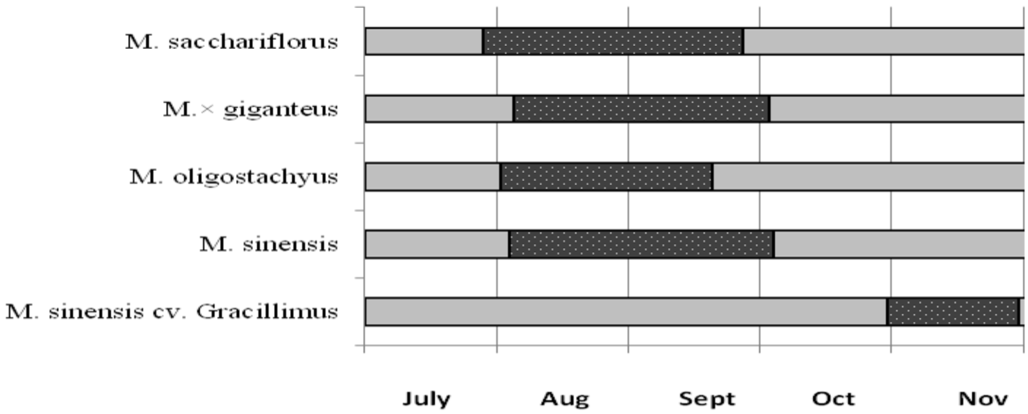

Fig.3 - Flowering stage of Miscanthus species under steppe zone conditions of Ukraine

Vegetation period of *M. s. cv. Gracillimus* is longer than other varieties. Its leaves yellowing continue during December. The flowering stage also begins later, in November, and may remain unfinished in the event of early autumn frosts. The studied Miscanthus species under introduction conditions do not form seed and can only be propagated vegetatively. Miscanthus spread naturally by means of underground rhizomes. *M. sacchariflorus* has very long rhizomes which quickly colonizes the big areas. In a single growth season the size of its patch may increase five times. *M. × giganteus, M. oligostachyus* and particularly *M. sinensis* are more cespitose, their spread are slow and there is little risk of uncontrolled invasion of hedges or field, compared to the *M. sacchariflorus*. Despite that stands of *M. sacchariflorus* tend to be lager but less dense than stands of others Miscanthus species. *M. s. cv. Gracillimus* has the highest stem density per unit of area.

It has been revealed that such morphological features as the number of leaves per stem, width and length of lamina have small variability and are determined mainly by the plant genotype. The number of leaves per stem in tall species is 9-10, in medium tall *M. oligostachyus* – 4-5. The lamina width of *M. sacchariflorus, M. sinensis* and *M. × giganteus* is 1.5-2 cm, *M. oligostachyus* is 1 - 1.5 cm. The *M. s. cv. Gracillimus* has the narrowest leaves whose width does not exceed 0.6-0.8 cm. In the same time their length is about 98 - 105 cm, while the leaf length of other species varies within the limits 55 - 70 cm. *M. oligostachyus* has the shortest leaves, their length being only of 35 - 40 cm.

Such productivity parameters as canopy height, stem number per plant and stem diameter, are considerably dependent from environment influence and the crop age. For the first 3 years of cultivations Miscanthus can grow up to 189 (*M. sacchariflorus*) – 198 cm tall (*M. sinensis*) under insufficient water supply. Comparison of the stem number per plant for the 2-year plants has shown the least values for *M. sacchariflorus*, and the largest for *M. sinensis* and *M. oligostachyus*. The stem diameter depends on the plant age and on species features. Interestingly, the stem diameter of the three-year plants *M. s. cv. Gracillimus* is almost equal to that of the fifteen-year plants *M. sinensis*. The greatest value of this indicator was detected in *M. × giganteus* (Table 3).

Table 3

Morphometric parameters of Miscanthus in the steppe zone conditions

Miscanthus species, age	Canopy height, cm	Stem number per plant	Stem diameter, mm
M. sacchariflorus (1 year)	80.0 ± 1.23	-	4.2 ± 0.15
M. sacchariflorus (2 year)	188.8 ± 2.93	16.2 ± 0.44	4.4 ± 0.13
M. × giganteus (1 year)	86.7 ± 0.98	-	8.1 ± 0.21
M. sinensis (2 year)	142.5 ± 1.66	30.3 ± 1.25	4.3 ± 0.11
M. sinensis (15 year)	198.3 ± 2.16	61.9 ± 1.05*	5.7 ± 0.18
M. sinensis cv. Gracillimus (3 year)	196.0 ± 2.31	51.3 ± 3.04	5.2 ± 0.13
M. oligostachyus (2 year)	93.7 ± 1.86	33.7 ± 1.14	3.4 ± 0.10

** Stem number per 0.1 m^2*

Yields of above-ground biomass increase with the age. For instance, the biomass of *M. sacchariflorus* which was collected with a 2-year plantation is increased three times in comparison with biomass yield with an one-year plantation. Productivity of 2-year *M. sacchariflorus* and *M. sinensis* is almost the same. At the same time, the biomass productivity of 1-year plants *M. × giganteus* is only 30% less than 2-years plants aforementioned species (Fig.4).

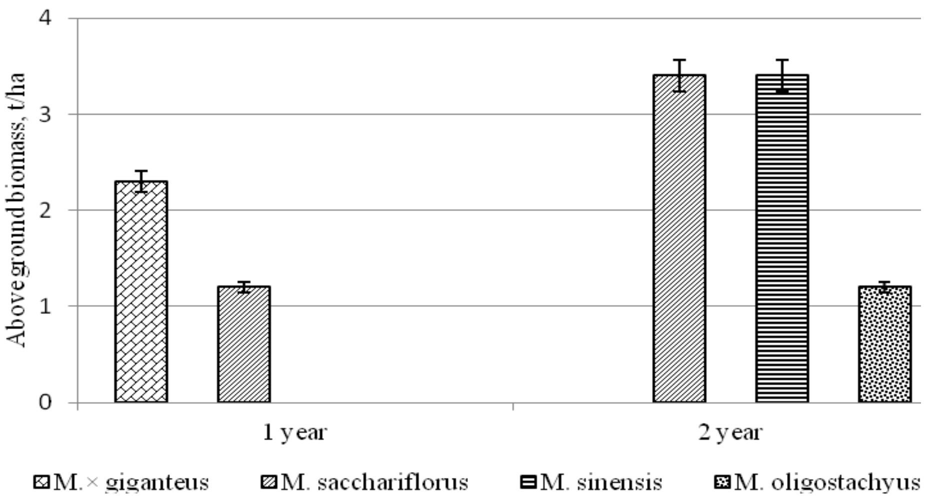

Fig.4 - Aboveground biomass production of various Miscanthus species under steppe zone conditions

The maximum biomass yield has been registered for 15-year plantation of *M. sinensis* and amounted to 41.5 t/ha. Biomass efficiency of 2-year plants *M. oligostachyus* was not great, only 1.2 t/ha. Good potential was showed by 3-year plant *M. s. cv. Gracillimus*, which biomass productivity was 9.1 t/ha. The maximum biomass yield have been registered for 15-year plantation of *M. sinensis* and amounted to 41.5 t/ha.

The aboveground biomass of Miscanthus can be significant source for bioethanol production. Usually technologies of bioethanol production by Miscanthus biomass includes following stages: pretreatment removes hemicellulose and gets reactive cellulose; hydrolysis for fermentable sugars; fermentation for production of ethanol (*Lien et al., 2005, Alvira et al, 2010, Huang et al., 2010*). At the same time the biomass of Miscanthus besides lignocellulosic components contains water soluble carbohydrates. And their total content is almost the same as at traditional sacchariferous crops: *Sorghum*, *Eclrinochloa frumentacea*, *Setaria italica* etc (*Almorades and Hadi, 2009*).

The soluble sugar content was estimated in the end of the growth season *(Fig.5)*.

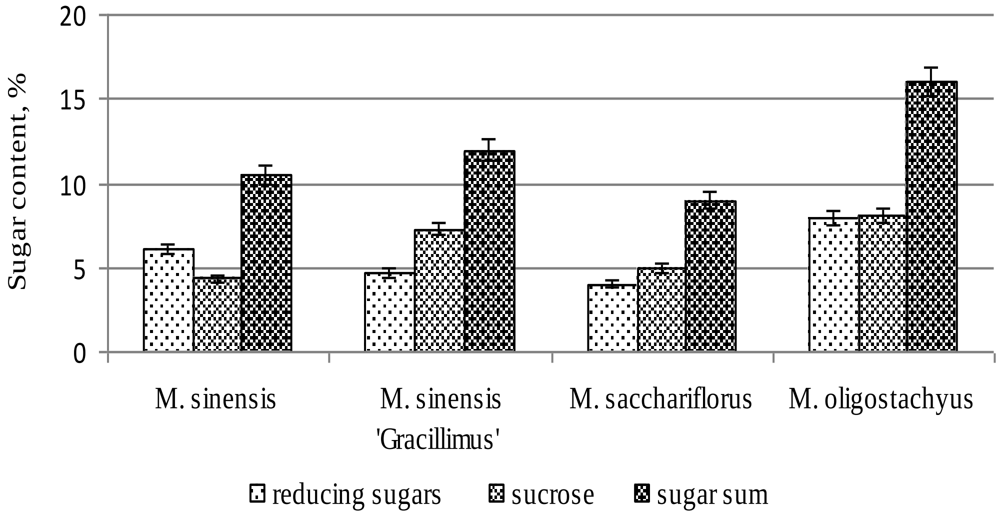

Fig.5 - Soluble sugar content in aboveground biomass of Miscanthus

At this period vegetation is still in progress. However plants already have accumulated enough nutrients necessary for normal wintering and a cut of aboveground biomass will not damage of plant.

Determination of soluble carbohydrates in *Miscanthus* leaves and stems has shown high values of reducing sugars and sucrose. The sugar sum content varies in different species in range from 9.0 (*M. sacchariflorus*) to 16.05% (*M. oligostachyus*). Reducing sugars-sucrose ratio was nearly 50:50 at *M. oligostachyus*. At the *M. sinensis* reducing sugar content was greater than sucrose content on 40-60%. And vice versa the biomass of *M. s. cv. Gracillimus* accumulates greater quantity of sucrose than reducing sugars on 56% and at *M. sacchariflorus* on 22.5%.

CONCLUSIONS.

The yield of Miscanthus increases due to rhizomes planting in the early stages. Optimum planting depth is 8...10 cm. The effect of date and depth of planting on the yield of biomass was observed only in the first year of vegetation. The trend continues due to the difference of plant density.

It was shown that various Miscanthus species are adapted to rather wide range of soil and can give the high biomass yield under insufficient water supply condition. The results of preliminary work assume that optimum time for biomass harvesting is a late autumn (November) for the solid types of fuel production or in the end of the growth season (October) for the bioethanol production. The further studies of the biomass component composition will allow selecting the most suitable species for specific conversion process. The subsequent search of crop management optimum practices is also significant for enhancement of biomass productivity.

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DECONTAMINATION OF AGRICULTURAL SOIL POLLUTED WITH LEAD USING A SUNFLOWER *HELIANTHUS ANNUS* / DÉCONTAMINATION D'UN SOL AGRICOLE POLLUÉ PAR LE PLOMB (PB) À L'AIDE DE TOURNESOL COMMUN *HELIANTHUS ANNUS*

Zerrouki D., Bboukirat D., Maatoug M., Mokhtar A.
Laboratory of Agro Biotechnology and Nutrition in Semi-arid Zones, Faculty of Natural Sciences and Life. Ibn -Khaldun University - Tiaret, Algeria
KHARYTONOV M., State Agrarian-Economic University, - Dnipropetrovsk, Ukraine
e-mail:envteam@ukr.net

Keywords: *Soil, decontamination, Sunflower, lead, pH, CEC, clay*

ABSTRACT

In this work, we have studied the possibility of decontaminating the soil polluted by lead from traffic road, using Helianthus annus as a heavy metals hyperaccumulative plant. High concentrations of lead stored at the horizons of soil surface (1714.39 ± 512.62 ug/g) have revealed that the traffic and road infrastructures are important sources of toxic heavy metals to the environment. In addition, we noticed that Helianthus annus may hold a total of 35.69±37.24 ug/g, which correspond to 2% of that accumulated in the soil. Importantly, highest values were observed in the roots (17.97±32.79 ug/g), which means 50.50%, whereas, the rates of heavy metals in the stems and leaves were 8.33±4.65 ug/g and 7.36±4.81ug/g , respectively. Otherwise, the accumulation of lead was influenced by physical and chemical properties of the soil: pH, cation-exchange capacity (CEC), percentage of clay. A high content of lead was observed in the plant at low pH; while, at the CEC of the soil and the percentage of clay, are positively correlated with plant Pb. However, a strong correlation between soil Pb and plant Pb was noticed. Accordingly, lead uptake by Helianthus annus seems to be influenced by its bioavailability in soil.

RÉSUMÉ

Le but de ce travail est d'évaluer la possibilité de décontaminer un sol, pollué par le plomb en milieu routier, par Hordeum vulgare, utilisée comme plante hyperaccumulatrice des métaux lourds. Les concentrations élevées, en plomb enregistrées dans les horizons de surface du sol (1714,39 ± 512,62 µg g-1), ont permis de mettre en évidence que le trafic et les infrastructures routières constituent une source importante en métaux lourds toxiques pour l'environnement. Ces métaux peuvent se disperser et retomber par voie sèche ou humide sur les bordures de chaussée, transportés par le ruissellement des eaux pluviales vers le sol. Les résultats obtenus montrent que Hordeum vulgare accumule au total 36,28±14,90 µg g-1, soit 2 % des valeurs enregistrées dans le sol. Les plus grandes valeurs sont observées dans les racines avec 18,32±8,38 µg g-1, soit 50,50%; par contre les valeurs observées dans les tiges et les feuilles sont, respectivement : 10,83±5,86 µg g-1 et 7,71±3,74 µg g-1, soit 29,95% et 21,25%. Cette accumulation du plomb a été influencée par les paramètres physico chimiques du sol (pH, capacité d'échange cationique, taux des argiles). Une forte teneur du plomb dans la plante a été observée à pH faible ; par contre, la CEC du sol et le taux des argiles sont corrélés positivement avec ces teneurs. Cependant, nous avons constaté une forte corrélation entre le Pb sol et le Pb plante, l'absorption du plomb, par Hordeum vulgare, semble être influencée par sa biodisponibilité dans la solution du sol.

INTRODUCTION

Heavy metals are found as trace in natural soils and include their sources in leaching by rain and the case of multiple contaminants (*Rial-Otero R. et. al*) . The heavy metals can reach very high concentrations in certain substrates polluted by human activities such as the mobility of agrochemicals in soils that plays an important role in the transport of contaminants in the environment (*Pateiro-Moure, M et el*.). Particularly, zinc, lead, cadmium and copper are present in emissions of different industrial and agricultural activities and are also emitted by the exhaust gas of motor vehicles. High rates in soils could modify considerably the composition of the flora; consequently few species might tolerate their toxicity. According to (*Martirnelli I*), the main sources of lead are: exhaust gases and brake linings. The lead is deposited on the pavements and is conveyed by the storm water runoff, resulting in significant contamination of these waters.

As a result, during their infiltration into the soil at the roadside, an accumulation of pollutants in the surface layers of soil is observed. (*Pagotto C*.) reported that the levels of trace metals decrease sharply with soil depth. In parallel, the results shown by (*Bermúdez-Couso A. et al.)* who worked on the cadorufon say Carbofuran is moderately persistent in soils, where it has a half-life of 30 to 117 days depending on the particular agri-environment conditions (soil organic matter and moisture, for example content and pH), so it is highly mobile in soil and can easily reach waters by virtue of its high solubility. As a result, carbofuran has high potential for contamination of groundwater in aquifers, which it can penetrate through leaching and runoff from treated fields. As well, all pesticides in groundwater and most residues present in surface water enter via the soil (*Pateiro-Moure, M et el.*). There are two main routes by which pesticides enter the soil: spray drift to soil during foliage treatment pluswash-off from treated foliage and release from granulates applied directly to the soil (*Rial-Otero R. et. al*). It is of paramount importance to study the dynamics of pesticides in soil-sorption-desorption, transport (and the dependence of transport on entry dynamics and transformation processes (*Lopez-Perez Gonzalo C.*).

Indeed, it is well known that lead is generally more abundant at the surface humus horizons than in deeper horizons, nevertheless it is greatly enhanced by anthropogenic contaminations reaching the ground by its surface (*Baize D.*). According to (*Doelman, P. and Haanstra, L*.), soils are not the final trap for this element because when changes in physico-chemical conditions of the environment occur, lead can be remobilized by various mechanisms resulting in its migration to ground-water, contaminating water resource or assimilation by plants. Moreover, (*Mcbride, M.B.)* showed that metal particles deposited at the surface of leaves do not enter inside and can be easily washed by rain.

On the other hand, pollutants are in a soluble form usable (bioavailable) by the plant, once absorbed by the roots they can reach the aerial parts. The use of physico-chemical techniques for the restoration of polluted soils is very hard and expensive task. Recently, more and more studies are conducted on the rehabilitation of soils contaminated with heavy metals. The ability of some plants to tolerate or even to accumulate metals has opened a new area of research on soil treatment dealing on phytoremediation. Phytoremediation is both effective and low cost. It is a new technology used in the last decade for the decontamination of polluted soils, groundwater and wastewater. It is defined as the use of green plants (including grasses, herbaceous and woody) capacity to remove, contain, or render environmental contaminants harmless, such as heavy metals, trace elements, organic compounds and radioactive compounds found in soil or water.

(*Morel J.L*.) reported that barley, sunflower, dandelion, various *Cruciferae*, nettle and rapeseed were important heavy metals hyper-accumulative plants. These plants are capable, due to their adapted physiologies, to accumulate up to 1% of their dry matter in heavy metal, which is a rate much higher than normal. Therefore, this work aimed to use barley herb, as a hyper-accumulating plant, to clean an agricultural soil contaminated by lead from traffic road. The goal is an estimation of the concentration of accumulated lead by *Helianthus annus* in the vicinity of a national road with a high traffic pressure in the region of Tiaret (Western Algeria).

MATERIAL AND METHOD

Selection of sampling sites

The study was conducted in the region of Tiaret which is located in northwest of Algeria between the Tellian chain on the north and Atlassienne chain on the south, at an average altitude of 980 m. The climate type is Mediterranean semiarid with an average annual rainfall of 400 mm /year. The prevailing winds come from the west and northwest, their average speeds range from 3 to 4 m/s. The locality of Tiaret comprises over 200 km of urban road networks. In 2008, the car fleet of Tiaret department consisted of 8015 registered vehicles. This park is highly heterogeneous due to the variety of vehicles that are present (individual or utility vehicles, petrol or diesel, recent or old, etc..). New cars (0 to 5 years) represent only 11% of the park, however, the cars over 11 years account for 74%. Yet, it is precisely those older vehicles that are more polluting (*Maatoug M. et al.).*

Sampling: Initially, 20 surface horizons were chosen from soils located near two national roads (national roads N°14 and N° 23) to determine the levels of lead, considering that the lead is regarded as an element with a very low mobility and a strong tendency to accumulate at surface horizons (*Fernandez C. et al*.). It is important to note that the daily traffic recorded on Road N° 14 and N°23 is 600 and 800 vehicles per day respectively (*Amirat M.)*. During the second year, 20 plants of *Helianthus annus* were harvested at the same points (horizons) of soil sampling. These heavy metals hyperaccumulator and tolerant species, producing a large biomass, offer a useful alternative method in decontaminating polluted soils. Three plants control of common barley at nearly 5km distance from contaminated soil have been used and will serve as references when comparing to the contaminated plants in the same ecological conditions.

Treatment of samples: The preparation and analysis of metals in soil are the same as for the leaves, lichens and fungi (*Flückiger W., et al.; Deletraz G., Paul E.*). Case of soil samples 20 soil samples were collected in each point of the study area, near the road at a distance of 2 and 4 m. The first set consists of 10 horizons at a distance of 2m from the pavement, whereas, the second set, parallel to the first, is at a distance of 4m.

Protocol: Samples were air dried, sieved (<2 mm) and then grounded. Physicochemical parameters of soil, including pH, CEC and particle size were determined by standard methods (*Duchaufour P.*). The determination of lead in soil consists to weigh 0.5g of soil and put them in glass crucibles; a passage in an oven at 105 °C for 2 hours is necessary to obtain the dry state. The samples are then calcined at 450 °C in the oven for 3 hours and the dissolution is obtained from a mixture of 10ml of 40% hydrofluoric acid (HF), 3 ml of 70% perchloric acid ($HClO_4$) and soil samples; the mixture is then evaporated on a hot plate at 160 °C. The fine powder obtained is dissolved with 1 ml 65% nitric acid in vials of 100 ml graduated polypropylene; after an incubation of 24 h, the tubes are boiled in a water bath and supplemented with distilled water (*Certu.*).

Case of plant samples: On the same sampling points as of the soil, samples of *Helianthus annus* were collected (three plants per horizon) during the second year before seed formation. The harvested plants required a preliminary washing with distilled water to remove possible atmospheric deposits and were separated into three organs: roots, stems and leaves. They were subjected to a set of operations:

• dehydration of organs (roots, stems and leaves): the usual method is dehydration in an oven at 105 ° ± 2 ° C for 72 hours. The dehydrated organs were weighed separately to have the dry matter DM, which is 0.2 to 0.3 g.

• grinding: this step is highly critical as it can be a source of contamination or loss. For this, the grinder used is an agate mortar. The grinder was made of titanium and steel guaranteed, without "heavy metals". The resulting powder was calcined in an oven whose temperature was gradually increased to 500C, using quartz capsules.

Mineralization and dissolution: the fine powder obtained after calcination, was placed in an acid and oxidizing solution (0.5 ml mixture of nitric acid HNO_3, hydrofluoric acid HF and perchloric acid $ClHO_4$) and then heated in a water bath for 24 h until the complete destruction of organic matter. Tubes that have been put to boiling were supplemented with 10 ml distilled water. This method allows the determination of the set of mineral trace elements (*Certu.*).

Quality Control and Assurance: For the determination of lead by atomic absorption spectrometer (whose characteristics are: analytical line: 283.3 nm, slit width: 0.5 nm, correction system: Zeeman effect, systematic addition of 5 ul of diluted modifier matrix 1/5), the detection limit was 0.2 ug /g and the limit of quantification is 0.3 mg /g with a standard deviation of the blanks estimated at 0.2 ug /g[18]. The standard solution used in this experiment is the PbCl2 (10 mg / l) and the calibration curve was plotted according to the values: 0.5, 2.0, 5.0, 10.0; 20.0 µg//ml.

Initial control measurements include three assays performed; the coefficient of variation is 14.4% as the maximum value. The mean average is used as the midpoint of the diagram and alert thresholds are set to + 2 and -3 from standard deviations. On the basis of a normal repeat, 95% average measurements of later series should be within the range of +2 and -2 from standard deviations (0.00049 ± 0.02088 percentage Mass.).

RESULTS

Lead levels in the plant and soil

All results are presented in (Table 1) which summarizes the different concentrations of lead absorbed by *Helianthus annus*, in the three organs (roots, leaves and stems), as well as the levels of lead in soil bordering the pavements of the two roads concerned by this study.

Table 1

Descriptive statistics on levels of lead (ug/g) in the plant and soil

		N	Mean	Median	Min	Max	1er Q	3ème Q	S.D
Roots		20	17.97	17.97	17.97	17.97	17.97	17.97	17.97
Stems		20	8.33	8.33	8.33	8.33	8.33	8.33	8.33
Leaves		20	7.36	7.36	7.36	7.36	7.36	7.36	7.36
Total		20	35.69	35.69	35.69	35.69	35.69	35.69	35.69
witness	Roots	03	3.40	3.40	3.40	3.40	3.40	3.40	3.40
	Stems	03	4.74	4.74	4.74	4.74	4.74	4.74	4.74
	Leaves	03	1.54	1.54	1.54	1.54	1.54	1.54	1.54
	total	03	9.82	9.82	9.82	9.82	9.82	9.82	9.82
Norms (plants)		5	1.38	-	0.01	2.50	-	-	1.24
Soil		20	1714.39	1688.17	845.60	2712.00	1326.30	2082.00	512.62
(soil not contaminated		-	9 – 50 100	-	-	-	-	-	-

Data from table 1, reveal a strong contamination of the soil by lead (1714.39 ± 512.62 ug/g) with a remarkable variability between different sampling points; hence the recorded values of lead in the plant *Helianthus annus* (35.69±37,24 ug/g) greatly exceeded the control values (2.58 ± 0.16 ug/g) and standard values (1.38 ± 1.24 ug/g). Larger values were observed in the roots (17.97±10.70 ug/g), concentrations were lower in stems and leaves whose recorded values were respectively: 8.33±4.65 ug/g and 7.36±4.81 ug/g. Lead is mainly absorbed by root hairs and stored in the cell walls, which explains the high rates in roots (*Hughes, M. K. et al.*).

However, (*Jean L., et al.*) found much more Pb in the 0-20 cm layer than in deeper soil layers, where the roots are more abundant. The presence of metals in different parts of the plant indicates that there is an accumulation but also a translocation to aerial parts. However, in the case of soils contaminated by heavy metals, it is admitted that a relatively large proportion of Cu, for example, can accumulate in the roots without an increase of the concentration in aerial parts (*Martirnelli I.*). Therefore, the assessment of bioavailability of Cu concentrations by analyzing the roots in addition to the aerial parts is more relevant fot the manner in which lead reacts with organic acids in soil solution according to The following reactions (*Marie C.*):

$$R\text{-}COOH + Pb^{2+} \text{ ® } R\text{-}COOPb^{+} + H^{+} \text{ ou } R\text{-}OH + Pb^{2+} \text{ ® } R\text{-}OPb^{+} + H^{+}$$

With R-COOH: carboxylic acid, R-OH alcohol or phenol (organic ligands).

Moreover; (*Kabata P, Alina H. P.*) found that the lead threshold values of plants grown in non-contaminated areas, ranged from 0.05 to 3.0 mg g-1 during the period 1970 to 1980, while the average lead content for cereals from different countries appeared to vary considerably from 0.01 to 2.28 mg g^{-1}, in contrast, it was 2.1µg g^{-1} in the forages and 2.5µg g^{-1} for grasses.

Effect of soil physicochemical factors on lead absorption by the plant

The transfer of Pb to the plant is certainly conditioned by the physicochemical parameters of soil, including pH, CEC, rate of clay and the plant itself. Similar results are shown by (*Pose-Juan, E. et al.*) for metalaxyl; they found that the amount of dissolved metalaxyl depends mainly on the interaction of three factors: soil pH, its potential acidity, and the cation exchange capacity. The surfactants and soil have a synergic effect on the overall retention of metalaxyl. This should be considered in the estimation of metalaxyl mobility in agricultural soils.

Effect of soil pH

This correlation is illustrated in Fig.1, where a negative relationship is observed; with a correlation coefficient r = - 0.37***. Furthermore, analysis of variance indicated a significant effect of pH on plant's lead ($p < 0.01$).

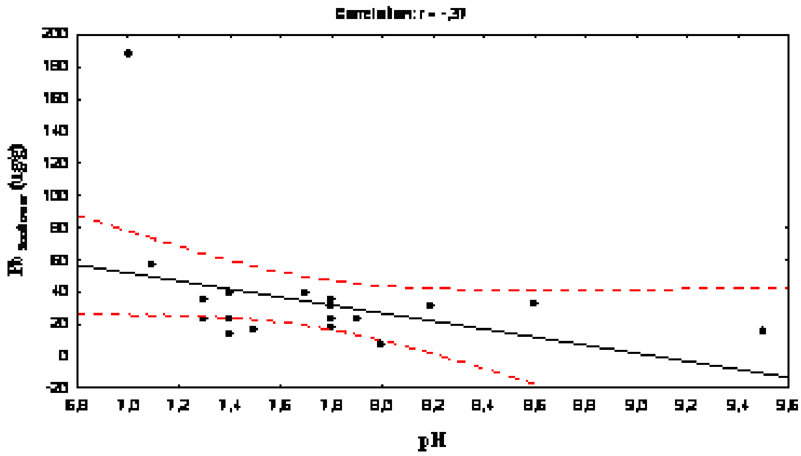

Fig. 1 - Correlation between the pH of the rhizosphere and accumulation of lead by *Helianthus annus*

It was observed that at low pH, metal cations are more available for absorption by the plant. Different interpretations have been advanced to explain the influence of soil pH on the accumulation of lead. (*Hinsinger P.*) found that Cd, Cu, Hg, Ni, Pb and Zn are strongly absorbed by the roots at pH <5.5, so it is possible to increase the phytoextraction by adding an acidic agent to a contaminated soil. On a physiological level (*Jean L.*) it can be noted that the pH can be modified by the exchange activity of roots: to maintain electrical neutrality, the plant has a compositing effect of ion uptake by a charge release at root level. When they take more cations than anions, roots compensate by releasing in the rhizosphere an excess of positive charges in the form of protons, resulting in acidification of the environment. (*Salt D.E. et al.*) showed that the increase in pH favors protons elimination from aqueous complexes and surface functional groups of the solid phases. Due to the decrease of protons, competition between protons and metal cations is lower and therefore repulsions are decreased which then accelerates the formation of new phases. Thus, the solubility of metal cations decreases with increasing pH. For the plant to maintain an electrostatic equilibrium and a constant pH in root cells; cation samples are exactly compensated by the release of H^+ ions or the removal of anions; in contrast, the anion samples are compensated by the release of OH^-, HCO^{3-} ions or by the removal of cations (*Salt D.E. et al.; Straczek A.*).

Effect of CEC

The cation exchange capacity of soil is positively correlated with concentrations of lead in the plant (r = 0.75 **) as shown in Fig 2. The Anova revealed a significant effect of this parameter (p <0.01). The cation exchange capacity is interdependent and determines much of the retained amounts of pollutants, including adsorption of pollutants that can be represented by the CEC, which is the maximum amount of cations that the soil can hold by physico-chemical adsorption. However, the root cation exchange capacity (CECr) is defined as the number of binding sites for cations (anionic groups) localized on the cell walls.

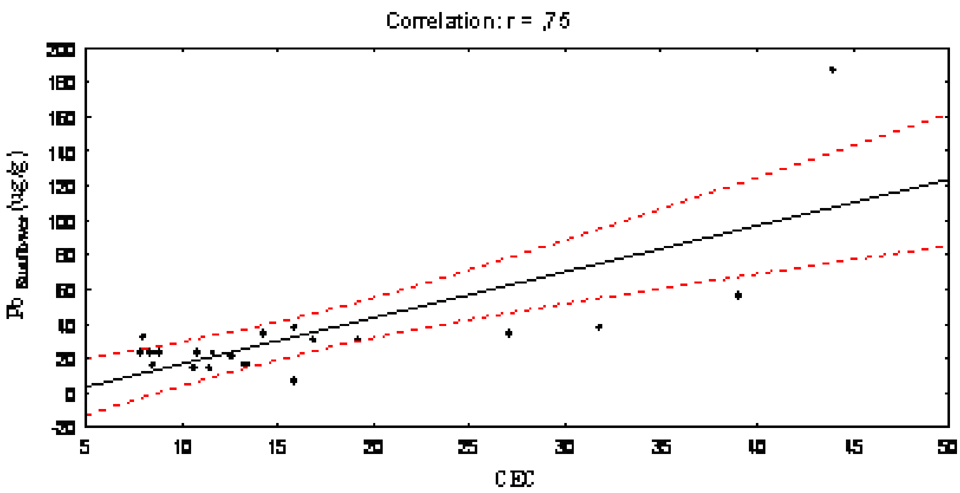

Fig. 2 - Correlation between the CEC and the accumulation of lead *Helianthus annus*

The increase in CEC gives to soil a chance for longer fertility. The CEC increase is also important for contaminants retention (*Pateiro-Moure, M. et al.*) found that the ratios of the variables measured between soil deposits and soils, it was found a significant correlation between the increase of PQ in soil deposits and their increase in CEC ($r = 0.826$, $p = 0.43$, $n = 6$).

Also (*Allan DL and Jarrell WM.*) showed that CEC decreases gradually as the external pH decreases. Elements present in large quantities in the soil solution, such as calcium or magnesium, are transferred to the soil-root interface by a mass flow which is often greater than the demand (*Lorenz S.E. et al.*). These ions can then accumulate in the rhizosphere and lead in calcareous soils to precipitates of calcium carbonate around the roots. Conversely, the elements present in small amounts in the soil solution, as is typically the case of trace metals (Pb, Zn, Cd, etc. ...), are also transferred by the mass flux, but are insufficiently compared to the removal of the plant (*Mico C. et al.*). Therefore, this leads to a decrease in the concentration of metals such as Zn and Cd in soil solution near the roots (*Lorenz S.E. et al.*). This reduction creates a concentration gradient between the soil (mineral, soil solution) and roots and a diffusive transfer of these elements to the roots. (*Diehl, K. H. et al.*) investigated the accumulation of Co in *Helianthus annus* growing in a soil contaminated by this element. The results showed a significant correlation ($r = 0.98$) between the contamination of the plant and increasing soil CEC; in contrast, no relationship between this contamination and organic carbon was found.

Effect of clays

Recall that the clays are characterized by a non-neutral electrical surface, which determines their ability to exchange ions. These minerals have two types of charge. The first, a negative charge, is structural and can not be changed. It is linked to Al^{+3}, Si^{+4} + or Mg^{+2}, Fe^{+2}, Al^{+3} substitutions, in the layers of clay. The second, related to chemical reactions that occur on the surface of minerals, is a surface charge variable depending on the pH of the medium. For a low pH, the majority of H^{+} ions binding to clay more than the OH^{-}. The result is an overall positive charge and the clay is characterized by an anion exchange capacity. For high pH, the dominant OH- lead to an opposite phenomenon, and clay develops a CEC.
A positive relationship exists between lead absorption by the plant, and the rate of clays; the more this rate is important, more the CEC is important, more the plant has a high accumulative power. Fig. 3 shows this relationship ($r = 0.37$ **). Analysis of variance showed a highly significant effect on the correlation ($p < 0.01$).

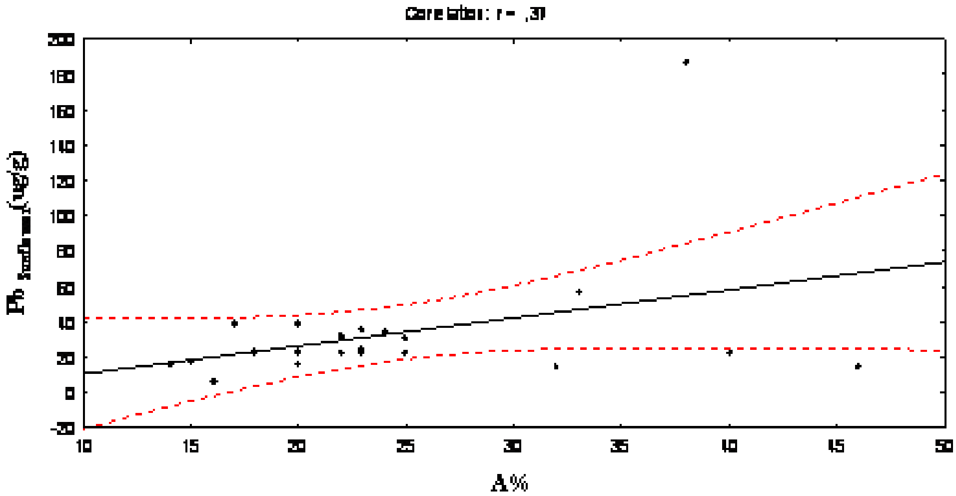

Fig. 3 - Correlation between the rate of clays (%) and the accumulation of lead for *Helianthus annus*

Indeed, the higher the clay, the higher the CEC and the higher the plant absorbs metal; in this case, lead transfer to the plant is passive. Organic matter and clays play an important role in the adsorption of lead by the plant. The trace elements show a high affinity for humic substances with which they form stable humic clay complexes, possibly soluble. This explains the abundance of trace elements on the surface especially in the presence of organic matter where trace elements are absorbed specifically by iron oxides and manganese oxides (*Baize D.*). The lead will be available at the surface in this way.

Correlation: Pb $_{Sunflower}$- Pb $_{soil}$

The correlation Pb plant - Pb soil is shown in Fig.4. This highly significant correlation (r = 0.1 **) may explain the high bioavailability of Pb to be taken by the plant (particularly by roots). The more the lead is bioavailable in the soil; the more it is easily absorbed by the plant. The best accumulation was recorded in the roots (r = 0.17**).

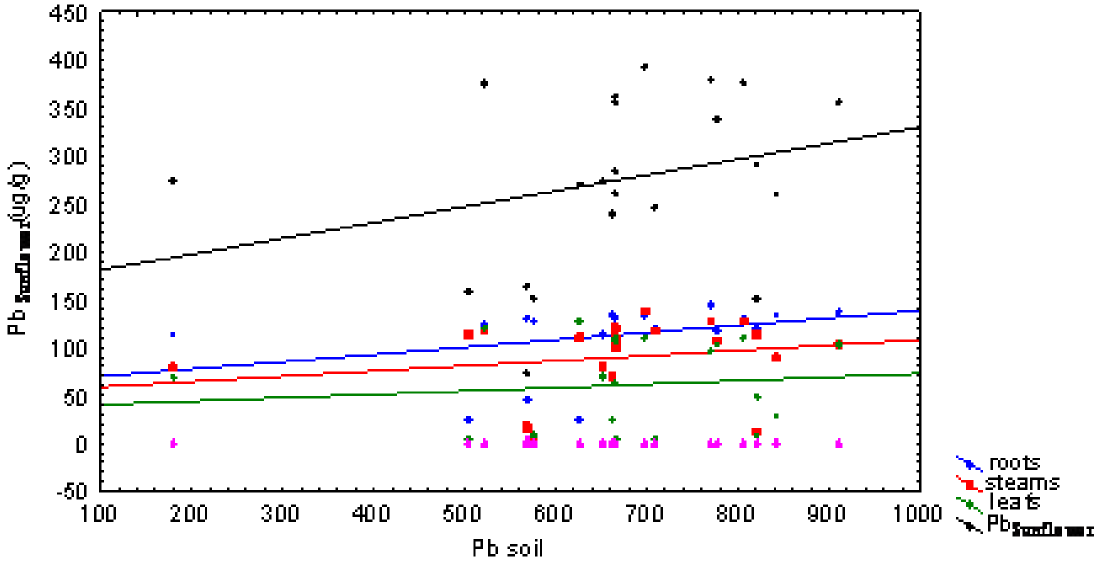

Fig. 4 - Correlation Pb $_{soil}$ – Pb *Helianthus annus*

Equations :

$$y(Pb_{Sunflower}) = 0,0089x+18,254,\ R^2=0,01 \quad (2)$$

$$y\ (Pb_{roots}) = 0,0114x+3,057,\ R^2=0,03 \quad (3)$$

$$y\ (Pb_{steams}) = 0,0005x+7,4662,\ R^2=0,0027 \quad (4)$$

$$y(Pb_{leafs}) = 0,0024x+10,932,\ R^2=0,05 \quad (5)$$

In the case of *Helianthus annus* (Fig. 5) shows that about 2% of lead in soil is absorbed by the plant, without any phytotoxic symptoms. In this case, several studies describe the toxic effects of lead on the biological processes of the plant, such as photosynthesis, mitosis and water absorption, but toxic symptoms in plants are not very accurate; it was not easy to establish that the concentrations of lead are toxic to vital processes in plants. (*Hagemeyer J.*) found that the particles of Pb in soils are rapidly converted into lead compounds soluble in water, easily available to plants.

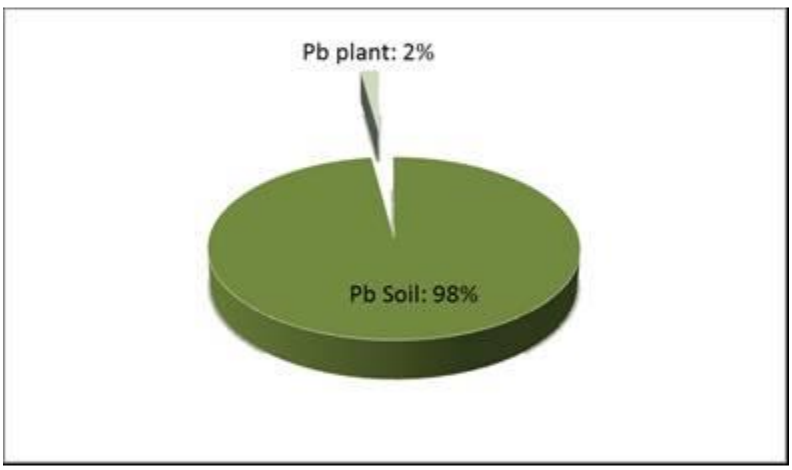

Fig. 5 - Percentage accumulation of lead in *Helianthus annus*

(*Doelman, P. and Haanstra, L.*) have shown that the accumulation of lead in surface soils has a great ecological importance because this metal is known to affect greatly the biological activity of soil which means its absorption by plants. The soil is a reservoir of metals for plants. This leads to consider that the totality of metals is also available for the plant. The concentrations of Cd, Zn, and Pb in the straw and wheat grain are directly dependent on those of the ground (*Prasad, M.N.V.)*.

CONCLUSIONS

The objective of this work was to show that the common barley *Helianthus annus* has the potential to effectively decontaminate soil, located near a high pressure traffic road, contaminated with lead. The experimental protocol consisted in determining the concentrations of this metal, in 20 soil samples and 60 samples of *Helianthus annus* (roots, stems and leaves). The results showed that the surface horizons of road soils were highly contaminated by lead (1714.39 ± 512.62 ug/g) and exceeded the international standards. However, 2% of this value can be absorbed by *Helianthus annus* that is 36.28 ± 14.90 ug/g. Larger values were observed in roots with 17.97±32.79 ug/g; while, the values observed in the stems and leaves were, respectively: 8.33±4.65 ug/g and 7.36±4.81 ug/g. This rate of annual accumulation remains interesting if the Algerian government sets the regulations for total halt to the sale of leaded gasoline. The plant Pb's accumulation is influenced by physicochemical parameters of soil such as soil pH, CEC and the rate of clays. At low pH, lead is available to be absorbed by the plant (r = -0,37 **) while CEC and the rate of soil clays are positively correlated with levels of lead in the plant (r = 0.80** and r = 0.37**, respectively). The transfer of the lead to the plant is done passively. Model the fate of pollutants from a contaminated site, to assess risks and hence choosing a remediation strategy.

The effects of heavy metals on local ecosystems and the mechanisms of their transfer, from soil to plants, are still not well understood. It is therefore very difficult to predict their long-term effects, to model the fate of pollutants from a contaminated site, to assess risks and hence choose a remediation strategy.

However, plants grown for consumption are a potential hazard to public health because of a possible accumulation of these elements in their tissues. Risks associated with contaminated soils are in fact closely related to the bioavailability of the metallic elements. Once absorbed, these metallic elements can return to the soil (biogeochemical cycles). Moreover, these contaminated plants, cannot and should not be used as human or animal food. Unfortunately, there is no concern whether the highly accumulative plants are used or not for certain animals and thus generating a contamination of the food chain. How to control the spread then? Researches should be conducted in this area. It is at this stage that checks should be performed. Studies on these phenomena are still not developed but seem promising.

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RISK ASSESSMENT OF CEREAL FUNGAL INFECTION IN THE SUPPLY CHAIN OF FARMING ENTERPRISES OF UKRAINE
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ОЦІНКА РИЗИКУ ІНФІКОВАНОСТІ ЗЕРНА ЗЛАКОВИХ КУЛЬТУР ПАТОГЕННИМИ ГРИБАМИ В ПОСТАЧАЛЬНОМУ ЛАНЦЮГУ СІЛЬСЬКОГОСПОДАРСЬКИХ ГОСПОДАРСТВ УКРАЇНИ

Pinchuk N. I, PhD. *[1)], Kharytonov M.M.,PhD, DSc [2)], Asst. Prof., Ph.D. Mykolenko S. Y. [2)] Vasylyeva T.L., MD, PhD, DSc [3]

[1)] Institute of Grain Crops of UAAS, Dnipropetrovsk, Ukraine;
[2)]Dnipropetrovsk State Agrarian-Economic University, Dnipropetrovsk, Ukraine;
[3)]Texas Tech University Health Science Center, Amarillo, TX, 79121, USA
Tel: 380664844773; E-mail: ecohous@ukr.net

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ABSTRACTS

According to environmental monitoring protocol, the risk of development of diseases for maize and winter wheat had been assessed. The effect of weather conditions on phytosanitary status of grain crops was taken into consideration. The results showed that in conditions of unsteady variation of humidity cereal crops require constant phytopathological control with identification of the affected areas, separated harvesting and storage areas for grains coming from infected fields, determination of the number of infected grains, and formation of separated parties according to the rate of infection for specific purposes.

There are several measures of reduction of the damage for cereals' head blights occurring after *Fusarium* infection and prevention of toxins accumulation in grain: a) minimization of the time for wheat seeding after other cereals; b) timely cleaning of the fields, which are used for the winter crops seeding from the straw and other plant residues; c) using of healthy seeding material d) treatment of the crops at the beginning of flowering period; e) drying of the grain; f) other agro - engineering and management measures that increase plant resistance to the disease.

ТЕЗИ

Розвиток хвороб кукурудзи та озимої пшениці був оцінений у відповідності з даними екологічного моніторингу. Ефект впливу погодних умов на фітосанітарний статус зернових культур був зафіксований. Результати досліджень свідчать, що посіви зернових культур в умовах нестійкого зволоження вимагають проведення фітопатологічного контролю над розвитком фузаріозу колоса, виявлення уражених площ, окремий збір врожаю і зберігання партій зерна з цих полів, визначення кількості ураженого зерна, відповідного формування партій за призначенням. Існує кілька заходів зниження ураженості фузаріозом колосу і накопичення токсинів у зерні: а) скорочення до мінімуму розміщення пшениці після колосових попередників і кукурудзи; б) своєчасне очищення полів, що йдуть під озимі культури від соломи та інших післяжнивних залишків; в)використання здорових насіння; г) обробка посівів на початку цвітіння; д)сушіння зерна; е)інші агротехнічні та організаційно-господарські заходи, що підвищують стійкість рослин до захворювання

INTRODUCTION

The agro-industrial is one of the most important sectors of Ukrainian economy. There are two main models of logistical organization of the agrarian business in Ukraine: corporate and cooperative (*Velychko, 2015*). Although wheat is the main cereal crop, they also grow maize, barley and rye in the country (*Kharytonov et al, 2009*). In order to achieve the high level of grain quality, controlling of grain fungal contamination at all stages of production process is required.

Global warming and climate changes may affect the global distribution of mycotoxinogenic fungi and their mycotoxins (*Magan et al, 2011; Paterson and Lima, 2010*). The formation of mycotoxins in food chain is considered to be a global problem (*Shuman, E.K., 2010*). Meantime, in certain geographical areas, some mycotoxins occur more frequently than others (*Leeps et al. 1999; Van der Merwe, et al., 1965; Wagacha and Muthomi, 2008*).

In most European countries vomitoxin, ochratoxin, zearalenone are detected in food raw materials, such as maize, sorghum, barely, wheat, rice meal, cotton seed meal, groundnuts and other legumes, on the regular basis. Some field fungi, such as the *Fusarium spp*., are responsible for mycotoxins accumulation in the crops while growing on the fields, when other "storage fungi", such as the *Aspergillus spp*. and *Penicillium spp*., produce mycotoxins that accumulate in the crops after harvesting (*Filtenborg et al, 1996*). *Fusarium* fungi development have been traditionally associated with temperature and climatic conditions, since they are able to grow and produce toxins at lower temperatures than, for example, the *Aspergillus spp*. (*Paterson and Lima, 2010; Placinta et al, 1999*).

The most important, from the standpoint of toxicology, are *Fusarium* mycotoxins such as trichothecenes, including deoxynivalenol (DON) and T-2 toxin (T-2), zearalenone (ZEN) and fumonisin B1 (FB1). *Fusarium* mycotoxins have various acute and chronic effects on human health (*Maresca, M., 2013; Zain, M.E., 2011*). In a certain environmental, socio-economical and food production conditions especially in developing countries, the risk for food-associated mycotoxin exposure is higher (Wagacha and Muthomi, 2008). Besides the high risk of the acute mycotoxicosis in developing countries, in studies performed on animals it was demonstrated that low and moderate concentrations of those mycotoxins can also influence the resistance of mammals to infectious diseases (Wild and Gong, 2010). In addition, plant metabolites of mycotoxins may also be present in feed and are known as masked mycotoxins (*De Boevre et al, 2012*).*Fusarium* fungi and infected plants may produce conjugated DON forms such as 3-AcDON (3-acetylDON), 15-AcDON and DON-3G (DON-3-glucoside).The problem of mycotoxins are not just a cause of spoilage of animal feed but also responsible for reduction of livestock productivity; they also can transfer along food chains, concentrating in meat, eggs and milk and can create certain risk for consumers health (*Akande et al, 2006*). They may be toxic to vertebrates and other animals, even in relatively low concentrations. Some fungi produce toxins that can cause autoimmune illnesses, alter hormonal balance, and have allergenic properties, while others are teratogenic, carcinogenic, and mutagenic (*Bezerra da Rocha et al,* 2014). Such mycotoxins target DNA, RNA, protein synthesis and their pro - apoptotic action may cause changes in basic physiological mechanisms, such as cells reproduction, growth and development (*Niessen L., 2007*).

More than 40 fusariotoxins were isolated and identified so far (*Areshnykov B.A., 1992*). Because of their potential hazard for livestock and humans, most countries have set maximum permitted levels for vomitoxin concentrations in cereal products. The U.S Food and Drug Administration had set permissible limit of 1 part per million (ppm, or 1000 microgram vomitoxin/kg grain), while most of countries in Europe and Asia have set a limit of 0.5 ppm (*CAST, 2003*). The most common contaminants for grains are *Fusarium* toxins, such as desoxynivalenol or vomitoxin, which are produced mainly by the fungus *F. graminearum*. Their intake with food or forage can cause poisoning for human or animal. Forages and forage raw materials were selectively checked to evaluate the rate of presence of mycotoxins, with a regular procedure developed according to existing regulations for the food safety control implemented for Ukraine and European Union. Four types of mycotoxins in grain samples taken in the farms from Northern and Southern part of Ukraine have been studied (Ochratoxin A, zearalenonzearalenon, dezoxinivalenol and T-2 toxin). Potential risk for the health of animals was determined at the rate of 26.1 % in the tests with ochratoxin A, 43.5 % with dezoxinivalenol, 21.7 % with zearalenon and T-2 toxin (*Tsvilikhovskyi et al, 2012*).

Humans could be exposed to mycotoxines directly through the cereals consumption or indirectly through the animal products (e.g. meat, milk and eggs) consumption (*CAST, 2003*). Mycotoxicoses for humans or animals had been defined as food or feed relate, non-contagious, non-transferable, and non-infectious diseases. The majority of currently known mycotoxins are grouped, according to their toxic effects. Classification according to their site of action in human or animal organism divides all of them to hemo -, hepato -, nephron -, dermato -, neuro - or immunotoxins (*Niessen, 2007*). Mycotoxins could be metabolized in liver and kidneys and also by microorganisms in digestive tract.

A number of studies had demonstrated that mycotoxins are primary etiological factors for some of respiratory and neurological disorders and have certain cancerogenic action, nephrotoxicity and hepatotoxicity (*Wagacha, and Muthomi, 2008 Wild and Gong, 2010; Zain, 2011*). Recent studies had also shown that they play the certain role in the initiation and/or recurrence of nervous system disorders. Thus, the relationship between mycotoxicosis and Alzheimer's disease was discovered recently and addressed to repeated stimulation of neuro-receptors affected by mycotoxins, (Resanovic et al, 2013).The development of more progressive technologies of cereals cultivation significantly affects the phytosanitary status of crops and leads to changes in cereals pathogenic complex (*Hitokoto et al, 1978; Lawlor and Lynch, 2005*). Due to mentioned circumstances there is a need in more detailed study of the features of pathogenic complexes and mycotoxins formation in grain, and performance of risk assessment of the potential harm for animals and humans. Within this study, evaluation was performed for northern, central and southern parts of Ukraine.

MATERIAL AND METHOD

Ukrainian agricultural lands are located within three climatic regions: – forest, forest - steppe and steppe. The forest - steppe and steppe regions of Ukraine can be characterized by unstable humidification and irregular precipitations and unstable temperature regime (*Kharytonov et al, 2009*). For the steppe region average annual precipitation rate is approximately 470 mm, but varies from one year to the other and has recorded minimums at rate of 350 mm and recorded maximums at rate of 550 mm.

Those factors directly affect the development of pathogens and impact plant resistance to diseases. Technological measure provided during cereal crops growing play major role in morphogenesis and pathogenic complexes formation.

In Ukraine the monitoring of mycotoxins in grain or the products of its processing has not been carried out. Determination of mycotoxins is sporadically conducted at some independent testing laboratories, which were accredited to ISO 17025. Another problem is the difference between norms of maximum allowable contents of mycotoxins in Ukraine and the EU (Table 1). For instance, the EC Regulation №1881/2006 determines the maximum level of aflatoxin B1 content 2.5 times lower, and the content of zearalenone 10 times lowers than is allowable in Ukraine.

Table 1

Standards for levels of grain mycotoxins in Ukraine and the EU

Mycotoxin	Country	Wheat	Maize	Barley
Aflatoxin B_1, microgram/kg	Ukraine	5	5	5
	EU	2	5	2
Ochratoxin A, microgram/kg	Ukraine	5	-	-
	EU	5	5	5
Deoxynivalenol, microgram/kg	Ukraine	500	1000	1000
	EU	1250	1750	1250
Zearalenone, microgram/kg	Ukraine	1000	1000	1000
	EU	100	200	100
Fumonisins $B_1 + B_2$, microgram/kg	Ukraine	-	-	-
	EU	-	2000	-
T-2 toxin, microgram/kg	Ukraine	100	100	100
	EU	-	-	-

*according to data of EC Regulation №1881/2006 and national Ukrainian standards

It is important to manage the risks associated with contamination of cereals and food products, to harmonize standards and to control safety along all food chain. Therefore, there is a strong need to establish a state organization, which would control food quality in accordance with world food safety systems (HACCP, GMT, GMA) in Ukraine. A detail analysis of incidents of cereal crops on the incidence of their diseases and grain quality was conducted at the research stations of the Institute of Grain Farming of UAAS and at the other farms of Dnipropetrovsk region, which are located in the Northern part of the steppe zone of Ukraine. A study was carried out to determine the types, frequency of crop fungal deceases occurring, according to the generally accepted techniques (*Kharytonov and Dudka, 2009*).

RESULTS

Usually cereal disease etiology is divided into two big groups - infectious and non-parasitic. Main features of formation of a pathogenic complex for crops in the environment are presented in table 2. For maize, fungi represent larger part of plant microflora that for other crops for instance. For cereals, infection usually, starts in the field, during the ripening cobs, and may continue to develop during harvesting, handling and storage periods. Pathogenic and saprophytic mycoflora is an important factor, which have to be considered to achieve high quality of food, fodder and seed. Usually, when humidity is high, fungi initiate the process that can be noticed as discoloration and heating of grains, appearing of mold and finally decay and intoxication of grain. The epiphytic microflora of maize is different from other cereals and normally includes fungi, which was also common for samples obtained during this study. The study of samples of maize seedlings from different regions proved that germinating seeds affected by mold, and shootings, stem and root rots, smut, fusariosis of the maize ear, should be monitored in all regions covered by this study. Additionally, for every zone there are specific types of maize diseases that should be even more carefully attended – for Steppe zone – ear bacteriosis, for Forest Steppe – stem smut, for Western regions - leaf blight and red ear rots.

Considering the grade of damage, caused by disease, it is also feasible to monitor such particular maize plant infections as nigrosporosis and mold on ears. The rate of development of harmful microorganisms can vary a lot from region to region and for different types of farms within the region. Basically in the same environment with same uncontrollable factors (weather and climatic conditions, pathogenic organisms presented in the environment) the difference in the pathogenic microflora development pathways was caused mainly by anthropogenic factors, for instance using of different quality seeds, seeding of sensitive hybrids, using of inappropriate agricultural techniques and deteriorated equipment.

Indicators of development of malicious organisms may differ significantly not only within their range, but also within a specific region or sector. During all years when this research was held a phytopathological examination of the reaped grain always showed the presence of field and mold microflora (after storage). Twenty six species of fungi which belong to 18 orders were typically occurring in examined batches.
Obligate parasites *Ustilago maydis* and *Sorosporium reilianum* were most frequently occurring harmful microorganisms found.

Table 2

Food chain and pathogenic fungi impacts on grain quality

Components of pathological process	**Factors regulating the development of grain crops diseases**	**Measures to control**	**Target regulation**
Plant	Genetic resistance	Crops varieties genetic resistance	Obligate parasites, facultative – partially
	Acquired resistance	Immunization of plants with physical, chemical and biological means	Prevalence of parasites
	Viability	Measures of resilience and compensatory ability of plants	Facultative parasites
Pathogen	Virulence	Selection of plant varieties with appropriate resistance genes	Obligate parasites
	Infectious load	The crop rotation. Elimination of contagious fundamentals of physical, chemical, biological methods	All obligate and facultative parasites
Environment	Weather conditions	Irrigation and other agricultural methods avoid plant stress to water and temperature limitations	
	Soil	Tillage, application of fertilizers, ameliorants	
	Biotic	The choice of the precursor, the use of antagonists and their metabolites. Pest control	
	Nutrition regime	Fertilization, irrigation, preventing the emergence of competing organisms	
Human and animal	Analytical control	Control of toxin content in food products	
	Technological Measures	The technology of harvesting and storage of crops Physical, chemical and biological treatment of grain	

It was found that bubble smut damage of ears occurred for 5 – 8 % of plants during years when study was held and up to 1 % had smut damage of stem (table 3), but has to be mention that their presence does not affect grain storage while *Nigrospora oryzae* and *Rhizopus maydis* can affect grain mold resistance.That's why, they can be a source of contagious basis of appropriate types of seedlings and rot of ears. *Fusarium* fungi behave differently. They accompany the plant throughout the growing season of maize crop, causing rotting of sprouts, roots and stems of adult plants and cobs. The infection can penetrate inside the grains. The rot continues to develop during storage of grain. Infection rate can be significantly increased if during ripening of cobs it is raining a lot. The share of maize affected by these parasites can reach 100 %, and the incidence of grains with symptoms of internal infection is 7 – 15 %. *Fusarium root rot*, and diseases of the cob were found to be the most frequently occuring in the steppe zone of Ukraine. The results of the 5 year research in the northern part of Dnipropetrovs'k region steppe zone indicate that from 10 to 48.1% of the cob were infected. Contamination of winter wheat by *Fusarium* fungi results in reduction of grain yield and deterioration of its quality. *Fusarium* affected grain, made it to lose its shine and hardness, whitish, shriveled, wrinkled, with a deep groove, sometimes with a tinge of cobwebby mycelium of the fungus and non-viable embryo. In infected grains fungi break down protein, starch granules and other cells, accumulate mycotoxins. Protein yield losses for winter wheat from fungus disease were estimated at rate 17.6 - 38.3 %, maize ? of 11.9 - 22.3 % (*Kharytonov and Dudka, 2009; Leeps et al. 1999*). For reducing such losses, it is necessary to consider hydrothermal conditions during all crop growing period, to prevent further losses during storage of harvest.

Table 3

Harmfulness of most spread diseases depending on the area of sowing of maize

Disease	Steppe zone	Forest-Steppe zone		Forest zone
		western	central and eastern	
Musty seeds and seedlings	+++	++	++	++
Root rotof seedlings	++	++	++	+
Stem rot	+++	+++	+++	++
Bubble smut	+++	+++	+++	++
Cephalosporin	+			
Stem smut	++	+++	+++	+
Helminthosporiu*m* leaf	+	+++	++	++
Blight		+		
Viruses diseases	+	+	+	+
Fusarium cob	+++	+++	+++	++
Red rot of ears	+	+++	+	+
Nigrospora cobs rot	++	++	++	+
Mouldy cobs	++	++	++	++
Mouldy cobs	++	+	+	+
Bacteriosis ears	+++	++	+++	++
Damage of ears	++	++	++	+

Note. +++ – annual presence of foci exceeding the economic threshold of harmfulness;
++ is the presence of foci exceeding economic thresholds of harmfulness in some years;
+ – excess of economic thresholds of harmfulness occasionally and only on some fields.

Phytopathological evaluation shows that in the Steppe zone during storage of untreated crops the remains of infectious of fungi from orders *Fusarium, Penicillium* and *Cladosporium* are present in most of cases.

After six months of storage, the rate of infection occurring (depending on years of research) of *Fusarium rot* or *Penicillinum cladosporiosis* varied from 10.3 to 55.3% of the grains.

Overall share of other fungal diseases has not exceeded 1.3%. The pathogens caused the mold growth and rotting of infected crops after sowing of maize in a field and more noticeable before storage than after drying where *Fusarium* fungi always dominating (Fig.1).

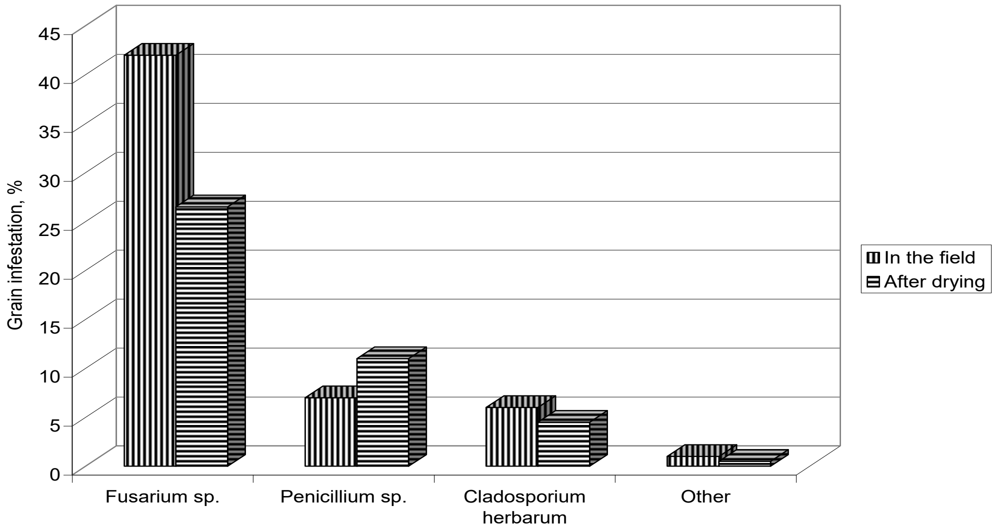

Fig.1 - Maize grain infection in field and after drying

The strong positive correlation (r = 0,873) was observed only between the growth of molds and sprouts for grains contaminated with two types of fungi: *Cladosporium herbarum, Cladosporium*. These pathogenic organisms compete for nutrients but do not interfere other organisms growth. Moreover, it had a significant impact on the development of other diseases. As shown by statistical analysis, there is a close inverse relationship between the presence of *Cladosporium herbarum* in crop grains and appearing of *Fusarium seedling rots* (r = 0.985), and *Penicillinum* (r = 0.737), and other (r = 0.449) types of molding in the field. Mold growth in field conditions with *Penicillium sp.* (r =-0,472 respectively) was competitive with the other pathogens. At different stages of production and storage of seeds after sowing in the field can be traced the succession of the species composition of fungi. Immediately after harvest fusaria were present at most (88.7%) of grains of maize.

After drying and sorting, the contamination of grains with microorganisms has decreased by 6.8 times and continued to decline during the five-year storage from 13.0% to 2.7%. The number of other epiphytes also dramatically decreased. As it was observed, after a year of storage, the rate of infection with *Penicillium* fungi had been significantly lower (Fig.2).

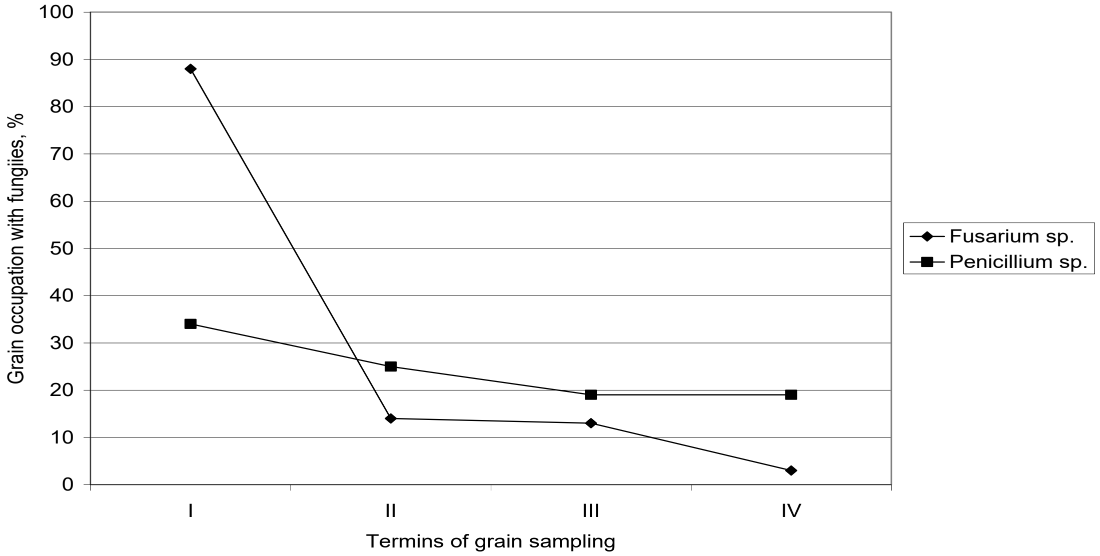

Fig. 2 - Maize grain occupation with two fungus, %

Comments: I-in the field; II-before storage; III-after 1 year of storage; IV- after 5 year of storage.

Intensive development of fungi and saprophytes happens when storage conditions are not supported on the required level, and particularly, with increase of humidity of the storage. The development of mildew contributes to cracks in the casings of grains, mechanical injury, *Fusarium* population, and other diseases.

Study of composition of the mycoflora species of the grain showed that among pathogen mold at various stages of storage there are fungi of the 7 genera: *Penicillium, Cladosporium, Aspergillus, Alternaria, Trichothecium, Botrytis, Trichoderma*. Dominance of a species of the fungus was visually determined by the color of the plaque on the weevil. In our conditions, the development of the following types of mold was founded more often:

- penicilina (*Penicillium glaucum, P. martensis*, etc.), plaque in the form of particles of bluish or greenish colors;
- cladosporiosis (*Cladosporium herbarum*), plaque dark brown-olive color;
- aspergilla (*Aspergillus flavus*), plaque light yellow;
- black (*Alternaria tenius*), patina black velvet oil;
- pink (*Trichothecium roseum*), felt pieces pink;
- gray (*Botrytis cinerea*), gray, dirty gray haze.

Proper storage suspends the development of seed microflora. In case of storage conditions violation fungi may restore their activity. At high humid environment, those fungi and other saprophytic microflora (bacteria, fungi of the genera of *Mucor, Saccharomyces*, etc.) lead to spontaneous heating and deterioration of the grain. Therefore, under the terms of epiphitoties development of maize smut disease, the presence of the teliospores maydis *Ustilago* and *Sorosporium reilianum* at the time of storage grain does not affect its properties. The seeds can be a source of contagious bases of these diseases.

Phytopathological examination of selected samples of soft winter wheat showed that, depending on the species, and other growing conditions, fungi (mainly of the genera *Fusarium, Bipolaris, Alternaria*) were inhabited from 36 to 100% grains. The occupancy rate of grain mycoflora correlated with rainfall during the growing season: earing – harvesting. According to local weather stations of Dnipropetrovs'k region, in the south area (zone 1) during this period fell 93.0 mm, in the center (zone II) – 195.7 mm, in the north (zone III) of 202.7 mm of rainfall. Accordingly, the low occupancy rate of grain mycoflora was in samples from farms in the first zone. In the grain samples, selected from seven fields in the south, increased to 54.0% was determined only in two cases. The growing fungi were present in 78.5 to 100% of wheat grain samples from the other areas (Fig.3).

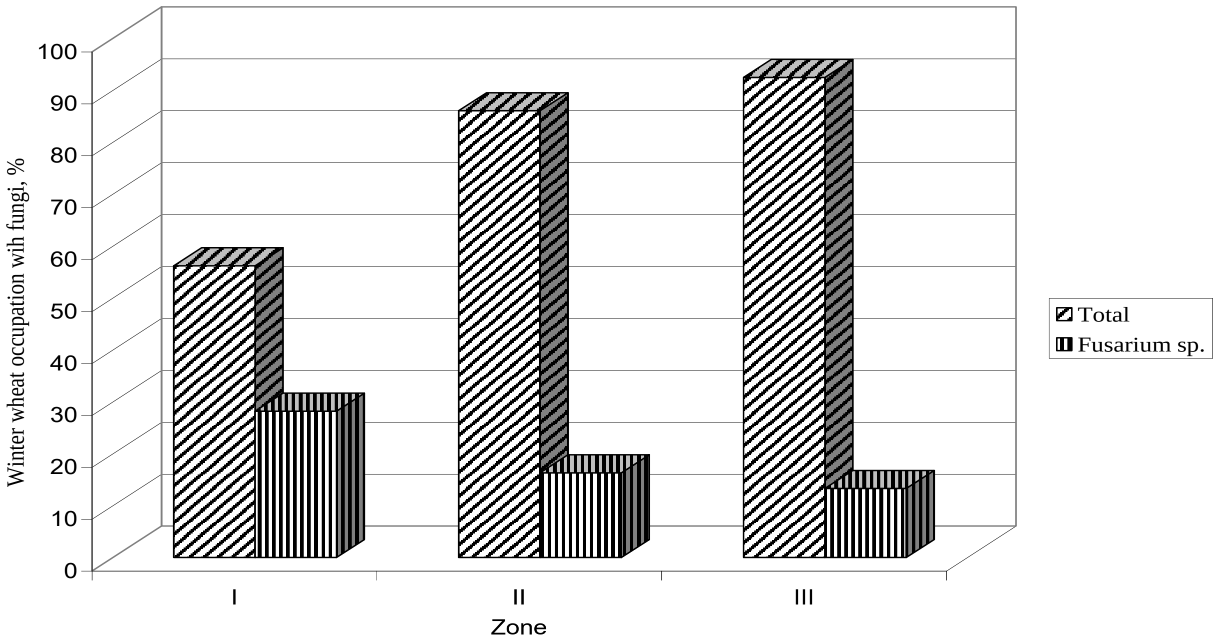

Fig. 3 - Winter wheat grain occupation by fungus, %

Comments: rainfall zone I- 93.0 mm; II-195.7mm; III-202.7mm;

Fungi of the genus *Fusarium* (*F. graminearum, F. moniliforme, F. sporotrichiella, F. culmorum, F. avenaceum*) were identified 4.8-39.6% of grains. In the total complex of seed mycoflora, the proportion of fungi of the genus generally ranged from 5.8 to 25.7 %. Meanwhile, in the two samples its level was in the range of 55.3-87.0 %. The grain occupancy by fungi *Fusarium graminearum* was low (5.0%). The vomitoxin (desoxynivalenol) trace presence (500-1000 microgram/kg) was found in 60% of cases after analysis of 20 samples of grain, which were taken on the basis of high grain occupancy by fungi (*Leeps P.E. et al., 1999*). According to the accepted standards in Ukraine, in soft wheat grain for ordinary food or grain for feed purpose mycotoxin presence cannot be more than 500 or 2000 microgram/kg respectively (*Areshnykov, 1992; Tsvilikhovskyi et al., 2012*). It is necessary to admit that vomitoxin is the most commonly detected *Fusarium* mycotoxin in Ukrainian steppe zone.

It is necessary to emphasize that the economic impacts of mycotoxins on animal production are generally considered to be mainly due to losses related to direct effects on animal health and trade losses related to grain rejection (*Wu, 2007*). Meantime, the indirect influence of mycotoxins on animal health, by enhancing other infectious diseases, should also be taken into account. These effects, as reviewed here, might occur even in case of low or moderate mycotoxin contamination levels of feed. Some publications showed that these effects can even occur at the contamination levels which are below the European standards, suggesting that the legislation may not cover all deleterious health effects of mycotoxins (*Streit et al, 2013*). In our case, analyzed 60% of grain samples are suitable for animal feeding. There is another suggestion for grain with 500-1000 microgram/kg toxin content: it should be mixed with less polluted grain for reducing the micotoxin content to allowable levels before further transfer in food chain.

Certain herbs, spices and essential oils contain naturally occurring antifungal substances that may exert a protective effect at normal usage levels. The mustard, green garlic, cinnamon bark and hops inhibit mould growth, whereas peppers, cloves, thyme and green tea inhibited only toxin production (*Filtenborg et al, 1996*). Other substances for example antifungal antibiotic natamycin (pimaricin) have strong antimycotic properties but are only permitted for limited use in USA. It was reported that 0.0005% (5ppm) natamycin delayed the growth of seven mycotoxinogenic species for 5 to 21 days (*Azzouz and Bullerman, 1982*).

Another way is usage of probiotics for the prevention or partial remediation of the damage grains induced by mycotoxins. It is known that certain probiotic strains can bind and remove mycotoxins from liquid media (*Vinderola and Ritieni, 2015*). Eukaryotic cell cultures showed that the complex probiotic-mycotoxin is less adhesive to enterocytes than the probiotic alone. It might favor the elimination of this complex from the gut through feces. Probiotics were also shown to be capable to restore some functions of the epithelial cells after mycotoxins exposure damage.

CONCLUSIONS

Using the tools of environment monitoring, the development of fungal diseases of maize and winter wheat has been assessed. The effect of weather conditions on phytosanitary status of grain crops was addressed. The analysis of special features of formation of pathogenic complexes in the crops was made. The results showed that in the conditions of unstable humidification the winter wheat requires phytopathological control over the development of Fusarium head blight.That includes identification of the affected areas, separation of harvesting and storage of grain lots with those fields, the determination of the number of infected grains corresponding to the formation of their parts. Reduction of damage done by Fusarium to the head blight of wheat and the accumulation of toxins in grain may be achived by timely cleaning of the fields from straw and other plant residues, the usage of healthy seeds, treatment of the crops at the beginning of flowering, drying of grain and other agro-technical and managment activities that increase cereals resistance to fungal diseases.

ACKNOWLEDGEMENT

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THE RESEARCH OF DOWNDRAFT GAS PRODUCER HEAT PRODUCTIVITY ON STRAW
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ДОСЛІДЖЕННЯ ТЕПЛОПРОДУКТИВНОСТІ ПРЯМОПОТОКОВОГО ГАЗОГЕНЕРАТОРА НА СОЛОМІ

S.Lect. Ph.D. Tsyvenkova N.M.*[1)], Teach. Asst. Grad.Stud. Golubenko A.A.[1)], Prof. D.Sc. Kukharets S.M.[1)], Asst. Prof. Ph.D. Biletsky V.R.[2)]
[1)] Mechanics and agroecosystems engineering department, Zhytomyr national agroecological university, [2)] Forestry faculty, Zhytomyr national agroecological university
tel: +380503138903, e-mail: thyvenkova@yandex.ru

Keywords: *heat productivity, gas producer, gas composition, tuyer circle diameter, gas blowing mode*

ABSTRACT
A connection between gas producer chamber design parameters and installation exploitation operational modes as well as fuel parameters, was studied. A multi-factor experiment that connects this parameters,was planed and installation tuning characteristics were built based on results. Using these results, under different fuel parameters, allows to gain maximum productivity under given conditions. Some recommended fuel parameters for effective gasification are substantiated also based on experimental data.

REZUME
Досліджено зв'язок між конструктивними параметрами камери газоутворення, технологічними режимами експлуатації установки та характеристиками палива, що планується до використання. Спланований багатофакторний експеримент, який пов'язує ці параметри, за його результатами побудовані регулювальні характеристики установки. Використання отриманих результатів дозволяє при різних параметрах палива отримувати максимально можливу за даних умов енергоефективність. За результатами експерименту також обґрунтовано рекомендовані параметри паливної маси для ефективної її газифікації.

INTRODUCTION
The gas producing process and its stability depend greatly on technical and operational parameters of gas producer installation and physical and chemical characteristics of straw (*Basu, 2013; Higman and van der Burgt, 2008; Knoef, 2012; Kollerov, 1950; Muller et al., 2016*). That is why raw material preliminary preparation for gasifying (*Golub et al., 2015; Kolerov, 1950; Mezin, 1948*) and coordination between gas producer design parameters and gas blowing mode are topical questions (*Kolerov, 1950;Mezin, 1941;Los et al., 2014;Tsyvenkova and Golubenko, 2014*). That will also allow us to gasify different types of biomass like corn stalks and cobs, sunflower chaff, Miscantus, wood etc. without big changes in design of the gas producer optimized for straw, gaining maximized heat productivity from equipment, depending on raw material.

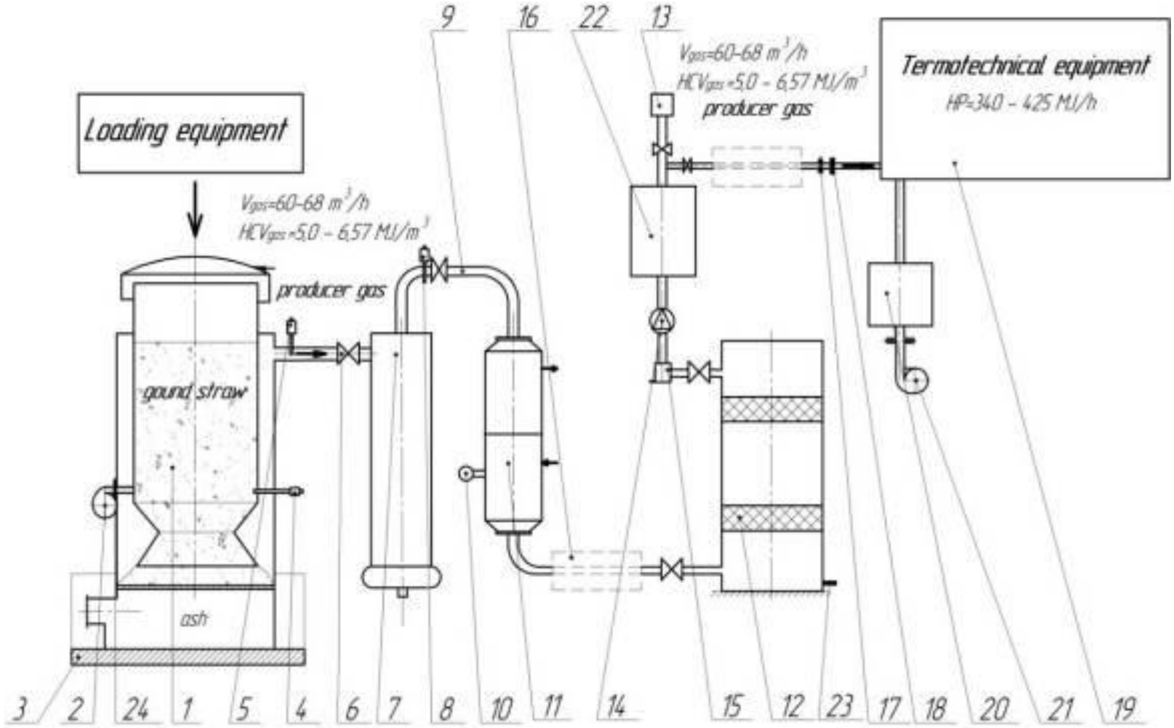
The analysis of written sources dedicated to improvement of the physical and mechanical properties of straw by processing it into pellets, briquettes, and fuel granules shows that this problem is enough explored. But these technological processes are energy cost and expensive (*EU energy in figures, 2012; Geletuha and Zheleznaya, 2014; Melnichuk et al., 2011*). A new method of straw preliminary preparation for gasifying was proposed – making a poly-fractional mixture from it, which makes its further usage in thermotechnical equipment economically advantageous.

There is a great variety of gas producer designs depending on way of receiving and appointment of producer gas, also by gas producer installation type, by degree of automatization and mechanization, by type of raw material (*Mezin, 1948*). In books (*Basu, 2013; Knoef, 2012; Kolerov, 1950; Mezin, 1948; Pandey, 2015*) the main accent was on creating an ideal gas producer design for exact type of raw material and main method of reducing moisture content to the acceptable level when operation of the gas producer will be economically expedient.

It was proposed a design of gas producer chamber where, depending on raw material initial moisture content, one can reduce energy expenditures on gasifying process and increase heat productivity of gas producer by changing tuyer circle diameter and appropriate gas blowing mode (*Tsyvenkova and Golubenko, 2014*). Also this gas producer can produce energy of any type of biomass which calorific value is close to straw`s, without any extra design changes, only changing position of moving tuyers along its axis. To ensure the effectiveness of this gas producer chamber design, an experiment on defining gas composition and gas producer heat productivity was made.

MATERIAL AND METHOD

Experiments on heat productivity of a downdraft gas producer working on straw where made on gas producer installation of ZhNAEU (fig.1) with laboratory measuring equipment of ZhNAEU and Institute of Gas NAS of Ukraine according to the accepted methods and branch standards.



a)

b)

Fig.1 – Basic scheme (a) and general view (b) of the experimental installation

where V_{gas} is gas producer productivity by gas, HCV_{gas} is higher calorific value of producer gas.

The installation consists of gas producer 1, electric air blower 2 with control, weights 3 for continuous registration of fuel consumption during operational cycle, thermocouples 4,5 and 8, for measuring fuel temperature in reaction zone, gas on the exit from gas producer and gas on the exit from cyclone scrubber 7 and on exit from cooler respectively, module of gas sample selection 16, module of fine purification 12, with condensate drain tube 23, moisture extractor 15 for separation water steam from gas. Since whole system has essential aerodynamical resistance and also for imitating consumer there is a vacuum pump 14 on the exit line. For leveling gas composition before feeding a furnace there is a receiver 22. Calorimeter 13 for on-line measuring and registering producer gas calorific value. For regulating gas supply installed throttling washer 17, and valve 18 for shutting off gas pipe.

A ground wheat straw was used as fuel for gas producer. On its base there were made a poly-fractional mixture: cylindrical stems ~ 35 mm long with nubs, wall thickness 0.5 – 1.1 mm; cylindrical even stems 25 – 35 mm long, wall thickness 0.2 – 0.3 mm, outer diameter 2 – 4 mm; squished stems 25 – 40 mm long, wall thickness 0.3 – 0.5 mm; bigger splintered stems 10 – 30 mm long, wall thickness 0.15 – 0.25 mm; small splintered stems ~ 8 mm long, wall thickness 0.15 mm; all other fractions content in all less than 3 %. Chemical composition of straw by dry mass N=0.52 %, C=44.43 %, H=5.86 %, O=44.43 %, S=0.11 %, cinder content 6.5%.

Finding connection between variable factors (D_t, V_{air}, W^P) and dependent (*HP*) ones, determination of the type of that connection and definition of the mathematical equation for expressing this connection is possible only by making a multifactor experiment.

Exploration of the operating modes of gas producer in laboratory consisted of such steps: loading a ground straw with predetermined, according to the plan, moisture content into the gas producer bunker; tuning the air blower 2 and moving tuyers to the initial position, when tuyer circle diameter D_t equals the tuyer belt diameter D_{Ch}; tuning calorimeter 13 and installing gas sample selection module 16; making the experiments, and result analyzing.

Air blower 2 productivity and tuyer circle diameter were changed during the experiment; control measurements of calorific value were registered by calorimeter 13. Gas sampling selection module consists of glass bulb 500 ml with two valves. Producer gas sampling was made by free-flow method. Producer gas chemical composition was determined with laboratory installation consisting of two channel chromatograph “Agilent 6890 N”, bulb with the carrier-gas – argon, manometer and a PC for logging. Calorific value of producer gas was calculated by gas chemical composition according to GOST 22667-83, and gas composition – by chromatography according to ISO 6974-1:2007.

Factor variation intervals are: air supply for gasifying process V_{air} 34, 40 and 46 m^3/h; straw moisture content W^P – 10, 20 and 30 %; parameter D_t – 272, 306, 340 mm. Factors encoding: D_t=X_1, W^P=X_2, V_{air}=X_3.

Variation levels of abovementioned factors are given in table 1.

Table 1

Variable factors and limits of their variation for definition of technological parameters of gasifying process.

Factor variation level	Tuyer circle diameter D_t, mm	Straw moisture content W^P, %	Air supply for gasifying V_{air}, m^3/h.
Upper level (+)	340	30	46
Middle level (0)	306	20	40
Lower level (–)	272	10	34

To reduce the number of experiments and obtain the regression equation, the mathematical method of the experiment planning based on Box-Behnken quadric plan (*Melnikov et al., 1980*) was used.

Planning stage included the following steps: factor encoding, scheduling, randomization tests, implementation plan of the experiment, testing of reproducibility of the experiments, calculation of regression coefficients, assessment of the significance of regression coefficients and adequacy of the test model.

The experiment consisted of 15 tests at threefold repetition in each of them.

RESULTS

As a result of laboratory experiments and statistical computation a heat productivity data array was got, given in table 2.

Table 2

Planning matrix of a multifactor experiment for determining gas producer heat productivity HP

№	Experiment planning method				Experiments results				Model adequacy check		
	X_0	X_1	X_2	X_3	HP_1	HP_2	HP_3	HP_{med}	$HP_{med.com}$	$(HP_{med} - HP_{med.com})$	$(HP_{med} - HP_{med.com})^2$
1	+	+	+	0	377.73	376.58	377.21	377.17	374.96	2.21	4.87
2	+	+	–	0	421.60	422.89	421.09	421.86	416.75	5.11	26.10
3	+	–	+	0	303.02	302.09	301.97	302.36	307.47	–5.11	26.10
4	+	–	–	0	337.88	338.00	337.97	337.95	340.16	–2.21	4.87
5	+	0	0	0	384.44	385.56	382.62	384.21	385.38	–1.17	1.37
6	+	+	0	+	345.26	344.93	343.10	344.43	345.93	–1.50	2.26
7	+	+	0	–	301.22	301.14	299.88	300.75	306.68	–5.93	35.12
8	+	–	0	+	275.42	275.10	275.01	275.18	273.89	1.29	1.67
9	+	–	0	–	241.31	240.82	240.18	240.77	234.63	6.14	37.68
10	+	0	0	0	385.18	386.65	384.94	385.59	385.38	0.21	0.04
11	+	0	+	+	298.73	297.69	297.56	297.99	296.85	1.15	1.31
12	+	0	+	–	260.45	260.52	260.25	260.41	257.59	2.82	7.97
13	+	0	–	+	333.34	332.93	333.17	333.15	334.08	–0.93	0.87
14	+	0	–	–	291.53	292.01	291.83	291.79	294.83	–3.04	9.21
15	+	0	0	0	387.94	384.79	386.30	386.34	385.38	0.96	0.92

Regression coefficients: $b_0=384.16$; $b_1=35.99$; $b_2=-18.35$; $b_3=19.63$; $b_{12}=-2.28$; $b_{13}=2.32$; $b_{23}=-0.95$; $b_{11}=-14.94$; $b_{22}=-9.39$; $b_{33}=-78.94$.

Experiment results were processed using the software "Statistica". Homogeneity of variances was tested by the Cochrane criterion. Since $G^{com}=0,176<G^{tabl}(0,05;\ 15;2)=0,4$ the process is reproduced. When determining of confidence intervals for regression coefficients, the Student test was used, tabulated value of which level was at a 5 % and the number of degrees of freedom of experiment variance reproducibility $f1=2$ was $t=4.3$ (*Melnikov et al., 1980*). The significance of regression coefficients was tested according to the established confidence intervals and covariance. As a result, the regression equation acquired the form:

$$HP=384.16+35.99\cdot X_1-18.35\cdot X_2+19.63\cdot X_3-2.28\cdot X_1\cdot X_2+2.32\cdot X_1\cdot X_3-0.95\cdot X_2\cdot X_3-14.94\cdot X_1^2-9.39\cdot X_2^2-78.94\cdot X_3^2 \quad (1)$$

where: X_1 - encoded value of tuyer circle diameter;

X_2 - encoded value of the moisture of ground straw;

X_3 - encoded value of the air supply for gasifying.

Adequacy test of hypotheses of obtained regression equation was performed by the Fisher criterion. The estimated value of this criterion in the dispersion of inadequacy $S^2_{inadeq}=1.17$ and dispersion $S_y^2=2.33$ reproducibility of the experiment was: $F^{com}=0.5$. Tabular value of Fisher's exact test adopted by the 5 % of significance, according to (*Melnikov et al., 1980*), was: $F^{tabl}(0.05;\ f_1;\ f_2)=19.38$, where $f_2=8$ variance inadequacy degrees of freedom $f1=2$ – variance experiment reproducibility degrees of freedom. Since, $F^{com}=0.5<F^{tabl}(0.05;\ f_1;\ f_2)=19.38$, the hypothesis by the adequacy of the regression equation is confirmed.

Final regression equation of the factors in the species acquired the form:

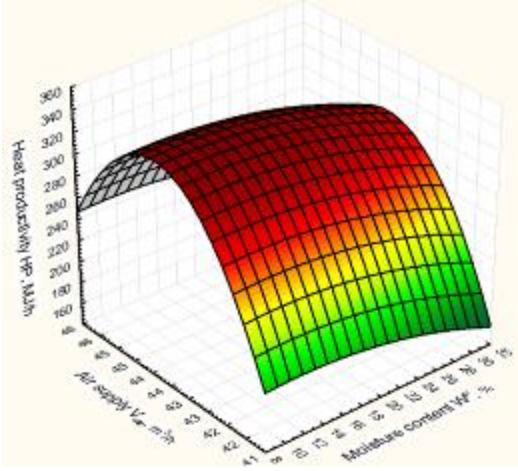
$$HP = 384.16 + 35.99 \cdot D_t - 18.35 \cdot W^P + 19.63 \cdot V_{air} - 9.386 \cdot \left(W^P\right)^2 - 78.94 \cdot V_{air}^2 \quad (2)$$

where: D_t – tuyer circle diameter,

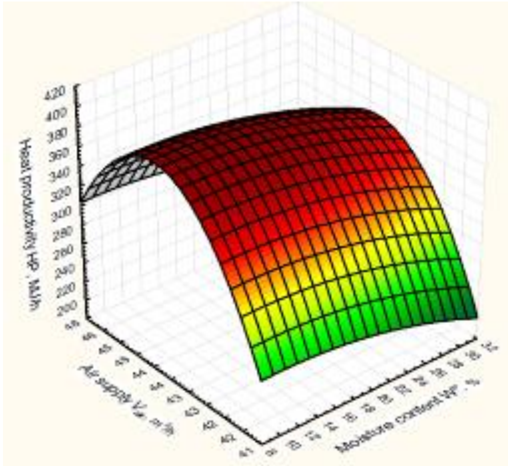
W^P – moisture content of a ground straw,

V_{air} – air supply for gasifying.

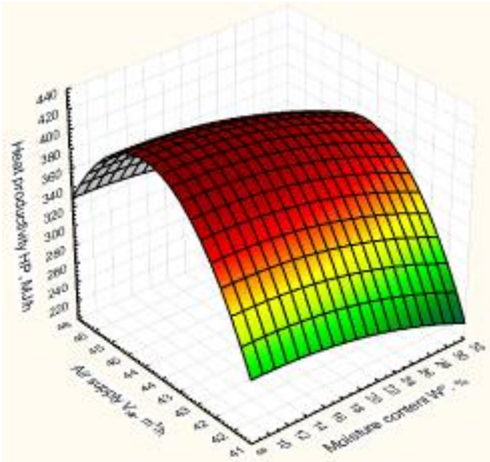
Graphical representations of the abovementioned equation are given on fig.2-4.



a)



b)



c)

Fig.2 – gas producer heat productivity HP against straw moisture content W^p and air supply V_{air}
a) - D_t=272 mm, b) - D_t=306 mm, c) - D_t=340 mm

As we can see from fig.2 unless air supply V_{air} is rising from 34 m^3/h till 41 m^3/h gas producer heat productivity *HP* is also rising. Raising trend is present in all three cases (a), b), c)). However maximum numbers are reached between 39 – 42 m^3/h of air supply. These limits were accepted as rational gas blowing mode for this gas producer working on ground straw with moisture content 10 – 30 %.

The phenomenon of rising productivity is explained by fact that when air supply to the chamber working zone is rising, the amount of oxygen rises, which promotes intensification of fuel carbon oxidizing reaction. Since oxidizing reaction is endothermic, significant heat is released in active zone, which is needed for creating CO – one of the main combustible components of the producer gas. This, in turn, leads to rising of producer gas calorific value, and, consequently, gas producer heat productivity.

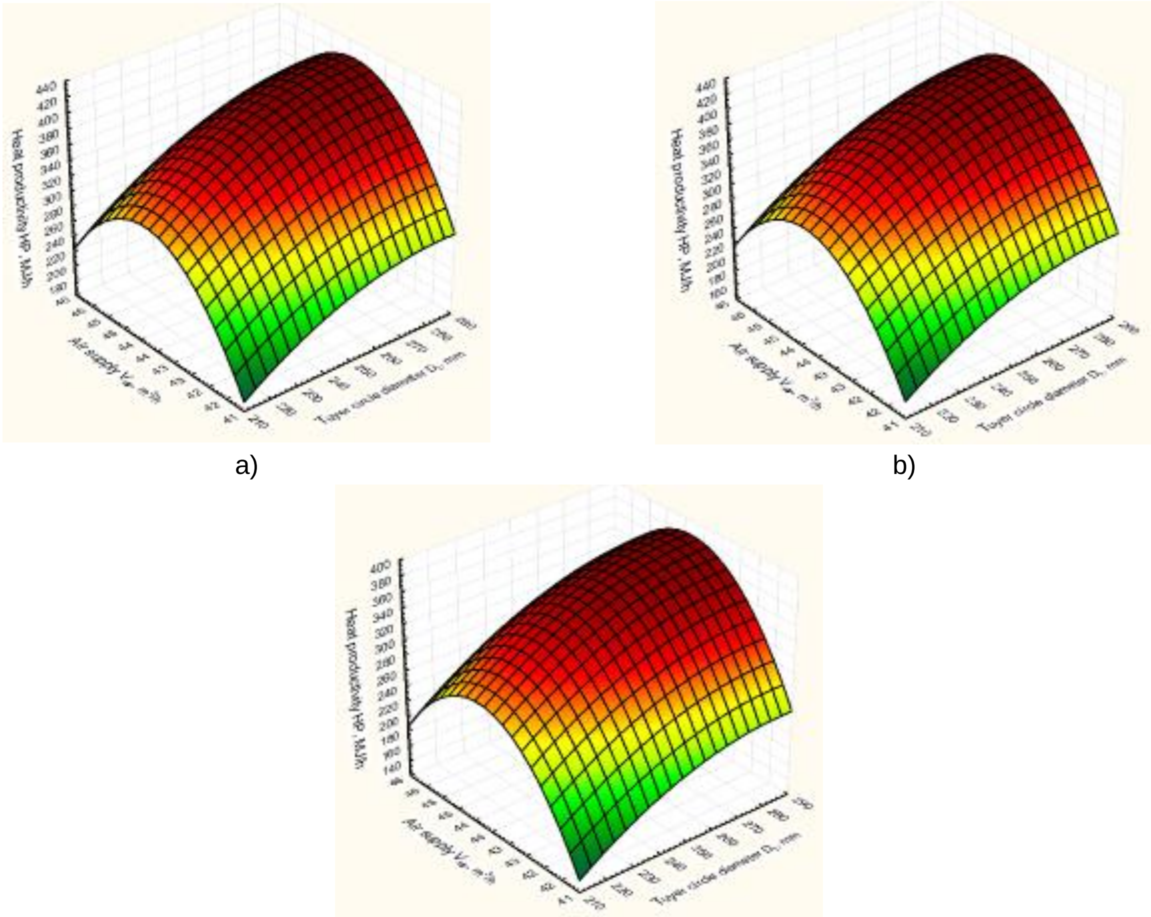
But further rising of air supply to more than 42 m^3/h gas producer heat productivity lowers, since extra air, while going through fuel layer in reaction zone, cooling it, promoting creation more CO_2 instead CO by blowing out fuel carbon with gas, which is taken away from gas producer.

In fig.3 is seen that expanding tuyer circle diameter D_t from 272 to 340 mm makes gas producer heat productivity rise due to better conditions for aerodynamical processes in gasification chamber. However excessive expanding of the D_t leads to instability of the gas producing process. The phenomenon of gasification zone localization and appearance of zones where fuel is not burning in the middle of gasification chamber are observed. Tars content in gas rises as a result. For a ground straw with moisture content W^P=30 % under normal conditions tars content was close to 3 g/m^3, moisture – 0.2 kg/m^3.

The other requirement which limits expanding or restricting D_t is providing proper D_t to d_g (gas producer diameter) ratio that is needed for creating favorable conditions for tars cracking process.

Restricting tuyer circle diameter D_t while air supply V_{air} and moisture content W^P are constant will lead to localization of combustion zone in the middle of gasification chamber and creating zones where fuel is not burned alongside the walls of gasification chamber, followed by lowering temperature in reaction zone and consequently to the gas producer heat productivity *HP* reducing.

Therefore, changing regulated parameter, like tuyer circle diameter D_t, we can tune gas producer heat productivity depending on straw initial moisture content W^P, while air supply V_{air} is constant.



a) b)

c)

Fig.3 – gas producer heat productivity *HP* against tuyer circle diameter D_t and air supply V_{air}

a) - W^p=10 %, b) - W^p=20 %, c) - W^p=30 %

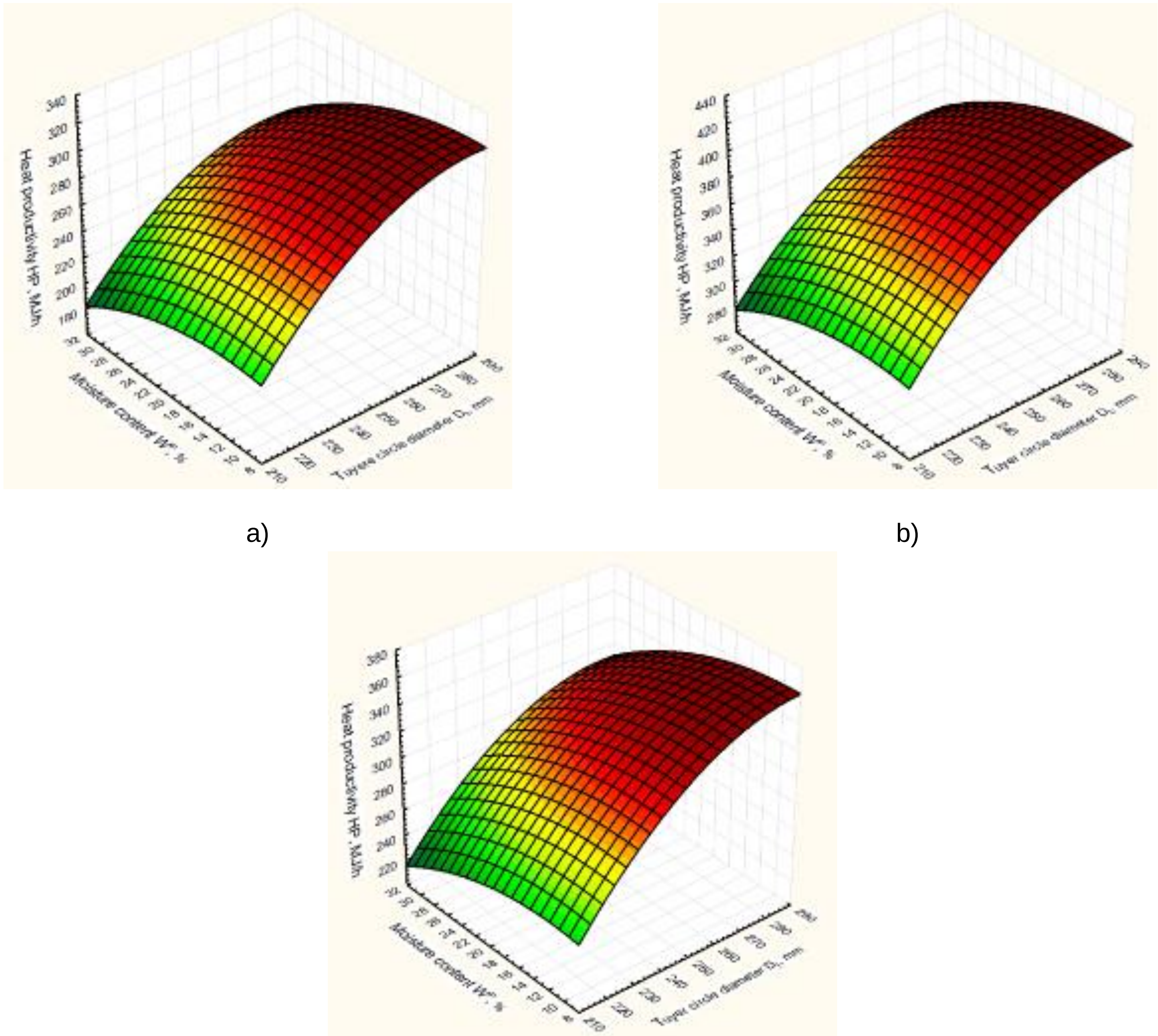
Most preliminary preparation activities of raw material before using it in any thermotechnical equipment, converge to reducing moisture content to the level when technological process and equipment, that is used, are economically reasonable.

For example, in our case lower limit of moisture content in straw is 8 %. This moisture is enough for formation of such combustible gas component as H_2 and its drying expenditures are relatively low.

In order to find the upper limit of moisture content next experiment was made. Ground straw with moisture content of 40 % was used as fuel for gas producer. Gas producer bunker was additionally equipped with condenser device, and grating design provides a rocking grating with blades inside another circular grating. Nonetheless satisfactory technological parameters of gas producer operation were not provided. Within the first hour of operation on straw with moisture content 40 % and ash content 6.5 % dry gas output reached v_d=1.4 m^3/kg with calorific value Q_L^{pg}=3.6 MJ/m^3 instead of v_d=2.14 m^3/kg and Q_L^{pg}=6.14 MJ/m^3 when working on straw with moisture content 8 %. Fuel layer resistance rised from 8 Pa to 25 Pa because of intensive slag production, and gas producer heat productivity reduced from 394 MJ/h till 151 MJ/h till the end of fifth operational hour. Gas producing stability was broken. Starting from 3rd hour of operation was necessary to move rocking grating with blades periodically. Comparing our experimental data with data from (mezin I.S. 4) about producing gas from straw briquettes and peat (ash content 12 % moisture content 15 % with cinder melting point 1300 ^{0}C), results show that slag producing from ground straw with moisture content 40 % is a bit more (1.24 kg/h) than straw briquettes (1.13 kg/h) and less than peat (3.14 kg/h). Nonetheless, straw slag, compared to slag from peat has a viscous structure because of low softening temperature, and covers fuel surface, reducing its gas permeability. Slag when mixed with fuel reduces the possibility of its pushing down into the lower part of chamber thus stopping operation. In this case using the poly-fractional composition from ground straw is much better than straw briquettes, since it has greater reaction surface and is more gas permeable when slaging. Therefore using ground straw with moisture content more than 30 % is inappropriate because of big heat productivity loses.

Analyzing fuel moisture content influence on gas producer operational characteristics, we can see that gas producer firing time is about 20 min when moisture content is 8 % and 45 min when 30 %, because of energy expenses on straw drying directly in gas producer bunker. Lower calorific value of a dry producer gas from 30 % moisture straw is Q_L^{pg}=5.43 MJ/m³, that is 1.2 times lower than from 8 % moisture straw – 6.14 MJ/m³, and quantity of producer gas from one kilogram of ground straw reduced by 1.3 times to 1.65 m³/kg.

Graphical representation (fig.4) shows nature of the change of gas producer thermal mode depending on rising moisture content in fuel. Rising moisture content from 8 to 30% leads to rising heat expenses on evaporating moisture from fuel by almost 15%, and its further rising leads to reaction zone temperature sharp reducing, and gas producing process instability. So, moisture content interval of 8 – 30% is rational, and all technological process of straw preparation for gas producing should provide limiting moisture content to the above mentioned limits.



a) b)

c)

Fig.4 – gas producer heat productivity *HP* against tuyer circle diameter D_t and straw moisture content W^P

a) - V_{air}=34 m³/h, b) - V_{air}=40 m³/h, c) - V_{air}=46 m³/h

However, analysis of fig.4 shows that moisture content in fuel influences heat productivity lesser than D_t. Maximum productivity of the gas producer depends more on the current position of moving tuyers in the gas producer active zone.

CONCLUSIONS

Summing all, we can say that:

- gas producer heat productivity rises by 30 – 35 % while air supply is rising from 34 to 41 m^3/h, and drops again while air supply is rising further. So, between 39 and 42 m^3/h gas producer heat productivity is maximized and is between 340 and 425 MJ/h for straw moisture content 8 %;
- while rising D_t from 272 to 340 mm heat productivity rises by 22 – 24 % with the fixed moisture content and V_{air}=34 – 46 m^3/h;
- while rising W^P from 10 to 30 % gas producer heat productivity drops by 12 – 15 % with V_{air}=34 – 46 m^3/h.

We should note that within moisture content 8 to 30 %, air supply 39 – 42 m^3/h and tuyer circle diameter between 272 – 340 mm high calorific value of dry producer gas was reached 5.0 – 6.6 MJ/m^3, and maximum gas producer productivity of 425 MJ/h was reached at V_{air}=40 m^3/h, D_t=340 mm and W^P=8 %.

Based on experimental results analysis we can do a conclusion that making a gas producer chamber with the variable tuyer circle diameter (with the tuyer that can moved along its axis during gas producer operation) is a real and effective design feature, providing appropriate gas blowing mode to fit moisture content that will let us gaining high heat productivity numbers.

Further research will be aimed to study the influence of fine-grained vegetal waste distribution irregularity of the fire surface on fuel combustion completeness, hence gas producer productivity.

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ENERGY PERFORMANCE OF AN INDUSTRIAL SECTOR - CASE STUDY OF CARNAUD METAL BOX. IKEJA LAGOS NIGERIA

Ologunye O.B.*[1)], Adedeji M.A.[1)], Familusi T.O.[2)]
[1)]Department of Mechanical Engineering Technology, Federal Polytechnic, Ede, Osun State, Nigeria
[2)]Science Laboratory Department, Osun State Polytechnic, Iree, Osun State, Nigeria.
Tel:+234-7068154452; maadedeji@fptb.edu.ng

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ABSTRACT

The efficient use of energy is of prime importance to all sectors of the economy. For many firms, energy can be a major factor in industrial and commercial costs. As a nation, we must try to reduce these costs and improve our profitability and competitiveness. Cost is of more immediate interest to manager or engineer in the industry and energy is one of the contributory factors in the total financial cost of a product and there is a considerable goal for reducing energy consumption. This was the essence of this research work. Four years data (1995 - 1998) were collected on energy performance of the Carnaud Metal Box (CMB), Ikeja, Lagos. These data were analyzed to know the total consumption of fuels, oil and electricity over the four years considered. Total energy consumed for each year was compared and normalized performance indicator (NPI) was calculated for each year. The treated floor area of the company was 222,94,55 m^2, the average annual energy consumption was 865204,505 GJ with fuel, oil and electricity making up 57.19%, 33.95% and 8.99% respectively. The average value of the normalized performance indicator (NPI) was 1.16.GJ /M^2. This implies that the energy performance of the company can be rated as fair. The average value of the annual energy for hot water services was 23,875 GJ while the average value of the annual energy for heating was 561873,73 GJ.

INTRODUCTION

Industry is a large consumer of energy using 30 – 40% of the total energy used in industrialized countries. The efficient use of energy is of prime importance to all sectors of the economy. For many firms, energy can be a major factor in industrial and commercial costs. As a nation, we must try to reduce these costs and improve our profitability and competiveness. The concept of energy is a measure of the efficiency of energy utilization in a manufacturing process based on the first and second laws of thermodynamics. The energy of any material depends on the materials temperature, pressure and chemical composition as well as on the respective properties of the environment. It remains true that in many manufacturing industries, the machines and operations directly used in the production process represent the largest consumers of energy. However, the ancillary operations may individually consume only small quantities of energy. Operations are called "**ancillary**" when they do not contribute directly to the manufacture of the product under consideration.

Energy consumption and costs

The first step in identifying areas for potential savings is to establish the quantity and cost of the energy and utilities used on the site. This includes not only fuel oil, coal, gas and electricity but also water and on some sites, vehicle fuel usage. Management control is an essential element in any cost reduction programme. Information on energy consumption and costs can be obtained from:

- Utility invoices for fuel, electricity and water for at least one year
- Site energy records/ sub-metering
- Production information.

The annual consumption for each energy type should be converted to a standard unit (e.g. gigajoules, GJ). The total annual energy use on a site can be used to calculate a performance index, to assess the energy performance and indicate whether there is likely to be a good opportunity for improvement.

Energy conservation

There is a real need to conserve conventional energy especially in industry and commerce in order to cut their costs and to remain competitive. Energy conservation is an important part of any country's energy strategy. Over half of the energy used by man is 'wasted and there is plenty of scope for improvement, though there are often practical difficulties (Gordon, 1977).

Monitoring and targeting (M & T)

The relative cost of energy and the equipment to use it efficiently needs to be carefully monitored. Monitoring and targeting is a management approach that enables firms to manage energy as a controllable resource in the same way as manage other resources such as finance and manpower. Energy conservation program must be continuously monitored to manage fuel usage efficiently (Abubakar et al. 2015).

Planning

Planning is an essential feature of energy conservation program to ensure that activities are undertaken in a logical and efficient manner. To reduce costs to the minimum, management's energy conservation plan must involve every member of the organization. The most important tasks are monitoring or tracking energy consumption, keeping track of trends, and measuring performance. In planning, consideration should be given to how the process will be operated and by whom (Thomas, 1979). The first step in the planning process is setting objectives. Management's energy objectives usually focus on the quantity, cost, and effect of energy savings. Objectives should always be reviewed to ensure that they are specific, consistent and attainable (Thomas, 1979). The second step of the planning process involves outlining procedures. This process forms the framework for how the plan's objectives will be accomplished. Basically, it is a four-step process:

1. Defining activities
2. Establishing a time table
3. Reviewing resources
4. Determining locations

The third step of the planning process is to assign responsibilities, that is, who has the skills to carry out each activity.

Electrical energy

The greatest proportion of all electricity used in industrial countries is derived from thermal generating techniques using Fossil fuels such as coal, oil and natural gas. The consumption of electricity is measured in the unit "kilowatt hour (kWh) and the conversion unit is 3.6 MJ/kWh (CIBS, 1982). In terms of costs for energy used, a large percentage of electrical tariffs base their maximum demand charges on kVA and not kW in order to discourage the use of equipment with a low power factor. From an economic viewpoint it is desirable to keep the power factor of installed equipment as high as possible as this reduces the kVA for the same power consumption (CIBS, 1982). Reducing the kVA reduces the heat losses ($I^2 R$) in the cables. The use of multiple meters can be used to monitor the power consumption in a building.

Thus electrical bills can be reduced by up to 30% if:

- Utility rate structure is known
- The plant power factor is improved
- Peak loads is reduced
- Efficient use of lighting

MATERIAL AND METHOD

Design assessment

At the design stage, the future energy requirement of a proposed building may be expressed as an average power per unit area of treated floor. This is termed energy demand for a building. Many of the variable values have to be assumed during design stage. The energy requirements of a particular building may be assessed based on the following parameters:

Q_H, the heating thermal power requirement

Q_{HWS}, the hot water services thermal power requirement, QR the recovered thermal power requirement.

Q_{ND}, the heating thermal requirement supplied by non-depleting sources.

Q_E, the electrical power requirement.

The summation of these components gives the total average annual power requirement Q_T (kW).

Assuming that some aspect of the building is changed as an energy conserving measure then a revised estimate of the total average annual power requirement (Q'_T) may be made. If the total energy consumption for a given period is E_T . Then an estimate of the total energy consumption to be expected after the building and/or system changes would be equation (1):

$$E'_T = E_T \times {Q'_T}/{Q_T} \tag{1}$$

The likely energy saving being $(E_T - E'_T)$ (CIBSE, 1982). Experience has shown that, in this country 1110st people are comfortable (when resting) in a room when ordinary mercury thermometer registers 18.33^{0}C to 21.11^{0}C. The outside design temperature (term "basic" design temperature") in general use for domestic dwellings of traditional design and construction in this country is 1.11°C (Barton, 1969).

Reducing building energy losses

Depending on the time of year, a heat loss or a heat gain of waste energy for example, a heat loss during the winter means wasted energy in heating the building. Similarly, during the summer months, a heat gain means wasted energy in cooling the building. Heat loss refers to heating loads while heat gain refers to cooling loads. The building construction affects the heat loss and heat gain. By considering building materials and constructions, the associated heat loss and heat gain can be reduced. For example, when one surface of the air space is covered with aluminum roof, heat loss can be reduced. Heat from the sun's rays increases heat gain of a building. When an engineer is specifying building materials, he or she should consider the following factors:

- The angle of the sun's rays
- The colour and roughness of the surface
- The reflectivity of the surface
- The type of construction

In estimating the relative heat gain through glass, Equation (2) formula can be used:

$$Q = UA(t_0 - t_1 + A \times S_1 \times S_2) \tag{2}$$

where:

Q = the total heat gain for each glass

U = the conductance of the glass

$A =$ the area of glass, the area used should include framing

$t_1 =$ inside temperature

t_0 = the outside ambient temperature

S_1 = the shading coefficient ;it takes into account external shades

S_2 = the solar heat gain factor and takes into account direct and diffused radiator from the sun.

Performance indicator

Performance indicators arc values of energy consumption, which can be used to indicate whether the actual consumption is low or high. They are expressed as the total annual site energy consumption for a building (GJ) per unit of treated floor area (m^2) in GJ/m^2 (CIBS, 1982). [The performance indicators thus include energy derived both from fossil fuels and electricity. Normalized performance indicators (NPI) is also a useful parameter to assess the energy performance of a building.

Data generation and analysis

The case study for this project is Carnaud metal box, Ikeja, Lagos. The building type is the factory and the total area is 27868.192m. The treated floor area of the factory is 22294.5536m. The company carried out production from power supplied by its four (4) generating sets. They also have boiler that uses black oil (low petroleum fuel oil) as its source of energy and some other equipment/machines such as pumps, motors &

drives, compressors etc.) that use electricity as their source of energy. Generators are in use 24 hours a day. The data generated include the followings:

1. The amount of electricity consumed per month over a period of 4 years
2. The amount of fuel consumed per month over a period of 4 years
3. The amount of oil (black oil) consumed per month over a period of 4 years.
4. The total production rate per month over a period of 4 years
5. The number of working hours per day
6. The number of occupancy (shift) per day
7. The floor area of the factory in m^2

The data were recorded in tabular form Table 1 to 4, amount of electricity consumed monthly from 1995 to 1998. From recommended table- 'Energy conservation factor conversion factors for energy units, we have: 1kwh = $3.6x10^6$ J = 3.6MJ.

1Mwh = 10^3kWh

Therefore, 1800.0658MWh = 1800.0658x10^3kWh = 3.6x1800065.8x10^{-3}G = 6480.2369GJ

Table 1

Amount of electricity consumed in 1995

Month	Amount in MWh	Amount in kWh	Amount in GJ	Unit charge in N	Cost in N
January	1800.0658	1800065.8	6480.24	2.37	4266155.95
February	1661.5992	1661599.2	5981.76	2.37	3937990.10
March	1869.2991	1869299.1	6729.48	2.37	4430238.87
April	1730.8325	1730832.5	6231.00	2.37	4102073.03
May	1869.2991	1869299.1	6729.48	2.37	4430238.87
June	1800.0658	1800065.8	6480.24	2.37	4266155.95
July	1800.0658	1800065.8	6480.42	2.37	4266155.95
August	1869.2991	1869299.1	6729.48	2.37	4430238.87
September	1800.0658	1800065.8	6480.24	2.37	4266155.95
October	1800.0658	1800065.8	6480.24	2.37	4266155.95
November	1800.0658	1800065.8	6480.24	2.37	4266155.95
December	1800.0658	1800065.8	6480.24	2.37	4266155.95
Total	21600.79	21600790.0	77762.88		51193871.39

Table 2

Amount of electricity consumed in 1996

Month	Amount in MWh	Amount in kWh	Amount in GJ
January	1740.6225	1740622.5	6266.24
February	1611.6875	1611687.5	5802.08
March	1676.1550	1676155.0	6034.16
April	1676.1550	1676155.0	6034.16
May	1740.6225	1740622.5	6266.24
June	1611.6875	1611687.5	5802.08
July	1740.6225	1740622.5	6266.24
August	1740.6225	1740622.5	6266.24
September	1611.6875	1611687.5	5802.08
October	1740.6225	1740622.5	6266.24
November	1676.1550	1676155.0	6034.16
December	1676.1550	1676155.0	6034.16
Total	20242.80	20242800	72874.08

Table 3

Amount of electricity consumed in 1997

Month	Amount in MWh	Amount in kWh	Amount in GJ
January	1771.6698	1771669.8	6378.01
February	1574.8176	1574817.6	5669.34
March	1706.0524	1706052.4	6141.79
April	1706.0524	1706052.4	6141.79
May	1771.6698	1771669.8	6378.01
June	1640.4350	1640435.0	5905.57
July	1771.66981	1771669.8	6378.01
August	1706.0524	1706052.4	6141.79
September	1706.0524	1706052.4	6141.79
October	1771.6698	1771669.8	6378.01
November	1640.4350	1640435.0	5905.57
December	1771.6698	1771669.8	6378.01
Total	20538.25	20538250	7393.69

Table 4

Amount of electricity consumed in 1998

Month	Amount in MWh	Amount in kWh	Amount in GJ
January	1979.0172	1979017.2	7124.46
February	1759.1264	1759126.4	6332.86
March	1905.7203	1905720.3	6860.59
April	1905.7203	1905720.3	6860.59
May	1905.7203	1905720.3	6860.59
June.	1905.7203	1905720.3	6860.59
July	1979.0172	1979017.2	7124.46
August	1905.7203	1905720.3	6860.59
September	1905.7203	1905720.3	6860.59
October	1979.0172	1979017.2	7124.46
November	1832.4225	1832422.5	6596.72
December	1979.0172	1979017.2	7124.46
Total	22941.94	22941939.5	82590.98

Analysis

Amount of fuel consumed in the generator and boiler. (From 1995 - 1998) is illustrated in Tables 5 to 8. From the recommended table: (Heat supplied basis energy valued of fuels).
1 Litre of fuel = 40.8 MJ

Table 5

Amount of fuel consumed in 1995-generator

Month	Amount in litre	Amount in MJ	Amount in GJ	Price /litre N	Cost in N
January	445229.6667	18165370.40	18165.37	9.00	4007067.00
February	410981.2308	16768034.22	16768.03	9.00	3698831.08
March	462353.8846	18864038.49	18864.04	9.00	4161184.96
April	428105.4487	17466702.31	17466.70	9.00	3852949.04
May	462353.8846	18864038.49	18864.04	9.00	4161184.96
June	445229.6667	18165370.40	18165.37	9.00	4007067.00
July	445229.6667	18165370.40	18165.37	9.00	4007067.00
August.	462353.8846	18864038.49	18864.04	9.00	4161184.96
September	445229.6667	18165370.40	18165.37	9.00	4007067.00
October	445229.6667	18165370.40	18165.37	9.00	4007067.00
November	445229.6667	18165370.40	18165.37	9.00	4007067.00
December	445229.6667	18165370.40	18165.37	9.00	4007067.00
Total	5342756.0	217984444.8	217984.44		48084804.00

Table 6

Amount of fuel consumed in 1996-generator

Month	Amount in litre	Amount in MJ	Amount in GJ	Price /litre N	Cost in N
January	485399.0350	19804280.63	19804.28	9.00	4368591.32
February	449443.5510	18337296.88	18337.30	9.00	4044991.96
March	467421.2930	19070788.75	19070.79	9.00	4206791.64
April	467421.2930	19070788.75	19070.79	9.00	4206791.64
May	485399.0350	19804280.63	19804.28	9.00	4368591.32
June	449443.5510	18337296.88	18337.30	9.00	4044991.96
July	485399.0350	19804280.63	19804.28	9.00	4368591.32
August	485399.0350	19804280.63	19804.28	9.00	4368591.32
September	449443.5510	18337296.88	18337.30	9.00	4044991.96
October	485399.0350	19804280.63	19804.28	9.00	4368591.32
November	467421.2930	19070788.75	19070.79	9.00	4206791.64
December	467421.2930	19070788.75	19070.79	9.00	4206791.64
Total	5645011.00	230316448.8	230316.45		50805099.04

Table 7

Amount of fuel consumed in 1997-generator

Month	Amount in litre	Amount in MJ	Amount in GJ	Price/litre N	Cost in N
January	455674.9457	18591537.78	18591.54	9.00	4101074.51
February	405044.3962	16525811.37	16525.81	9.00	3645399.57
March	438798.0958	17902962.31	17902.96	9.00	3949182.86
April	438798.0958	17902962.31	17902.96	9.00	3949182.86
May	455674.9457	17214386.84	17214.39	9.00	4101074.51
June	421921.2460	17214386.84	17214.39	9.00	3797291.21
July	455674.9457	18591537.78	18591.54	9.00	4101074.51
August	438798.0958	17902962.31	17902.96	9.00	3949182.86
September	438798.0958	17902962.31	17902.96	9.00	3949182.86
October	455674.9457	18591537.78	18591.54	9.00	4101074.51
November	455674.9457	18591537.78	18591.54	9.00	4101074.51
December	421921.2469	17214386.84	17214.39	9.00	3797291.21
Total	5282454.00	215524123.20	215524.12		47542085.98

Table 8

Amount of fuel consumed in 1998-generator

Month	Amount in litre	Amount in MJ	Amount in GJ	Price/litre N	Cost in N
January	512152.9936	20895842.14	20895.84	9.00	4609376.94
February	455247.1054	18574081.90	18574.08	9.00	4097223.95
March	493184.3642	20121922.06	20121.92	9.00	4438659.28
April	493184.3642	20121922.06	20121.92	9.00	4438659.28
May	493184.3642	20121922.06	20121.92	9.00	4438659.28
June	493184.3642	20121922.06	20121.92	9.00	4438659.28
July.	512152.9936	20895842.14	20895.84	9.00	4609376.94
August	493184.3642	20121922.06	20121.92	9.00	4438659.28
September	493184.3642	20121922.06	20121.92	9.00	4438659.28
October	512152.9936	20895842.14	20895.84	9.00	4609376.94
November	474215.7348	19348001.98	19348.00	9.00	4267941.61
December	512152.9936	20895842.14	20895.84	9.00	4609376.94
Total	5937181	242236984.80	242236.98		53434629.00

Normalized Performance Indicator (NPI)

NPI = (Total energy x hour of use factor) / Treated floor area.

Calculation of NPI

Length of the factory = 600 ft. (182.871m)
Breath of the factory = 500 ft. (152.393m)
Area = length x breath =182.871 x 52.393 = 27868.192m^2
Area = Letting Area (Treated floor area) x 1.25
27868.192 = Treated Floor Area x 1.25
Treated floor area = 27868.192/1.25 =22294.554m^2

Amount of energy going in to space heating = 80% of Fossil energy from a standard table: (Proportion of fuel used for space and hot water).

Percentage of energy savings

To know the percentage of energy saving for the four years program, take the total energy consumed for 1995 as a base line, equation (3):

That is,

$$\left[\left(\text{Total energy consumed in 1995} - \text{Total energy consumed in 1995} \middle/ \text{Total energy consumed in 1995} \times 100\%\right)\right] \quad (3)$$

Percentage cost of energy savings

To know the saving for the four years program, take the total cost of energy consumed for 1995 as a base line. That is Equation (4):

$$\left[\left(\text{Total Cost of energy consumed in 1995} - \text{Total Cost of energy consumed in 1995} \middle/ \text{Total Cost of energy consumed in 1995}\right) \times 100\%\right] \quad (4)$$

1995

No. of working hours /Day = 24 hours
No.of working days per year = 312
No .of working hours / Year = 312 x 24 = 7488 hours
Total fossil energy = 485306.04 + 292780.80 = 778086.84 GJ
Space heating energy = 0.8 x 778086.84 = 622469.472 GJ
Non heating energy = 855849.72 – 622469.472 = 233380.248 GJ
For single shift = (233380.248)/ 4 = 77793.42 GJ
Standard working hours = 312 x 8 = 2496 hours

Hours of used correction = $\left(77793.42 \times 2496 / 7488\right) = 25931.14$

NPI = $25931.14 / 22294.554 = 1.16 \text{ GJ} / m^2$ 5

Assessment performance is fair, since the calculated NPI is within the fair range 1.0 – 1.2 with floor area above 20,000 m^2.

RESULTS

Table 9 shows total energy consumed by the company for the four years investigated:

Table 9

Total energy consumed in (GJ) for four years

Month	1995	1996	1997	1998
January	71320.81	74540.92	73439.95	76490.7
February	65834.59	69019.38	65279.95	67991.74
March	74063.92	71780.15	70719.95	73657.71
April	68577.7	71780.15	70719.95	73657.71
May	74063.92	74540.92	73439.95	73657.71
June	71320.81	69019.38	67999.96	73657.71
July	71320.81	74540.92	73439.95	76490.7
August	74063.92	74540.92	70719.95	73657.71
September	71320.81	69019.38	70719.95	73657.71
October	71320.81	74540.92	73439.95	76490.7
November	71320.81	71780.15	67999.96	70824.72
December	71320.81	71780.15	73439.95	76490.7
Total	855849.72	866883.34	851359.42	886725.52

From Table 9, the total energy consumed for each year was compared and the highest value (886725.56 GJ) was recorded in 1998. While the lowest value (851359.41GJ) was recorded in 1997. Variations during the year were due to change in load or efficiency. They could also be attributed to change in operating practice or lack of control. The consumption rate in 1998 was very high because of the fuel crisis and poor maintenance. The energy efficiency (Total energy consumed per unit of production) was calculated for each year and the average was 0.02475GJ/kg. This value will help the engineer or energy manager to track the energy consumed per unit product and also to keep track of the progress of the conservation program. From Figure 1, changes in energy efficiency can be easily seen, the highest energy efficiency value was recorded in 1998 which is 0.0254GJ/kg and the lowest energy efficiency value was in 1997.

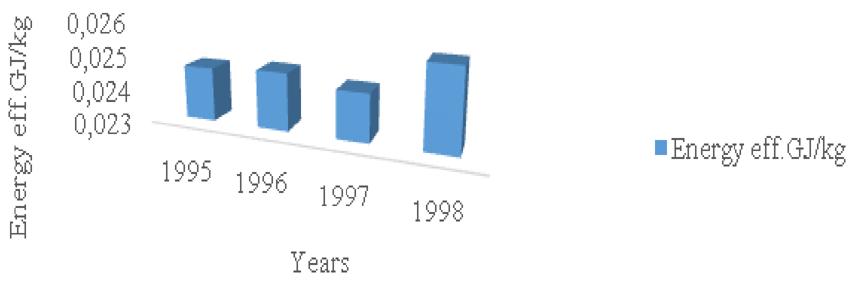

Fig. 1 - Energy efficiency

Figure 2 shows the percentage of energy conserved or wasted for the 4years. Much energy was wasted in 1998 (- 0.02GJ) because the facilities were not fully utilized. Less energy was consumed in 1997 (0.005GJ) because of good maintenance and control.

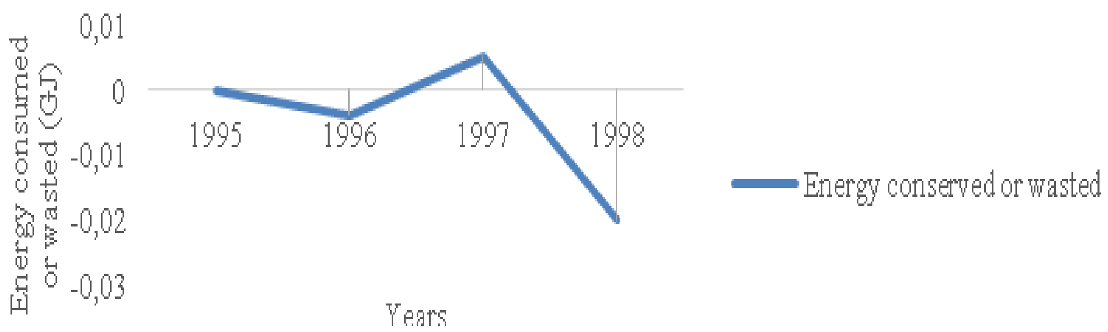

Fig. 2 - Energy consumed or wasted

Percentages of energy savings were calculated and the savings through electricity gave the lowest value in 1998 to be -6.21 (Fig.3). This was due to the fact that certain inessential items and lighting system have not been switched off when not needed (Antonino et al, 2016).

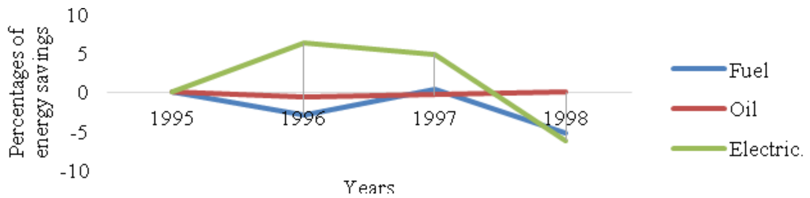

Fig. 3 - Percentages of energy savings

Normalized performance indicator (NPI) was calculated for each year and the average value was found to be 1.16 GJ/M^2. The assessment performance is fair since this value is within the range 1.0-1.2 as obtained from standard table: This means barely average performance in energy usage. For typical situations significant savings should be achievable (Xi Yang et al, 2014, Zexuan and Hongsheng, 2014).

CONCLUSIONS

The energy efficiency of the Carnaud Metal Box (CMB), Ikeja Lagos had been studied based on the analysis of 4 years data collected on energy performance of the company. The following conclusions were made at the end of this project work:

1. The treated floor area of the company was 222.94.55 m^2
2. The average annual energy consumption was 865204.505 GJ with fuel, oil and electricity making up 57.19%, 33.95% and 8.99% respectively.
3. The average value of the normalized performance indicator (NPI) was 1.16.GJ / M^2. This implies that the energy performance of the company can be rated as being fair.

Recommendations

1. The efficiency and economy of total energy systems could be improved by additional research into prime movers, heat exchangers and control systems.
2. Energy flow diagrams indicating how and where energy is used in industry should be prepared.
3. An evaluation should be made of processes which can convert waste materials of all types into fuels or energy suitable for use in industrial processes.
4. To ensure the plant or machine is well maintained in line with the manufacturer's recommendations.
5. Repair of steam leaks without delay.
6. Insulating process plant for cost saving and reduce the energy input.
7. Management's energy conservation plan must involve every member of the organization in order to reduce cost to minimum.
8. Understanding energy use in industrial processes can be assisted by preparing an energy flow diagram as part of an audit based on examining current practices and patterns of use. In this way improvement in operation and the potential for energy saving project can be identified.

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COMPARATIVE ASSESSMENT OF OKRA *(HIBISCUS ESCULENTUS)* PERFORMANCE UNDER IMPROVISED DRIP AND SPRINKLER IRRIGATION SYSTEMS

Amoo M.O. [1)], Adedeji M.A.*[2)], Ali G.A.[2)], Lasisi M.O. [1)]
[1]Department of Agricultural and Bio-Environmental Engineering, Federal Polytechnic, Ado-Ekiti, Ekiti State, Nigeria.
[2]Department of Mechanical Engineering Technology, Federal Polytechnic, Ede, Osun State, Nigeria
Tel:+234-7068154452; E-mail: maadedeji@fptb.edu.ng

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ABSTRACT

Methods of irrigation have very significant influence on okra (Hibiscus esculentus) production.Okra is a common and popular vegetable crop used in Nigeria. A careful comparative assessment was carried out on okra performance under improved drip irrigation (IDI) and sprinkler irrigation (SI) systems which were subjected to the same conditions. An open field area of 27.0 m by 12.0 m was properly cleared, stumped, ploughed, harrowed and levelled. The experimental field was divided into two equal plots of 13.5 m by 6.0m, each for the two systems. High yielding and disease resistant okra variety seeds obtained from a research institute were carefully selected and planted at a regular interval of 0.6m. The results of statistical analysis (ANOVA, $P < 0.05$) revealed that there were significant differences on water application which reflected in increase in some agronomic parameters such as growth, weight, yield and vegetative development of the okra. These selected okra agronomic parameters showed that the okra performed better under IDI than SI. Maximum fruit yield of 95.43kgm^{-2} was obtained by using IDI system while 84.48kgm^{-2} was obtained from SI system. Based on the results obtained from the study and for maximum water utilization, IDI system is highly recommended.

INTRODUCTION

The available lands in the tropical regions need irrigation to improve economic returns for the production of crops especially during dry season. Irrigation practices are to complement or substitute the available water from natural sources such as rainfall, flood, dew and ground water. Irrigation is needed in most parts of West Africa where there may be a prolonged drought period and mostly where water from natural sources is inadequate (especially Northern part of Nigeria) for effective crop germination and production (Modupe et al., 2015; Fasina, 2008).

Increased demand for okra has made many farmers to go into large scale production for the purpose of profitmaking (Pravukalyan et al., 2011). Okra (*Hibiscus esculentus*) is indigenous to tropics Africa but is grown throughout the tropics and in some parts of the sub-tropics (Philip and Poleman, 2006). The leaves are lobed and hairy. The plant produces dark yellow flowers that are about 5.0 cm in diameter. The plant is cultivated in tropical countries such as Nigeria, sub-tropical and warm temperature region around the world. (Modupe et al., 2015). Okra is a vegetable crop that belongs to the genus *Abelmoschus*, family *Malvaceae*. Okra is a crop which requires a long warm and humid growing season. Okra can be grown in all types of soils, but the soil should be friable. However, it grows best in light soils ranging from sandy loam to loam. Okra can tolerate slightly acidic soil condition (pH 6.8 to 6.0). Typical okra fruits and farm planted in a row are demonstrated in Figures 1a and 1b below, respectively.

Fig. 1a - Typical okra freshly harvested fruits

Fig. 1b - Typical okra farm planted in a row

Puneet and Arun (2015) reported that availability of water is very crucial as an inevitable input, especially in areas where vegetable production lacks this input due to scarcity and or irregular distribution of rainfall. Efficient use of water by irrigation is becoming increasingly important, and alternative water application methods such as drip and sprinkler, may contribute substantially to the best use of water for agriculture and improving irrigation efficiency. The trend in recent years has been towards conversion of surface to drip irrigation which is considered to be a more efficient delivery system. Irrigation water scheduling is very critical to making the most efficient use of drip irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production. On the other hand, the intensity of the operation requires that the soil water supply be kept at the optimal level to maximize returns to the farmer.

High-frequency water management by drip irrigation minimizes soil as a storage reservoir for water, provides at least daily requirements of water to a portion of the root zone of each plant, and maintains a high soil metric potential in the rhizosphere to reduce plant water stress. Okra is an annual herb and vegetable crop grown throughout the tropical and subtropical parts of the world either as the sole crop or intercrop with maize or another (Abd El-Kader et al., 2010). IDI has considerable advantages over furrow or even SI in terms of water application efficiency and has created interest among the farmers because of less water requirement, increased production and better quality production (Abubaker et al., 2014). It is very important to carry out a study on the best irrigation system that is most suitable for the production of okra in Nigeria in order to maximize profit and at the same time reduce the cost of production.

MATERIAL AND METHOD

Location of the Experimental Field and Land Preparation

The improvised drip and sprinkler irrigation field was located at the Processing Centre of Agricultural and Bio-Environmental Engineering Department, School of Engineering of the Federal Polytechnic, Ado Ekiti, Ekiti State, Nigeria. The plot has a flat topography and the area was chosen for its suitable soil structure, texture, water retention capacity, loamy fertile soil, nearness to water source (well) and availability of power supply to operate the electric water pump.Land preparation involved the use of tractor for ploughing and harrowing. The levelling was done manually by using hoes, spade and cutlass to make it suitable for undisturbed, unobstructed free flow of water and good crop management. If the field is not properly levelled, water may stagnate in the depressions whereas higher parts may lack necessary water. This may eventually results to uneven water distribution, uneven crop emergence and uneven early growth, uneven fertilizer distribution and possibly unwanted weeds. Total experimental plot of 27.0 m^2 by 12.0 m^2 was used.

Irrigation Designs

The purpose of irrigation layout is to transmit information from engineering plans to the irrigation field. This will locate the work and provide such lines and elevations as needed for the development of IDI and SI systems. Pictorial details of IDI andSI layouts are shown in Figures 2a and 2b below, respectively.

Fig. 2a - IDI layout

Fig. 2b - SI layout

Pump Design and Selection for Sprinkler Irrigation System

Pump design and selection involved the design and selection of the most suitable pump for sprinkler irrigation field. The most suitable pump obtained was 2.20 hp and the details of pump design and selection calculation is as follows:

Design calculations

$$P = Qpg H \tag{1}$$

where:

P = required pump power (hp). Q = total discharge (m^3/s).

p = pressure head $\left(\frac{\mathrm{N}}{\mathrm{m}^{-2}}\right)$. g = acceleration due to gravity (m/s^2).

H = total head losses (m)

$$H = (\text{foot valve head loss} + \text{elbows head loss} + \text{union head loss} + \text{socket head loss} + \text{T} - \text{joint head loss} + \text{stopper head loss} + \text{riser head loss} + \text{other l} \tag{2}$$

Head losses

Suction

Foot valve

$h_v = \frac{kv^2}{2g} = \frac{1.55(1)^2}{2 \times 9.81}$ = 0.07900m =7.900 × 10^{-2}m

Elbow

$h_{el} = \frac{kv^2}{2g} = \frac{2.2(1)^2}{2 \times 9.81}$ = 0.01121 = 1.121 × 10^{-1} × 2 = 0.2242 m = 2.242 × 10^{-1}m

Union

$h_u = \frac{kv^2}{2g} = \frac{0.4(1)^2}{2 \times 9.81}$ = 0.002039 = 2.039 × 10^{-3} m

<u>Socket</u>

$h_s = \frac{kv^2}{2g} = \frac{2.2(1)^2}{2 \times 9.81}$ = 0.01121 = 1.121 × 10^{-1} × 2= 0.2242 = 2.242 × 10^{-1}m

MAIN

Elbow

$h_{mel} = \frac{kv^2}{2g} = \frac{2.2(1)^2}{2 \times 9.81}$ = 0.01121 = 1.121 × 10^{-1} m

SUBMAIN

T- Joint

$h_{tj} = \frac{kv^2}{2g} = \frac{1.8(1)^2}{2 \times 9.81}$ = 0.09174 × 4 = 3.670 × 10^{-1} m

Socket

$h_{ss} = \frac{kv^2}{2g} = \frac{2.2(1)^2}{2 \times 9.81}$ = 0.01121 × 4= 0.3363 = 3.363 × 10^{-1} m

Stopper

$h_{stp} = \frac{kv^2}{2g} = \frac{2.2(1)^2}{2 \times 9.81}$ = 0.01121= 1.121 × 10^{-1} × 2=0.2242 = 2.242 × 10^{-1} m

LATERAL

Ball valve

$h_{bv} = \frac{kv^2}{2g} = \frac{0.20(0.71)^2}{2 \times 9.81}$ = 0.005139 =0.005139 × 3=0.01542 = 1.542 × 10^{-2} m

T- Joint

$h_{ltj} = \frac{kv^2}{2g} = \frac{1.8(0.71)^2}{2 \times 9.81}$ = 0.04625 =0.04625 × 9 = 0.4163 = 4.163 × 10^{-1} m

Stopper

$h_{lstp} = \frac{kv^2}{2g} = \frac{2.2(0.71)^2}{2 \times 9.81}$ = 0.05652 = 0.05652 × 3= 0.1696 = 1.696 × 10^{-1} m

Riser

$h_{lr} = \frac{kv^2}{2g} = \frac{2.2(0.57)^2}{2 \times 9.81}$ = 0.03643 = 0.03643 ×9 = 0.3279 = 3.279 × 10^{-1} m

Suction = 12.4 m

Main = 5.3 m

Sub-main = 15 m

Lateral = 15 × 3 = 45 m

Riser = 0.4 × 9 = 3.6 m

$$h_{fs} = \left(\frac{2.160 \times 10^{-3} \times 12.4^{0.54}}{(0.283 \times 100)0.0508^{2.85}}\right)^{1.85} = \left(\frac{0.008412}{0.01297}\right)^{1.85} = 0.4489 \text{ m}$$

$$h_{fm} = \left(\frac{2.160 \times 10^{-3} \times 5.3^{0.54}}{(0.283 \times 100)0.0508^{2.85}}\right)^{1.85} = \left(\frac{0.005316}{0.01297}\right)^{1.85} = 0.1920 \text{ m}$$

$$h_{fs2} = \left(\frac{2.160 \times 10^{-3} \times 15^{0.54}}{(0.283 \times 100)0.0508^{2.85}}\right)^{1.85} = \left(\frac{0.009323}{0.01297}\right)^{1.85} = 0.5429 \text{ m}$$

$$h_{fi2} = \left(\frac{4.909 \times 10^{-4} \times 45^{0.54}}{(0.283 \times 100)0.0254^{2.85}}\right)^{1.85} = \left(\frac{0.003835}{0.002169}\right)^{1.85} = 2.870 \text{ m}$$

$$h_{fi3} = \left(\frac{2.0224 \times 10^{-3} \times 45^{0.54}}{(0.283 \times 100)0.01905^{2.85}}\right)^{1.85} = \left(\frac{0.004042}{0.001033}\right)^{1.85} = 12.48 \text{ m}$$

Other losses = 0.500 m

Using equations 1.0 and 2.0 above;

H = (0.007900 + 0.2242 + 0.002039 + 0.2242 + 0.112 + 0.3670 + 0.3363 + 0.2242 + 0.01542 + 0.4163 + 0.1696 + 0.3279 + 0.4489 + 0.1920 + 0.5429 + 2.870 + 12.48 + 0.500) m

=19.126698 m

$$P = 1.7989 \times 10^{-3} \times 1000 \times 9.81 \times 19.126698 = 337.5478\text{W} = \frac{745.7}{337.5478} = 2.209168598 \text{ hp}$$

P = 2.2 hp

Installation procedure

Drip Irrigation and Sprinkler Irrigation System

In drip irrigation system, the two drums were placed on the raised platform that serve as water reservoir, the main pipe, sub- main pipe, lateral (PVC) pipes were measured and cut into difference sizes with measuring tape and saw, respectively. The pipe was connected to the reservoir with the aids of a valve, the screen filter was attached, and then a quick coupling elbow was used in the coupling of the main line of the length 450.0 m. The lateral line of 210.0 m was fixed on the main line at equal interval from each other. In sprinkler irrigation system, the suction pipe, main pipe, sub-main pipe, lateral and risers were measured and cut into different sizes with measuring tape and saw, respectively. The pipes were proportionally positioned and buried at the predetermined depth in the soil. The water pump was well positioned and the suction line was immersed in the well and connected to the pump through the inlet point, while the main pipe was connected to the pump outlet at the other end. The riser was connected to the laterals at regular intervals. The layout of IDI and SI systems are clearly illustrated below in Figures 3a and 3b, respectively.

Fig. 3a - Layout of the IDI system

Fig. 3b - Layout of SI system

Planting of Okra and Data Collection

Planting of Okra

Before planting of the seeds, the irrigation system was tested by pre-irrigation in order to locate and correct any high or low spots which can lead to uneven water supply to the plants. The okra seeds were planted at 2.0 cm depth with 60.0 cm interval, the weeding was carried out manually on both plots. The same treatments and measurements were carried out on the IDI and SI systems and controlled at the same time on the same day to avoid predisposition of the results. The pesticide and NPK fertilizer were applied to control the diseases and increase the quality and quantity of okra yields from both systems.

Fig. 4a - Testing of SI system

Fig. 4b - Testing of IDI system

Data collection and Analysis

The moisture content and soil temperature were measured by means of soil moisture and soil thermometers, respectively from the day of planting to the maturity stage of the plants. The following agronomic parameters were measured and recorded: height, girth, number of leaves, flowers and buds, using digital weighing balance with accuracy of ± 0.01g. The consumptive water used of okra under IDI and SI systems were measured and recorded. These agronomic data collected were analysed using Completely Randomized Blocked Design (CRBD) ANOVA method.

RESULTS

The results are illustrated in the graphs below and show the performance of okra under IDI and SI systems. The data were collected between 25th of February and 18th of May, running through 99 days:

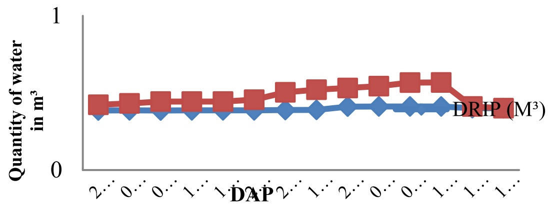

Fig. 5 - Quantity of water (m³) against DAP

From Figure 5 above the quality of water has linear relationship with DAP both for the IDI and SI systems. Statistical result shows that there is significant difference between the two systems of irrigation used. However, Saxena et al., (2013) justified this fact.

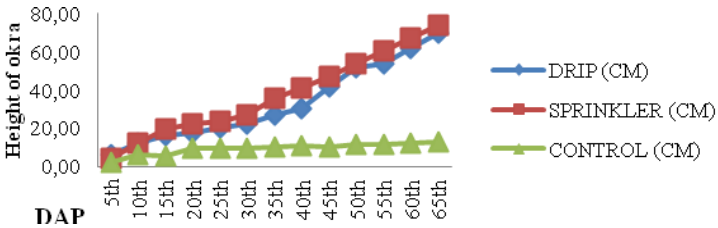

Fig. 6 - Height of okra (cm) against DAP

Figure 6 illustrates the results obtained for height of okra against DAP and statistical analysis proved that there is significant difference in the methods used with respect to the height of okra for IDI, SI and the control (Okunade et al., 2009; Choudhary et al., 2012).

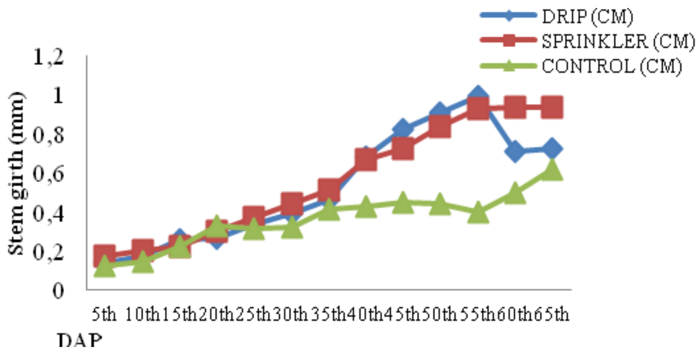

Fig. 7 - Stem girth of okra against DAP

From Figure 7 results indicated that there is no significant difference in the methods used with respect to the Stem girth of okra against DAP.

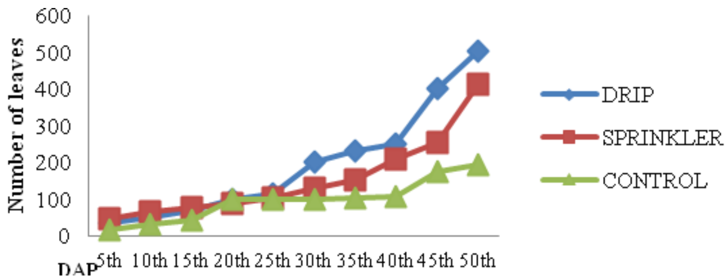

Fig. 8 - Number of leaves against DAP

Figure 8 above demonstrates the relationship between number of leaves against DAP; from the results obtained there is significant differences at 0.05 percent.

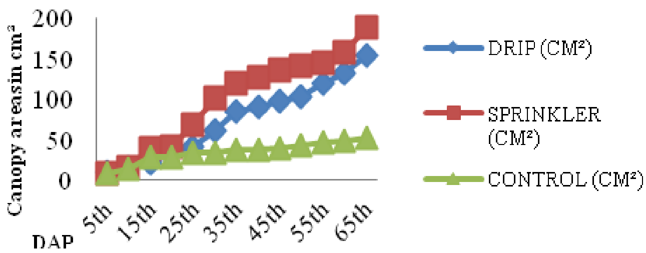

Fig. 9 - Okra canopy area against DAP

There is linear increase in the canopy area of okra (Figure 9) as the DAP increases and the analysis disclosed that there is significant differences in the two systems used. Babar et al., (2008) obtained similar results in their study.

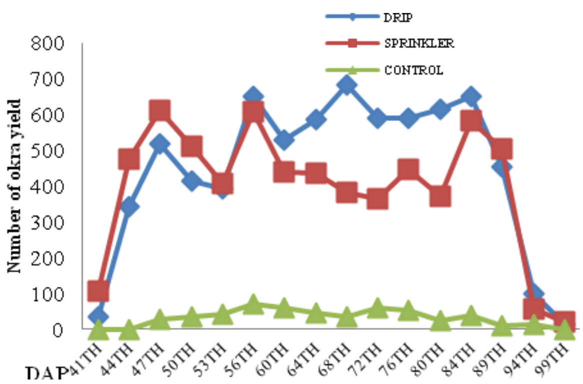

Fig. 10 - Number of okra yield against DAP

Based on the above results in Fig. 10, the analysis carried out proved that there is significant difference in the systems used with respect to the number of okra yield against DAP (Jayapiratha, et al., 2010).

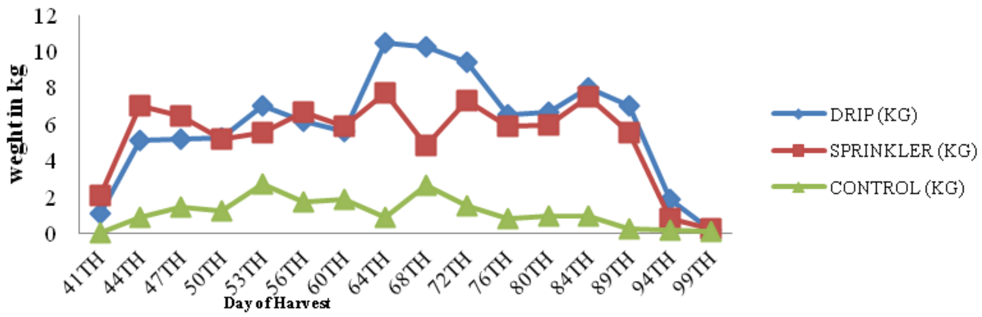

Figure 11 - Weight of okra (kgha^{-1}) against day after harvest

The Figure 11 above displayed the relationship between the weight of okra against day after harvest, the relationship is linear and there significant difference in the two systems (Danso et al., 2015).

CONCLUSIONS

Different irrigation systems play a noteworthy role in okra production. Therefore, for maximum land and water utilization as well as production of okra call for an effective irrigation system. This study clearly revealed better plant growth, high water use efficiency and enhancement in the yield under IDI system when compared to the SI system.

Recommendations

Based on the comparative assessment carried out, the following recommendations are suggested to enhance better performance of the system in future:

1. Further study should be carried out using more standard IDI system and field for the production of other crops and vegetable.
2. Comprehensive performance evaluation of IDI system using other types of irrigation systems.
3. The same study could be carried out with different fertilizers with manure on different soil types.
4. Same study but emphasis on the effect of the systems on the germination and growth processes on okra.

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REGULATING THE MOISTURE OF OILSEED MATERIAL IN A TOASTER FOR VEGETABLE OILS EXTRACTION
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РЕГУЛИРАНЕ НА ВЛАЖНОСТТА НА ЗЪРНЕН МАТЕРИАЛ В ПЕКАЧ ЗА ИЗВЛИЧАНЕ НА РАСТИТЕЛНИ МАСЛА

Lecturer Ph.D. Eng. Kadirova S. Y.
Rousse University "Angel Kunchev", Faculty of Electrical Engineering, Electronics and Automation / Bulgaria;
Tel: 00359 877 089537; E-mail: skadirova@ecs.uni-rue.bg

Keywords: *oilseed moisture, thermal-moisture treatment, electronic system, simulation model.*

ABSTRACT

The influence of the moisture in the process of thermal-moisture treatment of oilseed material has been determined. The behaviour of the electronic system for adjustment of oilseed moisture has been investigated. For this purpose, experimental data on the current moisture values have been obtained in treatment period via grain sample method. The obtained experimental data have been statistically compared with the simulation results from a model, which describes the thermal-moisture process.

РЕЗЮМЕ

Определено е влиянието на влажността на зърнения материал в процеса на добиване на растително масло. Изследвано е поведението на електронна система за регулиране влажността на зърнения материал. За целта са получени експериментални данни за моментната стойност на влажността в периода на обработка чрез зърнена проба. Тези данни са статистически съпоставени със симулационни резултати от предварително разработен модел, описващ влаготоплинния процес.

INTRODUCTION

The first operation after harvesting the oilseeds involves grinding, and then heat and moisture treatment. Decortication or shelling separates the oil-bearing portion of the raw material and eliminates the parts that have little or no nutritional value. Small-scale mechanical shellers are available for kernels and nuts although manual cracking is still prevalent. Most oil seeds and nuts are heat-treated by roasting to liquify the oil in the plant cells and facilitate its release during extraction. To increase the surface area and maximize oil yield, the oil-bearing part of groundnuts, sunflower, sesame, coconut, palm kernel and sheanuts is reduced in size. Mechanical discattrition mills are commonly used in rural operations *(Kabutey et al, 2011; Kadirova S., Manukova A., 2009; Manukova A., Kadirova S., 2009; Sigalingging, R. et al, 2014)*.

Moreover, mechanical pressing is most popular method in the world to separate oil from vegetable seeds crops. Thus, the impact of several variables on oil recovery, oil quality, rupture force of seeds, deformation, and energy cost for pressing is essential for an adequate design of equipment for pressing seeds crops *(Sigalingging, R., et al, 2014).* Heat treatment before extrusion is necessary for improvement of the amount of recovered oil. Pre-treatment has a significant impact on the efficiency of pressing *(Sayyar, S., et al 2009; Willems, P. et al, 2008; Кадирова С., Манукова А., 2009; Кадирова, С. 2008; Kadirova S., Manukova A., 2009; Sigalingging, R et al, 2014; Herák, D., et al 2013; Kabutey, A., et al, 2012.).*

The main point of thermal-moisture processing of meal is accomplished in the simultaneous action of water vapour and heat to the cells of the milled mass. Oleaginous cells consist of two main parts - a hydrophilic, which is associated with the water (carbohydrates, proteins and other nitrogen-containing substances) and hydrophobic, which is not associated with the water (oil and other substances dissolved therein). During the heating of the meal, the water contained in the cells, is associated with the hydrophilic portion that swells and intersects - coagulate. It is thus a sharp demarcation between hydrophilic and hydrophobic phase. To suppress the hydrophilic phase it is necessary a precisely defined amount of water. If naturally the water content of meal is insufficient, then it has to be additionally moistened by water or by wet steam *(Sigalingging, R et al, 2014; Herák, D., et al, 2013; Kabutey, A., et al, 2012)*.

The dynamics of variation of meal moisture and temperature as a function of time depends on many interdependent factors. The main parameters are the temperature values of the heating fluid and the incoming meal, the initial moisture content of meal, the relative weight of dry basis, thermal conductivity, heat exchange etc. The recognition of their influence during the thermal-moisture processing of the meal is possible based on the simulation model (*Кадирова, С. 2008; Herák, D., et al 2013; Kabutey, A., et al, 2012)*.

The moisture content of the meal is necessary to be controlled in each stage of the process. It significantly affects the quality of the treatment, which is necessary for the next operation, for extrusion. This requires control of meal moisture variation in all stages of the process (*Herák, D., et al, 2013, Кадирова, С. 2008).*

The aim of the publication is to investigate the efficiency of the developed electronic system for control of moisture content in the thermal-moisture treatment of meal.

MATERIAL AND METHOD

The structure of the investigated system is presented in Fig. 1. In the current research the parameters of corn-germ meal are investigated. Starting of the system begins with entering of initial conditions - kind of oilseed material and kind of treatment in depend of the next stage of the technological process for oil extraction. The initial moisture and specific density of incoming meal are determined by grain sample method, as there is a possibility for process interruption to enter data and to change the treatment parameters. The opportunity for simulation of the process for two main technological operations is provided in the developed software. They respectively are thermal-moisture treatment of meal for full pressing, and treatment for pre-pressing and next chemical extraction *(Manukova A., Kadirova S., 2009).*

Because of the continuous character of the process the meal in the toaster passes through the sections for exact duration, which depends of the current values of temperature and moisture content of the treated meal. The heating of the material is done indirectly by energy exchange between the meal and heating fluid through the metal wall of the toaster. The surface of the toaster is heated by the fluid circulating in the heating chamber. The meal is processing as it contacts with the heated surface of the section and receives its heating energy via heat exchange.

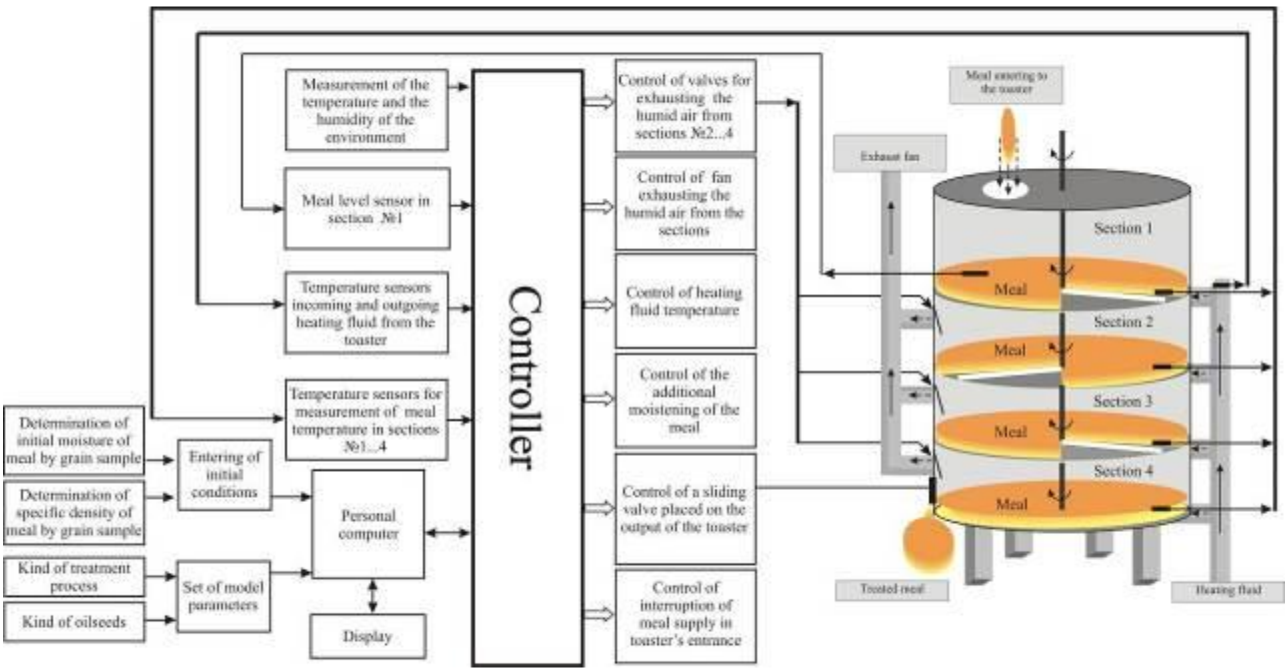

Fig.1 - Structure of the electronic system for control of thermal-moisture processing of oilseeds in a toaster for extraction of vegetable oils

The temperature and humidity of the ambient air are important input data for the environment parameters and they influence the processes' control. The steam saturated air from the section is exhausted by external vent pipe with exhaust fan, as at the output of each section are installed control valves. The initial moisture content of treated oilseeds is determined by grain sample method before it enters into the toaster. The current moisture content of meal is calculated by the proposed model at each stage of the processing. In case of not corresponding to moisture requirements, proposed in the criteria, the electronic system controls the operating mechanisms *(Кадирова С., Манукова. А., 2009)*.

Toaster's sections are closed vessels containing free airspace intended to absorb the moisture evaporated from meal during heating. This provides a better moisture exchange between the air and the processed material, which helps to intensive evaporation process of the material and leading away the humid air from the toaster. The movement of meal from one section of the toaster to the other one is realized by cross valves, connected to a mechanical system. It provides constant and uniform passing of meal in the toaster by an exact preliminary defined step in time as well as the quantity of treated meal. In each section are placed temperature sensors for control of the meal temperature in real time.

The amount of the discharging meal is controlled by a sliding valve, placed in section №4. The sliding valve is controlled by the electronic system based on the results obtained from process simulation via the developed model compared with the measured values of parameters at the current time. The positioner helps to position the operating mechanism of a sliding valve to a desired position. Thereby the treated material is being discharged from the toaster at the exact time which leads to a significant increase in system efficiency by reducing the material's duration of stay in the toaster and reduces the energy consumption.

RESULTS

For investigation of the efficiency of the developed electronic control system some experimental studies are implemented. They are based on the variance of the meal moisture. During the experiment the values of the meal moistures at the exit of each section have been measured at each 10 minutes because the process has a significant inertness.

The results are presented in tabular and graphic form. In the control points of the technological scheme the current values of the meal moisture of the experimentally obtained results are compared with simulation data from developed software. The software is based on literary and experimental data. The root-mean-square deviation, the absolute error and relative error of experimentally obtained moisture data to simulation data are estimated. The root-mean-square deviation of the current values of meal moisture at the control points is calculated by the following expression:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{n}}, \text{ [-]} \tag{1}$$

Experimental investigation at various moisture contents has been conducted and the observed data is summarized in Tables 1 to 4. In Figures 2 to 7 are presented graphical parities of change of meal moisture content in time. Studies, based on developed software model in MATLAB environment, have been conducted as the results are summarized in Tables 1 to 4.

› **<u>Comparison of the experimental data with the simulation results of the meal moisture at the output of section 1 of the toaster.</u>**

Table 1 presents the data for current values of the meal moisture at the output of section 1.

Table 1

Values of the meal moisture at the output of section 1.

Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[%]	[%]	[-]	[%]	[%]	[min]	[%]	[%]	[-]	[%]	[%]
10	9.5	10.5	0.81	0.9	2.26	110	9.4	10.2	0.64	0.8	2.04
20	9.7	9.9	0.04	0.2	0.51	120	10.3	9.1	1.44	1.2	3.09
30	9.3	10.1	0.64	0.8	2.06	130	9.7	10.1	0.16	0.4	1.01
40	9.9	9.1	0.64	0.8	2.11	140	10.2	8.8	1.96	1.4	3.68
50	10.1	10.2	0.01	0.1	0.25	150	10.4	9.6	0.64	0.8	2.00
60	9.7	10.4	0.49	0.7	1.74	160	9.7	10.2	0.25	0.5	1.26
70	8.8	9.7	0.81	0.9	2.43	170	9.2	10.1	0.81	0.9	2.33
80	9.6	10.1	0.25	0.5	1.27	180	9.9	9.7	0.04	0.2	0.51
90	10.2	8.9	1.69	1.3	3.40	190	9.8	9.9	0.01	0.1	0.25
100	10.1	9.5	0.36	0.6	1.53	200	10.2	9.6	0.36	0.6	1.52

The root-mean-square deviation of meal moisture at the output of section 1 of the toaster is $\sigma = 0.77\%$. At the current moisture values the calculated average value of the absolute error is $\varepsilon_{abs} = 0.69\%$, as the relative is ε_{rel}=1.76%.

Fig. 2 illustrates the change of meal moisture at the output of section 1. The moisture range of the meal is within the field of defined criterial diapason. The results presented in Fig. 2 are obtained from the simulation model, and the experimental ones are measured in the real toaster.

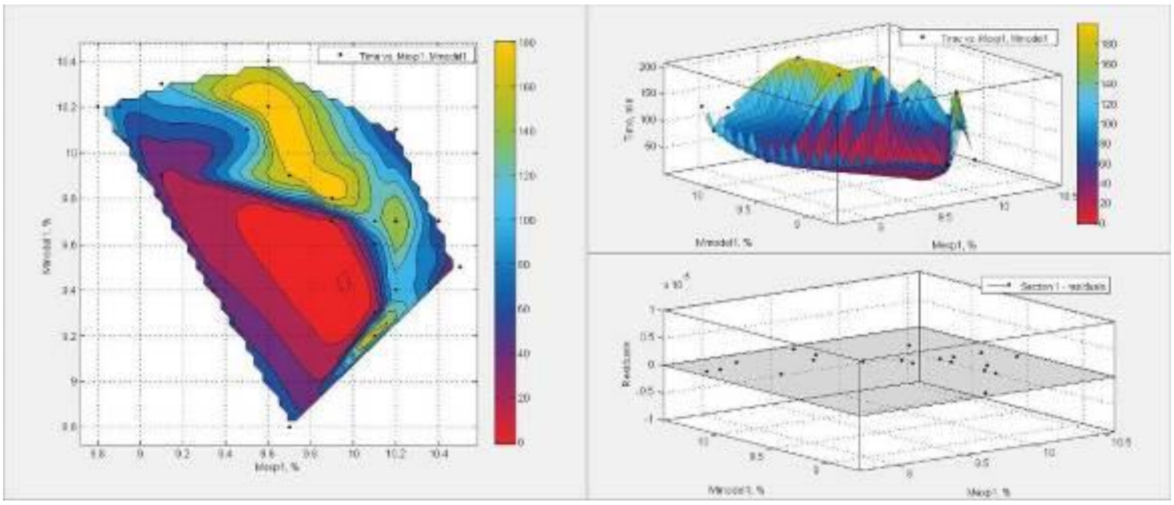

Fig. 2 - Variation of the meal moisture at the output of section 1 in dependence of time

During the model simulation the variation of moisture values is in the range of $M_{meal\_section\_1\_model}$ = (10.4…8.8) %, and the experimentally measured in the installation are $M_{meal\_section\_1\_exp}$ = (10.5…8.8) %. For section 1 the diapason of change of the meal moisture is $M_{meal\_section\_1\_criteria}$ = (11…9.5) %. Therefore, the technological requirements for the range of moisture change in section 1 of the toaster are adhered.

› **Comparison of the experimental data with the simulation results of the meal moisture at the output of section 2 of the toaster.**

Table 2 presents the data for current values of the meal moisture at the output of section 2.

Table 2

Values of the meal moisture at the output of section 2.

Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[%]	[%]	[-]	[%]	[%]	[min]	[%]	[%]	[-]	[%]	[%]
10	7.7	7.9	0.04	0.2	0.64	110	7.6	7.8	0.04	0.2	0.65
20	7.4	7.6	0.04	0.2	0.67	120	8	7.6	0.16	0.4	1.28
30	7.8	7.4	0.16	0.4	1.32	130	8.2	8	0.04	0.2	0.62
40	7.7	8.2	0.25	0.5	1.57	140	7.5	8.2	0.49	0.7	2.23
50	7.9	7.7	0.04	0.2	0.64	150	7.6	7.5	0.01	0.1	0.33
60	7.8	7.6	0.04	0.2	0.65	160	7.6	7.9	0.09	0.3	0.97
70	8.1	7.9	0.04	0.2	0.62	170	7.9	7.8	0.01	0.1	0.32
80	8	7.6	0.16	0.4	1.28	180	7.6	8.1	0.25	0.5	1.59
90	7.8	8.1	0.09	0.3	0.94	190	8.1	7.6	0.25	0.5	1.59
100	7.5	8.3	0.64	0.8	2.53	200	7.9	7.8	0.01	0.1	0.32

The root-mean-square deviation of meal moisture at the output of section 2 of the toaster is $\sigma = 0.38°C$. At the current moisture values the calculated average value of the absolute error is $\varepsilon_{abs} = 0.33\%$, as the relative is $\varepsilon_{rel} = 1.04\%$.

Fig. 3 illustrates the change of meal moisture at the output of section 2. The moisture range of the meal is within the field of defined criterial diapason. The results presented in Fig. 3 are obtained from the simulation model, and the experimental ones are measured in the real toaster.

During the model simulation the variation of moisture values is in the range of $M_{meal\_section\_1\_model}$ = (8.2…7.4) %, and the experimentally measured in the installation are $M_{meal\_section\_1\_exp}$ = (8.3…7.4) %. For section 2 the diapason of change of the meal moisture is $M_{meal\_section\_1\_criteria}$ = (9.5…7) %. Therefore, the technological requirements for the range of moisture change in section 2 of the toaster are adhered.

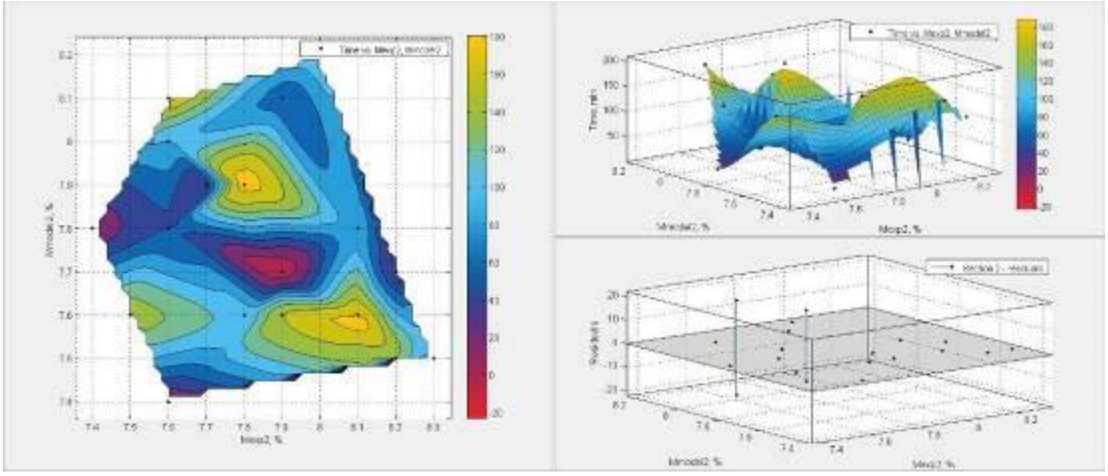

Fig. 3 - Variation of the meal moisture at the output of section 2 in dependence of time

› **Comparison of the experimental data with the simulation results of the meal moisture at the output of section 3 of the toaster.**

Table 3 presents the data for current values of the meal moisture at the output of section 3.

Table 3

Values of the meal moisture at the output of section 3.

Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[%]	[%]	[-]	[%]	[%]	[min]	[%]	[%]	[-]	[%]	[%]
10	5	5.5	0.25	0.5	2.38	110	5.3	5.6	0.09	0.3	1.38
20	5.7	5.6	0.01	0.1	0.44	120	5.2	5.9	0.49	0.7	3.15
30	5.8	5.3	0.25	0.5	2.25	130	5.6	5.7	0.01	0.1	0.44
40	5.4	5.4	0	0	0.00	140	5.1	5.2	0.01	0.1	0.49
50	5.3	5.8	0.25	0.5	2.25	150	5.2	5.4	0.04	0.2	0.94
60	5.5	5.6	0.01	0.1	0.45	160	5.3	5.2	0.01	0.1	0.48
70	5.2	5	0.04	0.2	0.98	170	5.7	5.3	0.16	0.4	1.82
80	5.4	5.2	0.04	0.2	0.94	180	5.3	5.8	0.25	0.5	2.25
90	5.3	5.7	0.16	0.4	1.82	190	5.1	5.5	0.16	0.4	1.89
100	5.6	5.8	0.04	0.2	0.88	200	5.2	5.3	0.01	0.1	0.48

The root-mean-square deviation of meal moisture at the output of section 3 of the toaster is $\sigma = 0.34$. At the current moisture values the calculated average value of the absolute error is $\varepsilon_{abs} = 0.28\%$, as the relative is $\varepsilon_{rel} = 1.29\%$.

Figure 4 illustrates the change of meal moisture at the output of section 3. The moisture range of the meal is within the field of defined criterial diapason. The results presented in Fig. 4 are obtained from the simulation model, and the experimental ones are measured in the real toaster.

During the model simulation the variation of moisture values is in the range of $M_{meal\_section\_1\_model}$ = (5.8…5.0) %, and the experimentally measured in the installation are $M_{meal\_section\_1\_exp}$ = (5.9…5.0) %. For section 3 the diapason of change of the meal moisture is $M_{meal\_section\_1\_criteria}$ = (7…4.5) %. Therefore, the technological requirements for the range of moisture change in section 3 of the toaster are adhered.

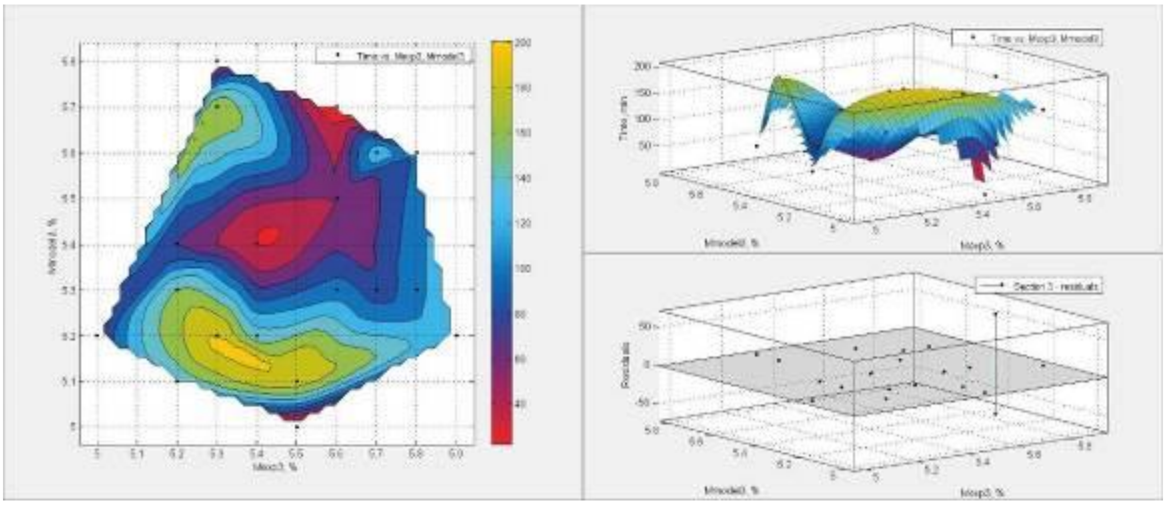

Fig. 4 - Variation of the meal moisture at the output of section 3 in dependence of time

› **Comparison of the experimental data with the simulation results of the meal moisture at the output of section 4 of the toaster.**

Table 4 presents the data for current values of the meal moisture at the output of section 4 (output of the toaster).

Table 4

Values of the meal moisture at the output of the toaster.

Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	M_{ml}, model	M_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[%]	[%]	[-]	[%]	[%]	[min]	[%]	[%]	[-]	[%]	[%]
10	3.2	2.9	0.09	0.3	2.46	110	2.8	3.1	0.09	0.3	2.54
20	2.5	2.7	0.04	0.2	1.92	120	3.1	2.8	0.09	0.3	2.54
30	2.7	2.6	0.01	0.1	0.94	130	3	2.9	0.01	0.1	0.85
40	2.8	2.9	0.01	0.1	0.88	140	2.5	2.6	0.01	0.1	0.98
50	2.6	3.1	0.25	0.5	4.39	150	2.9	2.6	0.09	0.3	2.73
60	2.9	2.7	0.04	0.2	1.79	160	2.8	2.9	0.01	0.1	0.88
70	3.1	2.5	0.36	0.6	5.36	170	2.9	3.1	0.04	0.2	1.67
80	3.2	2.7	0.25	0.5	4.24	180	2.6	2.9	0.09	0.3	2.73
90	3.2	2.9	0.09	0.3	2.46	190	2.5	2.9	0.16	0.4	3.70
100	2.9	2.8	0.01	0.1	0.88	200	2.6	2.8	0.04	0.2	1.85

The root-mean-square deviation of meal moisture at the output of section 3 of the toaster is $\sigma = 0.3$. At the current moisture values the calculated average value of the absolute error is $\varepsilon_{abs} = 0.26°C$, as the relative is $\varepsilon_{rel} = 2.29\%$.

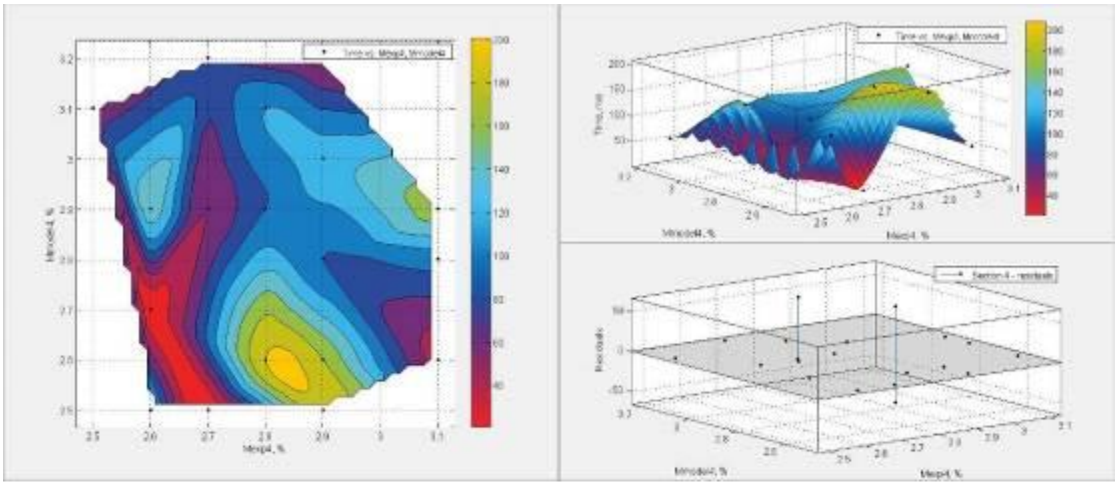

Fig. 5 - Variation of the meal moisture at the output of section 4 in dependence of time

Fig. 5 illustrates the change of meal moisture at the output of section 4. The moisture range of the meal is within the field of defined criterial diapason. The results presented in Fig. 5 are obtained from the simulation model, and the experimental ones are measured in the real toaster.

During the model simulation the variation of moisture values is in the range of $M_{meal\_section\_4\_model}$ = (5.8…5.0) %, and the experimentally measured in the installation are $M_{meal\_section\_4\_exp}$ = (5.9…5.0) %. For section 4 the diapason of change of the meal moisture is $M_{meal\_section\_4\_criteria}$ = (4.5…2.5) %.Therefore, the technological requirements for the range of moisture change in section 4 of the toaster are adhered.

The graphical interpretation of the evaluation of the adequacy of the software model is presented in Fig. 6. The comparative assessment of function $M_{(ml\_model)}=f(M_{ml\_exp})$ presents a linear distribution of results which provides a high accuracy of the effectiveness of the model. The deviation of the values of the model to experimental data can be read from Figures 2 to 5, where dependence is presented in time, and the character of the results'surface is flat.

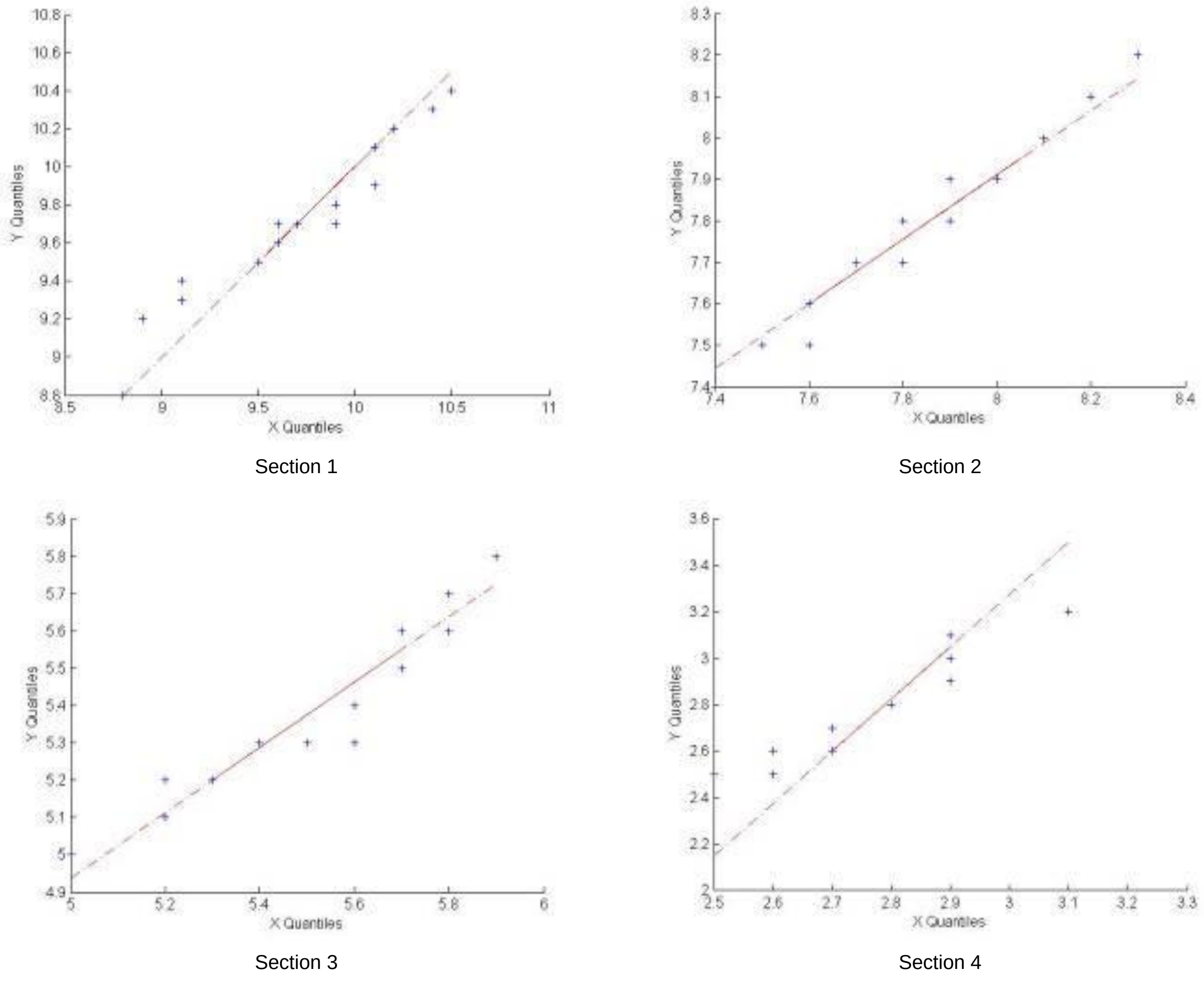

Fig. 6 - Variation of the meal moisture at the output of sections – model vs. experiment

The values of relative errors are around the permissible value of 2 %. It is highest at the last section (2.29 %) because the absolute value of the meal moisture is low and closed to 0. Although the variation of the values of the relative errors, the electronic system applies adequate control to the process and the thermal-moisture treated meal is with parameters as substantiated in the criteria.

CONCLUSIONS

The absolute and relative errors for the variation of meal moisture obtained in all control points are lower than the maximum allowable. This is an indicator for the effectiveness of the electronic system for control of meal moisture in the toaster.

The amount of the extracted corn oil increases with a decrease of moisture and increased the processing time. Results of experimental studies present that the electronic system has applied the appropriate variation of control parameters, which affect on the observing of a meal with the exact physicochemical changes and decreasing the effectiveness of the system.

The treatment for pressing meal has sufficiently plastic and elastic structure. These properties of the cooked meal are achieved by precise grinding of the oilseeds, and also by applying the most appropriate regime of thermal-moisture that provides the required temperature and moisture properties.

The regulation of the thermal-moisture treatment process via the proposed criteria for assessment of the effectiveness of the developed electronic system is based on adequate control, ensuring the reduction of technological processing time of the oilseed material and energy as it guarantees the quality of the final product.

ACKNOWLEDGEMENT

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EXPERIMENTAL EVALUATION OF LOW LEVEL BIOETHANOL-GASOLINE BLENDS ON ENGINE PERFORMANCE AND EMISSIONS
/
ZEMAS KONCENTRĀCIJAS BIOETANOLA-BENZĪNA MAISĪJUMU IETEKMES UZ MOTORA DARBĪBU UN EMISIJĀM EKSPERIMENTĀLAIS IZVĒRTĒJUMS

Asst. Prof. Ph.D. Eng. Smigins R.
Latvia University of Agriculture, Faculty of Engineering / Latvia
E-mail: ruslans.smigins@llu.lv

Keywords: *bioethanol, gasoline, emissions, power, fuel consumption*

ABSTRACT

The paper presents the results of experimental research of two low level bioethanol-gasoline blends E5 (5% bioethanol, 95% gasoline) and E10 (10% bioethanol, 90% gasoline) tested on Toyota Corolla vehicle on chassis dynamometer. The analysis of obtained results has showed that the increase of engine power and fuel consumption is slightly higher for both blends compared to gasoline, showing better perspectives for E5 than E10. Emission tests have shown increase of CO_2 and NO_x emissions for all mentioned fuels and testing conditions, as also decrease of CO and HC. The addition of bioethanol has left a positive impact on unregulated emissions, showing better reduction than for regulated emissions.

KOPSAVILKUMS

Raksts parāda eksperimentālo pētījumu rezultātus ar divu veidu etanola-benzīna maisījumiem E5 (5% bioetanols, 95% benzīns) and E10 (10% bioetanols, 90% benzīns), kas veikti ar automobili Toyota Corolla uz veltņu stenda. Iegūto rezultātu analīze parādīja motora jaudas un degvielas patēriņa nelielu pieaugumu abiem degvielu veidiem salīdzinājumā ar benzīnu, parādot labākas perspektīvas priekš E5 salīdzinājumā ar E10. Emisiju testi parādīja CO_2 un NO_x pieaugumu abām pieminētajām degvielām visos testēšanas režīmos, kā arī CO un HC samazinājumu. Bioetanola pievienošana atstāja pozitīvu efektu uz neregulētajām emisijām, parādot labāku samazinājumu nekā regulētajām emisijām.

INTRODUCTION

The use of ethanol as a transport fuel has a large history. Firstly it was used as a fuel for German's inventor Nicholas Otto prototype of today's well known four stroke Otto-cycle internal combustion engine, but the largest popularity it gets after the use in Henry Ford's model T in 1908, and also in other designed automobiles for ethanol use in 1920-s, which were designed to use corn alcohol. Different ethanol-gasoline mixtures were popular between World War I (WWI) and WWII and were used as an octane booster and were also in demand during WWII due to a fuel shortage.

One of the most popular blends, which were used in last century and is also used nowadays, is E10 or also known as "gasohol", which is a fuel mixture of 10% anhydrous ethanol and 90% gasoline and practically can be used also in modern SI engines without any modification of the engine or fuel system. Therefore, nowadays it is also used in more than 20 countries around the world. Other well known blends are E5 and E7. First one is widely used around the Europe as it is introduced as mandate blend in many EU countries, even in Latvia, to increase the share of biofuels in the conventional gasoline and fulfil Biofuels Directive *(Directive 2003/30/EC)*. Despite of that, new increase could be possible in the future to achieve Renewable Energy Directive *(Directive 2009/28/EC)* target reaching 10% share of renewable energy in transport till year 2020, which is also outlined in National Action Plans of EU Member States. In previous period reaching of outlined plans was not realized fully therefore EU Member States have to find a way how to increase biofuel consumption in their countries based on a new Directive. There are different solutions on how it could be realized: expanding the use of biofuels in non-road transport, applying high blends in road transport in niche application or increase the current blending limits till 10% *(Kampman et al, 2013)*. The last one option is most promising, but performing it still has some barriers *(Smigins and Shipkovs, 2014)*, especially those ones connected with customers – drivers usually are looking cautiously on any new fuel (like, E10) despite of slightly lower price, explaining it with fears to damage engines resulting the loss of the warranty on the car. In any case introduction of such type of fuel could help to increase the market for bioethanol, but only in combination with a reduction of the price. It is known that E10 practically does not leave any damage to the fuel system and can be used in largest part of vehicles available on the market, but for many customers there are still unknown reasons for usage of such fuel type.

Many researchers have studied the impact of the addition of oxygenates, mainly focussing on engine performance and gaseous emissions *(Bielaczyc et al, 2013; Elfasakhany, 2015)*. Results are different and could be affected by vehicle model, age and effectiveness. Besides of that, some researchers observed the generation of a variety of organic compounds during the combustion process of gasoline-bioethanol blends, which could be attributed to the bio-part in the blend *(Manzetti and Andersen, 2015)*. Totally, ethanol addition leaves positive impact on engine performance increasing torque, power and thermal efficiency, as also reduces the amounts of different components. Researchers have observed reduction in NO_x emissions testing various low level of ethanol-gasoline blends *(Yao et al, 2011)*, but others have found increase of NO_x *(Durbin et al, 2007)*. Similar situation was also observed according to HC and CO emissions, but their results are more convincing.

This paper shows investigation realized by researchers of Latvia University of Agriculture when testing different bioethanol-gasoline blends, like E5 and E10, compared to gasoline, in unmodified vehicle. Results include engine dynamical, economical and ecological factors using mentioned fuels in different testing conditions. Attention was devoted also to the unregulated emissions, which could be also included in the legislation in future.

MATERIAL AND METHOD

The impact of bioethanol added to gasoline on emissions and engine performance was tested on a *Toyota Corolla* vehicle. The main engine specifications are listed in Table 1. The engine used in the tests is a four-cylinder, four stroke, water cooled, 10.5:1 compression ratio engine with industrial application. Tests were realized in the Alternative Fuels Research Laboratory of the Latvia University of Agriculture.

Table 1

Technical characteristics of the tested vehicle

Parameter	Characteristics
Name	Toyota Corolla
Production year	2007
Engine capacity	1598 cm^3
Cylinder number and arrangement	4, in line
Compression ratio	10.5
Maximum power	81 kW at 6000 rpm
Maximum torque	150 Nm at 4800 rpm

The schematic diagram of the experimental setup used for studying engine emission characteristics, and also fuel consumption are shown in Fig. 1. Fuel consumption was measured on a laboratory chassis dynamometer MD-1750 by the AVL KMA mobile fuel measuring system. The device measures the volumetric consumption within very short measurement time and high precision (0.1% accuracy of reading). One of the main pieces of equipment is also chassis dynamometer, which is used to apply a load to the test vehicle. During the tests was obtained the power curve, necessary for engine power analysis for mentioned fuels. Fuel consumption and emission tests were realized at idling, IM-240 cycle, 50 and 90 km/h. The choice of last ones was done because it corresponds to the maximum allowed speed in Latvian urban and suburban areas. Constant speed measurements were performed for 2 minutes with reading step of 1 second. Additionally was realized a combined cycle IM-240, which simulates not only urban driving conditions, but also driving in non-urban area. The duration of the test is 240 seconds.

Emission measurements were realized by AVL SESAM *FTIR* multi-component exhaust gas measurement system, which allows to measure up to 25 gases simultaneously and some components can be calculated from this process. During research all those gases were fixed, but more detailed analysis was done only for the most essential regulated exhaust gas components: nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2) and unburned hydrocarbons (HC), as also unregulated exhaust gas components: ammonia (NH_3), methane (CH_4), acetylene (C_2H_2) and ethane (C_2H_6).

The drivability of the vehicle was unimpaired during tests; vehicle was tested with all the fuels in random order and each reading was repeated three times. The results of these three replications were averaged to decrease the uncertainty and reported.

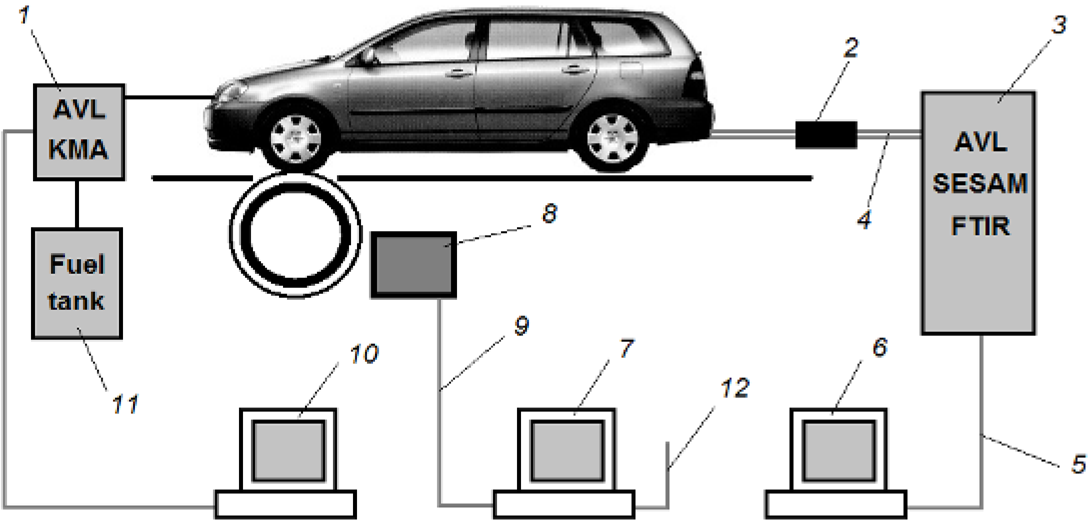

Fig.1 – Schematic diagram of the experimental setup

1 – AVL KMA Mobile Unit; 2 – heated filter; 3 – multicomponent exhaust gas measurement system AVL SESAM FTIR; 4 – heated gas line; 5 – AVL data communication cable; 6 – PC with special AVL software; 7 – Mustang chassis dyno control and data recording PC; 8 – power absorber unit; 9 – dyno date communication cable; 10 – fuel consumption and data recording; 11 – fuel tank; 12 – screen communication cable

The engine was operated on the gasoline (E0), meeting EN 228:2004 standard, and two blends containing:

- 5% (v/v) of bioethanol with 95% (v/v) of gasoline (mixture code: E5);
- 10% (v/v) of bioethanol with 90% (v/v) of gasoline (mixture code: E10).

Tested blends were prepared just before the experiments by splashing mixing technique in the proportions mentioned before.

RESULTS

The experimental data which characterize the variation of engine dynamical, economical and ecological factors using different fuels could be seen in figure below. According to test results, it could be seen increase in power with the addition of bioethanol, which could be explained by the density of the mixture and the engine volumetric efficiency, which increases based on the concentration of bioethanol increase and resulting in engine power increase. In current research it was observed the largest increase in power in range of 2000 till 3000 rpm, which is 5.2% at 2000 rpm for E5 and 5.6% at 3000 rpm for E10 (see Fig. 2). There was not observed significant increase in engine power in other speed ranges.

Based on the fuel consumption data obtained in experiments and presented in Fig. 3, it was observed an increase in fuel consumption with the addition of bioethanol in all testing conditions. Results for E5 were slightly similar comparing to gasoline and have not shown such rapid increase as E10. Largest differences were observed during idling – increase by 0.53% for E5 compared to E0 and by 1.42% for E10 compared to E0 – and during operation in 50 km/h: increase by 0.55% for E5 compared to E0 and by 1.38% for E10 compared to E0. Increase of fuel consumption could be explained by lower heating value of each additional bioethanol-gasoline blend instead of gasoline.

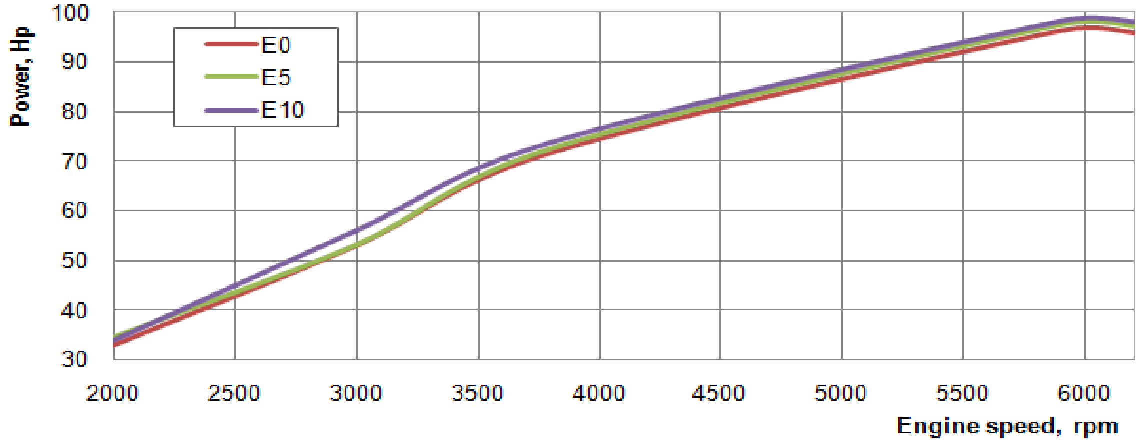

Fig.2 – Power curves for different fuels

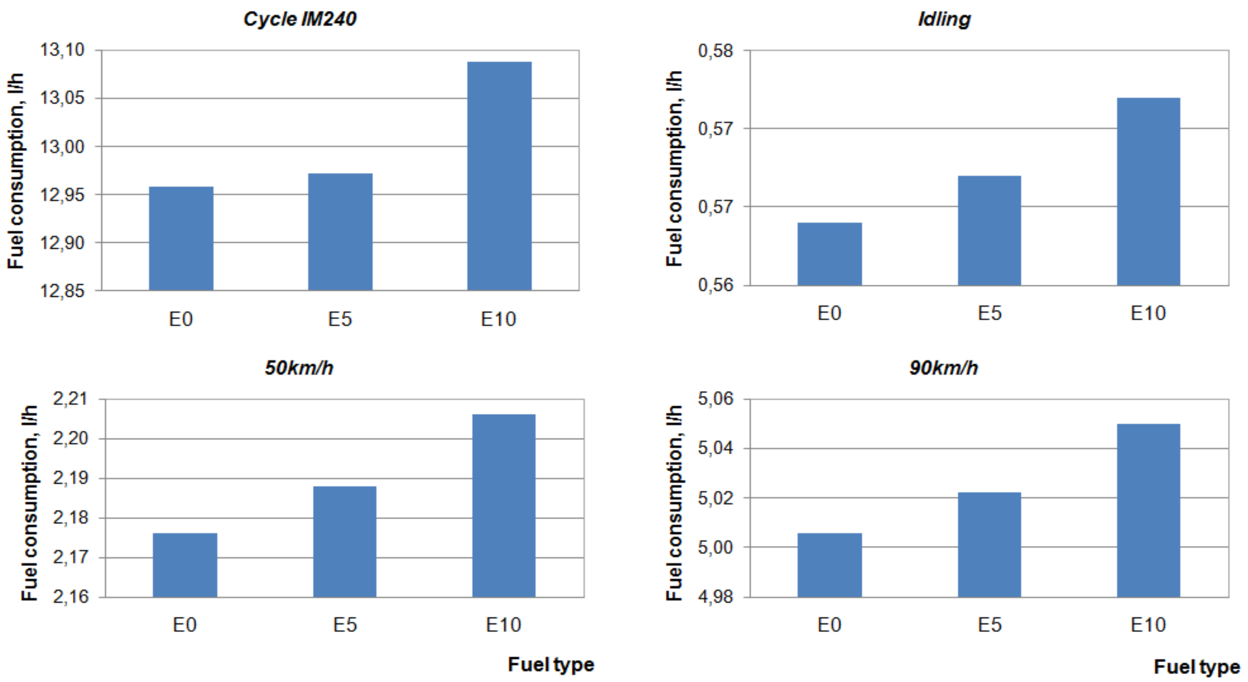

Fig.3 – Fuel consumption results in different testing conditions

Regulated emissions

Positive effect of bioethanol addition firstly could be observed according to emission reduction due to its oxygen content, which favours the further improvement of gasoline combustion. This is observed also in current tests, where was found considerable decrease of CO and HC emissions in all testing conditions. Largest reduction of CO was observed in idling almost by 98% adding even 5% of bioethanol to gasoline. Largest values for almost all tested fuels were registered at 90 km/h, and, at the same time, impact of bioethanol addition was insignificant and results were similar to gasoline. The same situation was observed also with HC emissions showing reduction in all testing conditions.

Oxygen content in blends results with opposite effect on CO_2 emissions opposed to CO – slight increase of CO_2 was fixed for almost all testing conditions for E5 and E10 compared to E0. Largest increase of CO_2 was found for E10 in idling (by 1.55%). There was also observed increase of NO_x emissions for all mentioned fuels and testing conditions. Largest increase was observed during idling and 50 km/h. Such increase in NO_x emissions could be explained by previously mentioned increase of the oxygen content in the blend resulted in increase in oxygen-to-fuel ratio in the fuel rich regions *(Masum et al, 2013)*. This stimulates more complete combustion and increase of in-cylinder temperature, which affects increase of NO_x and decrease of HC. Additional factor is also higher flame speed of bioethanol, which also assists in completing combustion.

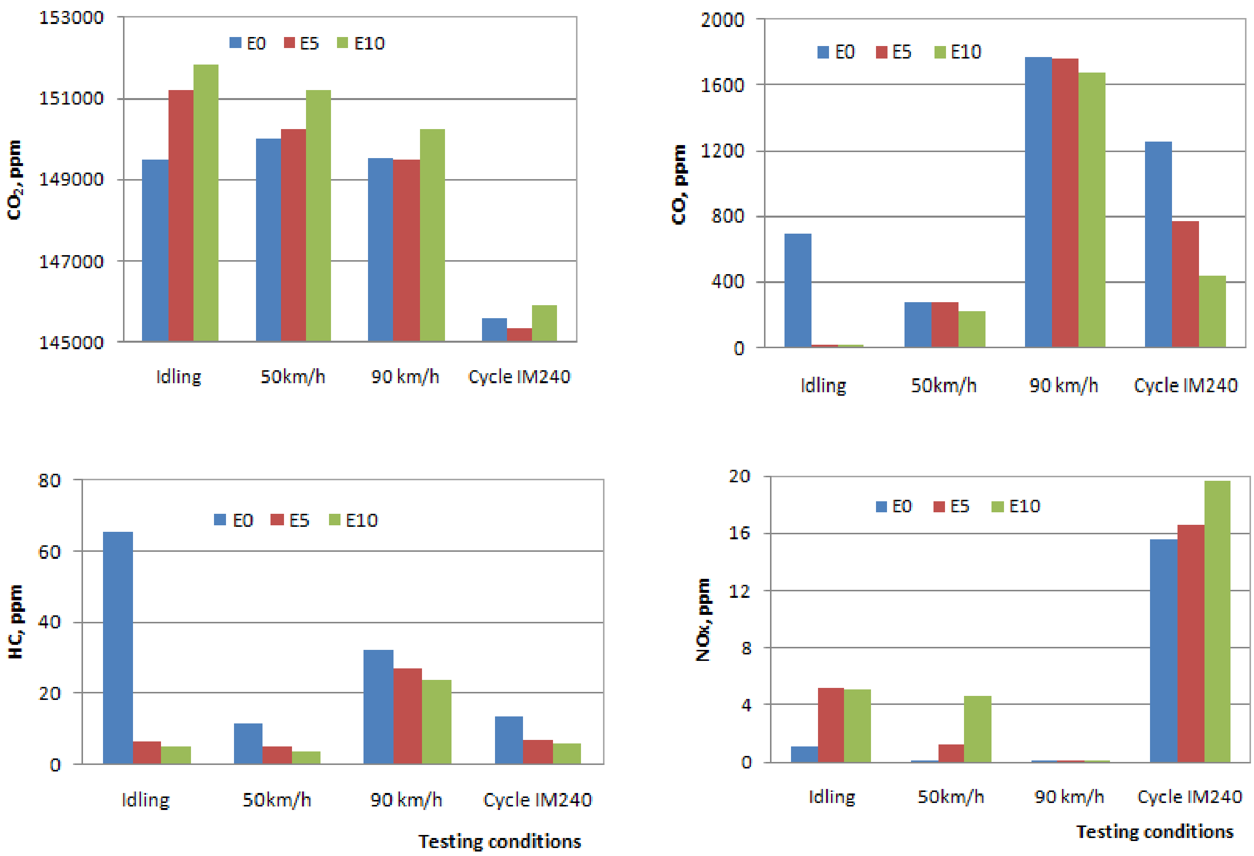

Fig. 4 – Results of regulated emissions in different testing conditions

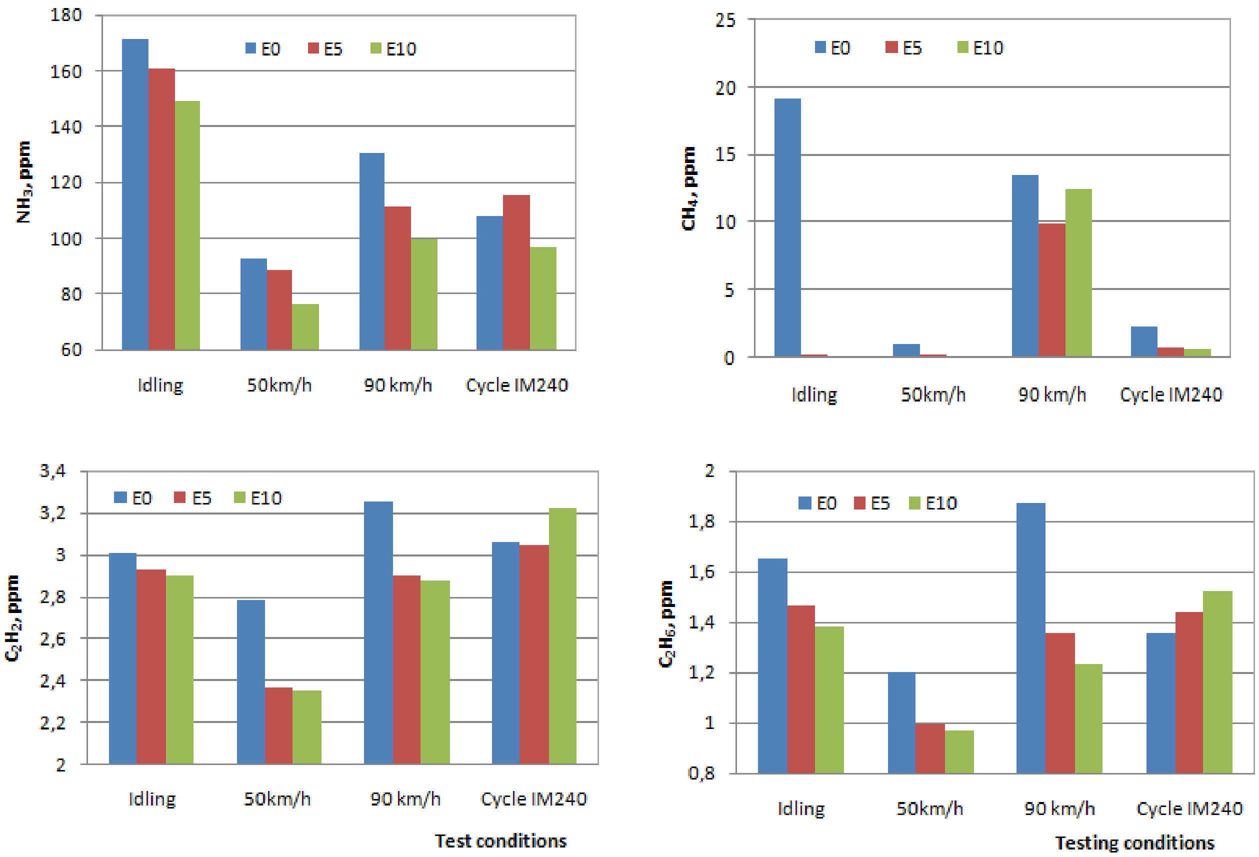

Fig. 5 – Results of unregulated emissions in different testing conditions

Unregulated emissions

The addition of bioethanol has left a positive impact to unregulated emissions, like ammonia (NH_3), methane (CH_4), acetylene (C_2H_2) and ethane (C_2H_6). Fig. 5 shows that all mentioned emissions decrease with the increasing bioethanol proportion in the fuel. It is positive as ammonia is a toxic compound and a precursor in the formation of atmospheric secondary aerosols, classified under the European dangerous substances directive (67/548/EEC), and vehicles with internal combustion engines are considered as main source of NH_3 in the urban environment *(Suarez-Bertoa et al., 2014)*. All other dominating hydrocarbons (methane, acetylene, ethan) presented in emissions showed great reduction for all blends.

CONCLUSIONS

The main objective of this experimental study was to analyze if the bioethanol addition of 5% and 10% into gasoline would have a positive effect on engine performance and emissions. The results showed positive tendency in bioethanol addition, but it also confirmed that E10 did not offer some essential advantages over the E5 in case of engine performance and regulated emissions. Most promising results were observed according to unregulated emissions. Totally, it should be noted that only certain components showed good results in tests, which were done with one vehicle. Further testing with larger number of vehicles is required, as also more detailed research in case of bioethanol-gasoline blends must be provided instead of ethanol-gasoline blends, as it emission profiles may differ in concentrations and types of emission products *(Manzetti and Andersen, 2015).*

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THE EFFECT OF SPELT ADDITION ON THE PROPERTIES OF EXTRUDED PRODUCTS WITH ENHANCED NUTRITIONAL PROPERTIES
/
WPŁYW DODATKU ORKISZU NA WŁASNOŚCI EKSTRUDOWANYCH WYROBÓW O PODWYŻSZONYCH WŁASNOŚCIACH ŻYWIENIOWYCH

PhD.Eng. Żelaziński T.*[1)], PhD. DSc. Eng. Ekielski A.[1)], MSc. Eng Siwek A.[2)], PhD. Eng. Stachelska M.[2)], PhD. Stud. Eng. Florczak I.[1)]
[1)]Department of Production Management and Engineering. Warsaw University of Life Sciences– SGGW / Poland;
[2]Food Technology and Gastronomy Institute, Lomza State University of Applied Sciences / Poland.
Tel: +48225934565; E-mail: tomasz_zelazinski@sggw.pl

Keywords: *extrusion, spelt, quality investigation*

ABSTRACT
The aim of the study was to produce extruded material with the highest possible content of spelt and to examine the qualitative properties of the products obtained. Tests were carried out on a synchronous twin-screw extruder with L:D ratio 27, at different temperatures, screw speed, material feeding and raw material moisture. To determine the quality properties there were used parameters such as density, expansion, WSI and WAI, water activity and porosity. The results were promising, all the products were characterized by a high degree of water-holding capacity, and their quality was similar to conventional corn extrudates.

ABSTRACT
Celem pracy było wytworzenie surowców ekstrudowanych z możliwie wysokim udziałem orkiszu i zbadanie właściwości jakościowych uzyskanych produktów. Badania przeprowadzono na ekstruderze dwuślimakowym, współbieżnym o stosunku L:D 27, przy różnych ustawieniach temperatury, prędkości obrotowej ślimaków, podawania surowca oraz wilgotności materiału. Do określenia parametrów jakościowych wykorzystano takie parametry jak: gęstość, ekspansję , WSI i WAI, aktywność wody oraz porowatość. Uzyskane wyniki były obiecujące, wszystkie produkty charakteryzowały się wysokim stopniem wodochłonności, a ich jakość była zbliżona do klasycznych ekstrudatów kukurydzianych.

INTRODUCTION
Extrusion is a universal process of raw materials treatment, which enables the production of new and innovative products. It is allowed not only by the specifics of the process itself but also by the possibility of raw materials processing, where traditional processing methods are not cost-effective or economically reasonable (Żelaziński et al, 2014a). Such materials include spelt wheat with numerous positive properties that support its broad application. However such products range is now very limited.
In Polish and world's literature spelt is described quite widely. The studies include not only the quality characteristics of the finished products but also the physicochemical parameters of grains themselves Sacchetti et al. 2004. Therefore, over the past few years there could be found a number of studies showing different quality characteristics for spelt products or their blends with other cereals. The most popular products include spelt bread and other baked products (e. g. muffins, pastries), widely reported in the research literature (Abdel et al, 2008; Ruibal-Mendieta et al. 2002; Pierogiovanni et al, 1996; Skrabanja et al, 2001; Escarnot et al, 2010). Research areas also include analysis of the spelt baking flour, for example the study conducted by Radomski et al, (2007).

There were also some attempts made to use spelt flour in pasta production (Marconi et al, 1999, 2002). These results suggest that the quality of spaghetti pasta is the highest with the maximum spelt share and relate it with a high content of high-quality protein in the flour. In the literature, there are also other spelt products compared. For example, quality analysis of the bread, pasta and crunchy extruded products manufactured on the basis of spelt flour were conducted by Bonafaccia et al, (2000). In this case, there were found large differences in the degree of starch gelatinization and easily digestible protein content.
The literature however still contains a few studies on the extrusion of spelt or its mixes, and presented research include products based on typical varieties of wheat (Kim et al, 2006; Yuan et al, 2013). It also addresses the topics such as the physical properties of grains, where the aim usually is to improve existing solutions or to find new ways of threshing and hulling spelt (Borkowska and Robaszewska, 2013; Frączek

and Reguła, 2010; Choszcz et al. 2010). Difficulties in obtaining clean grains in combination with a smaller wheat yield is also one of the main reasons affecting the small spelt production.

Summing up the above, spelt it is certainly a perspective raw material, and researches of its different products carried out recent years demonstrate the need to search for its new applications, e. g. with the use of extrusion process.

MATERIAL AND METHOD

Material and extrusion process

Input material designed for extrusion was whole-meal spelt flour (total fat 2.7%, total protein approx. 12%) and corn meal (total fat 0.7%, total protein approx. 8.3%, starch approx. 75%). From those materials there were prepared 4 blends in which the share of spelt flour was 70%, 80%, 90% and 100% of total volume. Raw material moisture amounted to approx. 13.6%.

Investigations were conducted in a laboratory twin-screw extruder Clextral Evolum 25 with length to screw diameter ratio L:D of 27. The extruders' cylinder was equipped with six heaters and cooling water system. Such number of sections in conjunction with the two-state automation system allowed very precise adjustment and control of the temperature profile during the extrusion process.

As extruder die, was used a circular one with a diameter of 2.5 mm. At the head of the extruder there was placed a cutter, with speed control possibility at the range of 0-1400 obr·min^{-1} (cutter speed was 400 obr·min^{-1}). The extruder was equipped with a calibrated volumetric feeder and a water pump to enable a precise dispensing of liquid directly into the extruder barrel of 0.001 dm^{3}·min^{-1} accuracy.

During the extrusion process, temperature and the screw rotation speed was being changed. Temperature profile set in the individual sections of the extruder barrel was 120°C, 120°C, 110°C, 80°C, 30°C, 30°C and 140°C, 140°C, 110°C, 80°C, 30°C, 30°C. During the extrusion process there was also being changed the screw speed in the range 300 or 350 obr·min^{-1}.

The resulting extrudates were prior to being cooled at room temperature for a period of about 3 hours until the moisture stability of approx. 11% was obtained. Below, there is a set points plan for the process of extrusion which was used for all extruded blends.

Table 1

Parameters of extrusion

Extrusion set points	Temperature	Rotation
I	120	300
II	140	300
III	120	350
IV	140	350

Quality properties analysis

Physico-chemical properties of obtained samples were determined by using the basic quality parameters such as density, radial expansion, water absorption (WAI) and water solubility (WSI) indices, water activity and structure measured in the cross-section of the extrudate.

Density was studied with displacement method carried out in accordance with the standard (BN-87 / 9135-05). Radial expansion (sectional expansion) was determined according to the method (Alvarez-Martinez et al. 1988) as the ratio of the extrudate diameter to the diameter of the nozzle array. Tests of WAI and WSI indices were conducted by the method of Anderson et al. (1969), shown in detail in the work of Ekielski et al. (2007).

Strength tests of extrudates (texture characteristics) were carried out on the testing machine AXIS 500 (Poland) equipped with a head for measuring the strength (max 25 N). Maximum force needed to cut the extrudate was examined. At the head it was placed a circular mandrel with a diameter of 2 mm (feed rate of 0.02 mm·s^{-1}, displacement of 11 mm). The samples used in the tests had a diameter between 5 and 7 mm and a length between 5.2 and 7.1 mm.

Porosity was studied on a test image analysis stand equipped with a microscope and image analysis software: stereo microscope Opta Tech SL + 3 Mpixel camera. Pictures were recorded in TIF format in the resolution of 2048 x 1536. The porosity was determined according to the method of Gosselin and Rodrigue (2005), using an irregular boundaries of the analyzed group of air pores on the evaluated images.

For the porosity analysis it was used package with LabView 2013 and the Vision Asistant 7.1.1 program, where the photos were graphical designed. Then, the obtained images with byte grayscale (256 levels) were

converted into divalent bitmaps and was chosen the appropriate thresholds of grayscale range from 1-255 (Żelaziński et al, 2014b; Ekielski A., 2011). In this way, the porosity of the samples was determined on the cross-sectional areas as the number of pores per unit area (cm^2) in accordance with Hayter et al. (1989).
For measuring the water activity of the products obtained there was used AquaLab 4TE measurer (Dekagon, USA). For research results description the Statistica 12 analytical program was used.

RESULTS

On the basis of the analysis of obtained results, it was found that changes in various parameters of the extrusion process had a significant impact on the qualitative changes of the samples obtained. It was found that the density of extrudate (Fig. 1) decreases with the increase of the spelt flour content in the mixture, which could be observed in all samples tested.

At settings of extrusion process I, III, IV charts' courses were similar and the highest density of approx. 0.13 $g{\cdot}cm^{-3}$ was observed with the spelt participation in a blend of 70%. At settings extrusion process II, all the extrudates have a higher density, the maximum average value was 0.175 $g{\cdot}cm^{-3}$ for a mixture of 70% spelt.

The graph course showing the change of radial expansion coefficient looks conversely (Fig. 2). It can be seen that with the increase of the spelt flour content index values clearly increase. In this case, the maximum values of the expansion index were achieved for blends involving 100% of spelt flour. Between the density and the expansion coefficient for process settings I, II, III, IV, it was also found negative correlations at -0.825, -0.648, -0.887, -0.641. Lower density and simultaneously larger degree of the radial expansion suggests that whole-meal spelt flour can be a good structure-forming raw material.

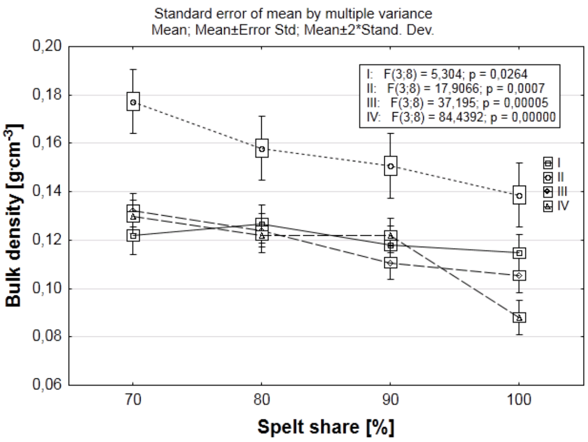

Fig. 1 - Influence of spelt content on density changes of extrudates

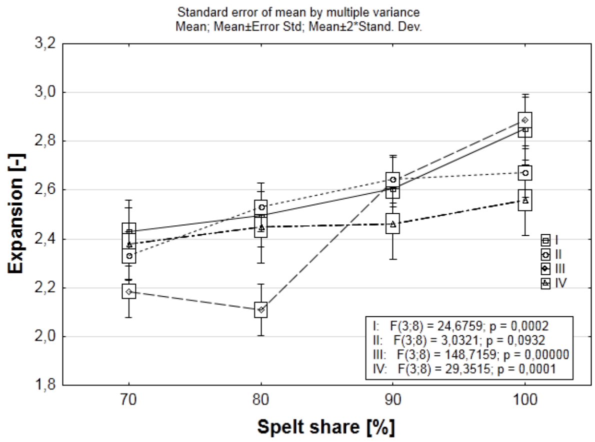

Fig. 2 - Influence of spelt content on expansion changes of extrudates

It was found that with increasing spelt content in the mixture water absorption WAI is also reduced (Fig. 3). In the case of setting I, III and IV, this parameter in the raw material consisting of 100% spelt was 3.45 to 3.5, while for the samples with 70% of spelt was 3.92 to 4.04 on average. The greatest water absorption was characterized by the samples obtained with setting III.

Proportionally and conversely there is presented the course of the WSI index chart (Fig. 4). On the graph it can be thus observed an increase in WSI with the increase of spelt content in the mix, where the maximum water solubility was achieved with 100% spelt participation. In this case, the parameters of the WAI and WSI are also strongly correlated, what is stated in all settings of the process I, II, III, IV (-0.845, -0.774, -0.623, -0.927). Water-holding capacity parameter was also strongly correlated with Aw, what was found with the extruder setting I, II and IV (-0.826, -0.853, -0.954).

Overall, according to the literature (Ekielski et al, 2007), the decrease of water absorption is an indicator of the starch gelatinization degree, so the greater the percentage of consumption-treated starch, thereby digestibility of the product increases. In this case, with the decrease of the WAI increases WSI, which may indicate an increase in the soluble fraction, e. g. resulting from the starch and also other components' degradation. This trend can be observed particularly for the specimens produced at 140°C. Charts courses of WAI and WSI may therefore indicate that in the case of spelt extrusion it can be searched temperature range lower than of the conventional extrusion of corn meal.

With the increase in the content of spelt in the mixture it was also observed increase in water activity (Fig. 7), which also can be observed in all settings of the process. The increase of this parameter, however, is disturbing, because it can contribute to the development of microorganisms, which in turn may impede the subsequent storage of these products, particularly after the package is opened.

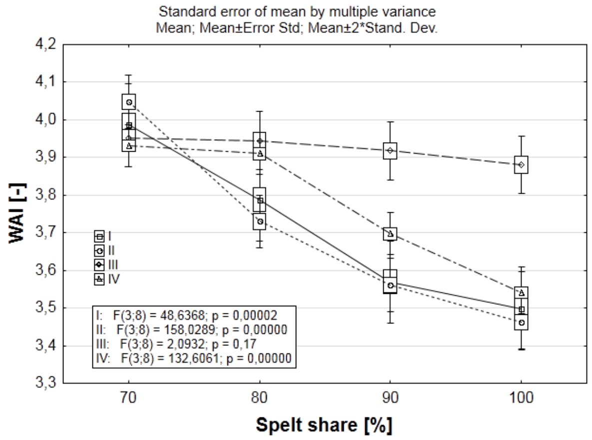

Fig. 3. Influence of spelt content on WAI changes of extrudate

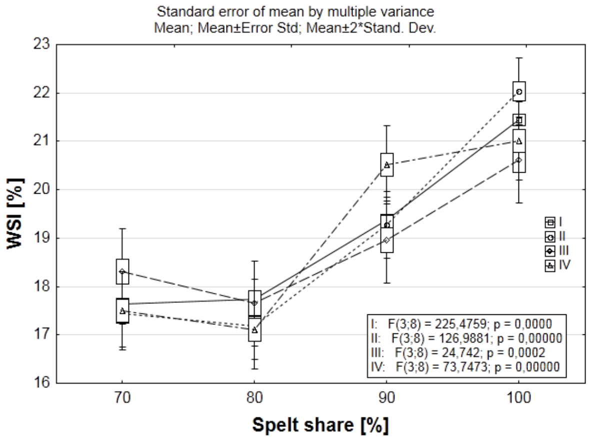

Fig. 4. Influence of spelt content on WSI changes of extrudate

The increase in the content of spelt in a mixture also caused a reduction in hardness of extrudates (Fig. 5), which clearly could be observed with the use at the process temperature of 140°C. Among the tested samples difference between the hardest sample and the sample with the lowest strength was about 5N. Together with the spelt content in the mix, however, it was observed an increase in the total work "Area" needed to puncture the sample (Fig. 6).

The hardness of the extrudates is in turn highly correlated to the density. It was found at the setting process I, III, IV (0.844, 0.919, and 0.891). Such parameters show that addition of spelt may considerably affect the performance of the textural parameters of extrudates in mixes with e. g. corn.

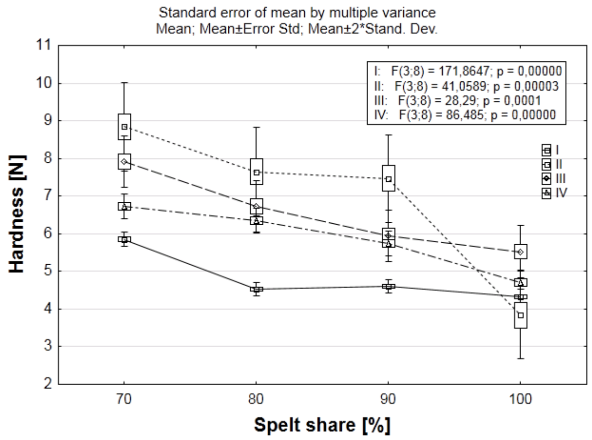

Fig. 5. Influence of spelt content on hardness changes of extrudates

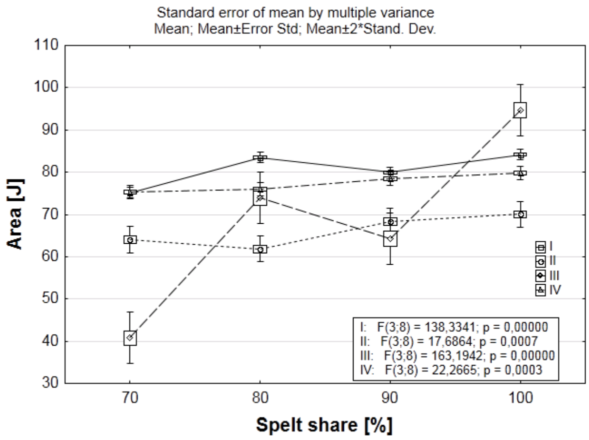

Fig. 6. Influence of spelt content on "Area-total work" of extrudates

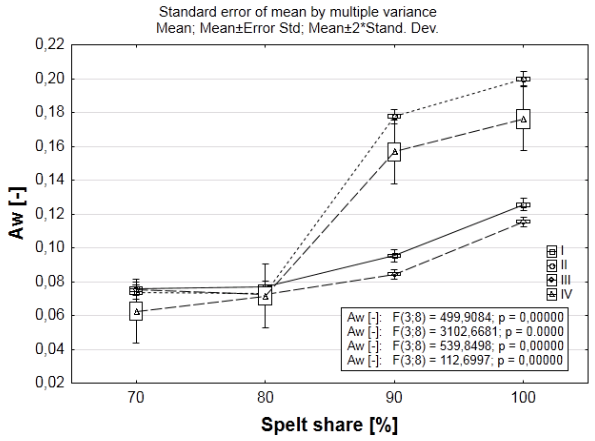

Fig. 7. Influence of spelt content on water activity Aw of extrudates

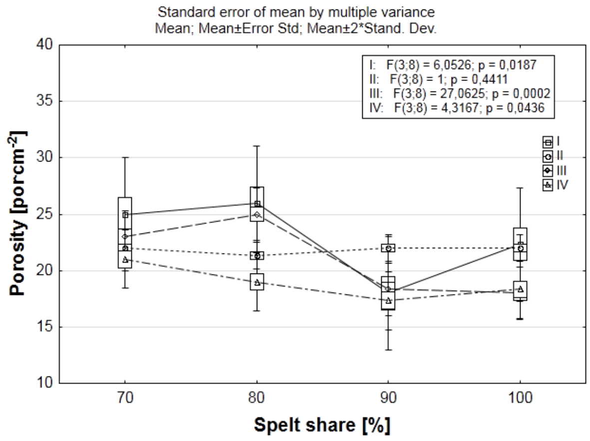

Fig. 8. Influence of spelt content on porosity changes of extrudates

Together with spelt content the porosity of extrudates slightly reduces its values (Fig. 8), so that the amount of air voids in cm^2 was the smallest for extrudates involving 100% spelt. The same samples obtained at 120°C had a porosity higher than the ones generated at the temperature of 140°C. In the higher screw speed range III and IV porosity strongly correlates with parameters such as Aw (-0.672) and Area (-0.74).

Less than that of corn extrudates porosity there is not positive feature of such products. There may also be a link between extrudates obtained with a lower density and a larger expansion (in this case no significant correlation was found). The literature research shows that more fine pores are far more positively perceived by consumers. Studies of this type are, however, subjective experiments, because in the case of the analyzed samples this thesis cannot be unambiguously confirmed without performing sensory analysis, planned in other studies.

CONCLUSIONS

The results of research and literature analysis indicate that spelt is a perspective grain which despite the weaker baking properties compared to the typical varieties of wheat can be a very interesting and, at the same time, a healthy raw material for the production of various food products. It was found that spelt is a very good material for baro-thermal extrusion process, and the quality parameters of the products obtained do not differ significantly from products with a high proportion of corn. The use of raw materials such as spelt to produce the typical snacks or crispy bread can reduce the impact of spelt on its poor baking properties. Despite the clear differences in the quality parameters in products containing spelt, the results for the largest content of spelt are satisfactory, and it can be used as a basic component of the mixture, e. g. in combination with corn or other starchy raw materials.

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CURRENT TRENDS IN AGRICULTURAL WATER ENGINEERING AIMING TO ANSWER TO CLIMATE CHANGES CHALLENGE / *TENDINTE ACTUALE IN INGINERIA APEI DIN AGRICULTURA CA RASPUNS LA PROVOCARILE SCHIMBARILOR CLIMATICE*

Asst. Prof. Ph.D. Eng. Halbac-Cotoara-Zamfir R.*, Prof. Halbac-Cotoara-Zamfir C.
[1)] University Polytechnic Timisoara, Faculty of Civil Engineering / Romania;
Tel: 0727315750; E-mail: raresh_81@yahoo.com

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ABSTRACT

Climate change are and will continue to generate severe challenges on water resources from agricultural sector affecting aspects related to food, energy, fiber, water security etc. Adaptation choices for agricultural water engineering able to cope with climate change challenges will need to consider current technological perspectives as well as project future technological change. This paper will analyze current trends in agricultural water engineering answering to climate changes challenge trying to provide a new conceptual framework for increasing the efficiency and resilience of water uses in agriculture and for mitigating the effects of climate changes on this sector.

REZUMAT

Schimbarile climatice genereaza si vor continua sa genereze modificari majore asupra resurselor de apa din sectorul agricol afectand aspectele legate de hrana, energie, fibre, securitatea apei etc. Variante de adaptare a ingineriei apei din agricultura pentru a face fata provocarilor generate de schimbarile climatic vor trebui sa considere perspectivele tehnologice actuale dar si pe cele viitoare. Aceasta lucrare va analiza tendintele actuale din ingineria apei din agricultura dedicate provocarilor generate de schimbarile climatice cu scopul de a oferi un nou cadru conceptual pentru cresterea eficientei si rezilientei utilizarii apei in agricultura si pentru a reduce efectele schimbarilor climatice in acest sector.

INTRODUCTION

Climate change are and will continue to generate severe challenges on water resources from agricultural sector affecting aspects related to food, energy, fiber, water security etc. The existing risks will be emphasized especially in the regions where water scarcity is already a concern.

Adaptation choices for agricultural water engineering able to cope with climate change challenges will need to consider current technological perspectives as well as project future technological change.

Agricultural water engineering can be defined as being the science which deals with the design of technical tools necessary to manage water in agriculture: irrigation and land drainage, water table management, water harvesting, water re-use, control of water erosion etc. Several studies stress that current water management practices may not be robust enough to cope with the impacts of climate change on agriculture and other water use sectors. Adaptive water engineering techniques, from field-scale water saving techniques, to basin level scenario planning, learning based approaches, and flexible management solutions, can help to create resilience to uncertain hydrological changes and impacts due to climate change.

Currently, there is a strong need in tailoring water management strategies to meet changing local/ regional needs ensuring that water resources are developed and managed in an equitable manner. We also need to improve the understanding of the role of natural ecosystems in buffering the variability in water resources.

Clearly, society's objective must fit well with agricultural water engineering and designation of associated infrastructure that can help to mitigate the impacts of drought and floods, stabilize river flows, and reduce erosion and silt loads, provide the necessary tools for managing the impact on water quality through changes in runoff, river flows, retention and thus loading of nutrients, can create multifunctional agro-ecosystems and can increase synergies among ecosystem services.

Agricultural water engineering must be treated within an integrated water resource management framework in which watershed plans aim at accommodating often conflicting objectives such as economic efficiency of water allocation, equitable water distribution, and environmental protection, including drainage needs and environmental flows. Moreover consideration of the environmental and social impacts is becoming an important factor in agricultural water engineering, with broader understanding of the multifunctionality of water and of human and ecosystem interactions.

MATERIAL AND METHOD

Climate change results in a future where the risks and opportunities of agriculture across different regions may vary (*Ciscar, 2009; Iglesias et al., 2012; Ponti et al., 2014*). It is clear that the changes in the areas are not uniform (*Rounsevell et al., 2005; Schröter et al., 2005*). First, exactly how crops respond to the different components of climate is a source of uncertainty. Second, marginal agricultural land in the different areas will not be able to enjoy the opportunities identified. Some changes imply potential benefits in the regional agricultural systems and therefore opportunities in the future. Nevertheless, the opportunities can only be realised if the necessary adaptations and knowledge and expertise are available.

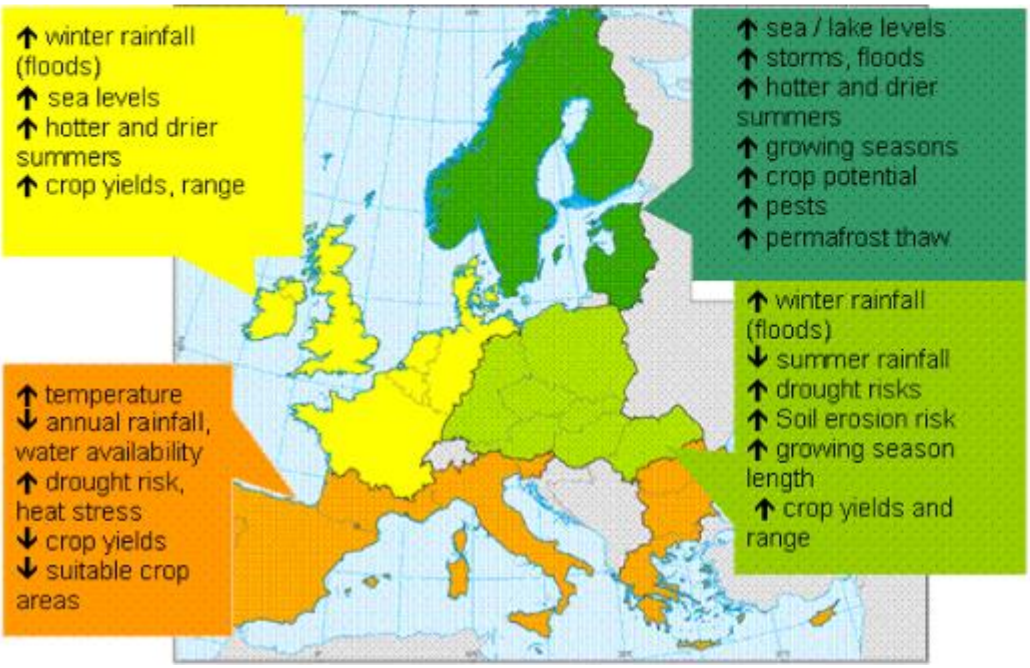

Fig.1 - Projected impacts from climate change in different EU regions
(Source: http://ec.europa.eu/agriculture/climate-change/index_en.htm)

Currently there are substantial challenges being faced in agricultural water management to secure efficiency and resiliency of water uses. These challenges are exacerbated by climate change making necessary to develop new approaches for designing, implementing and operating agricultural systems. Climate change is generally considered as a negative threat for agriculture – due, for instance, to harmful changes in temperatures and precipitation for food production or an increased likelihood of extreme events (*IPCC, 2014*). Further, it is of critically societal importance to develop more effective methodologies and tools to incorporate ecosystem services in the agricultural water management systems and to analyze the effects of such innovative systems on ecological landscape processes.

EU policy frameworks place great expectations upon technologies to improve water efficiency. The European Commission emphasizes 'technological innovation in the field of water, given that water efficiency will be an increasingly important factor for competitiveness' (*CEC, 2008*). According to the European Parliament, solutions should be found in 'clean technologies that facilitate the efficient use of water' (*E.P., 2008*). The main European farmers' organization has likewise advocated technological means to increase water efficiency. In particular this needs 'investments in more efficient irrigation systems, use of new technologies to better match irrigation with plant needs, and good agricultural practices', such as conservation tillage, management of soil fertility and water retention capacity, and scheduling of irrigation during night to reduce evaporation (*COPA-COGECA, 2007: 4*).

Interactions between the climate change, water and agriculture are numerous, complex and region-specific. Efforts to develop adaptation strategies for agricultural water engineering measures can thus benefit from understanding the risks and adaptation strategies proposed to date. Climate change can affect water resources through several dimensions: changes in the amount and patterns of precipitation; impact on water quality through changes in runoff, river flows, retention and thus loading of nutrients; extreme events (floods and droughts) and associated effects (water logging and water deficit). These changes in water cycle can deeply affect agricultural systems and, as such, need considering within the context of agricultural water engineering and policy development – in particular as a means to develop climate-resilient strategies.

Climate change will have its greatest impact on agricultural water engineering by further sharpening the trade-offs between conservation and protection of natural ecosystems, which ultimately support agriculture, and the allocation of land and water to sustain productive agriculture (*Turral et al., 2011*)

IPCC (2013) stress that current water management practices may not be robust enough to cope with the impacts of climate change on agriculture and other water use sectors. Adaptive water management techniques, from field-scale water saving techniques, to basin level scenario planning, learning based approaches, and flexible management solutions, can help to create resilience to uncertain hydrological changes and impacts due to climate change.

Currently there is a strong need in tailoring water management strategies to meet changing local/ regional needs ensuring that water resources are developed and managed in an equitable manner. We also need to improve the understanding of the role of natural ecosystems in buffering the variability in water resources.

RESULTS

Water engineering for agriculture knows a continuous increasing of its complexity (figure 2) due to the challenges of climate change which will have to be met through adaptation. Irrigation and land drainage, water table management, water harvesting, water re-use, control of water erosion etc. are facing the challenges generated by the transition from “water bankruptcy” policies to “green economy”. Water is a resource without substitutes and alternatives.

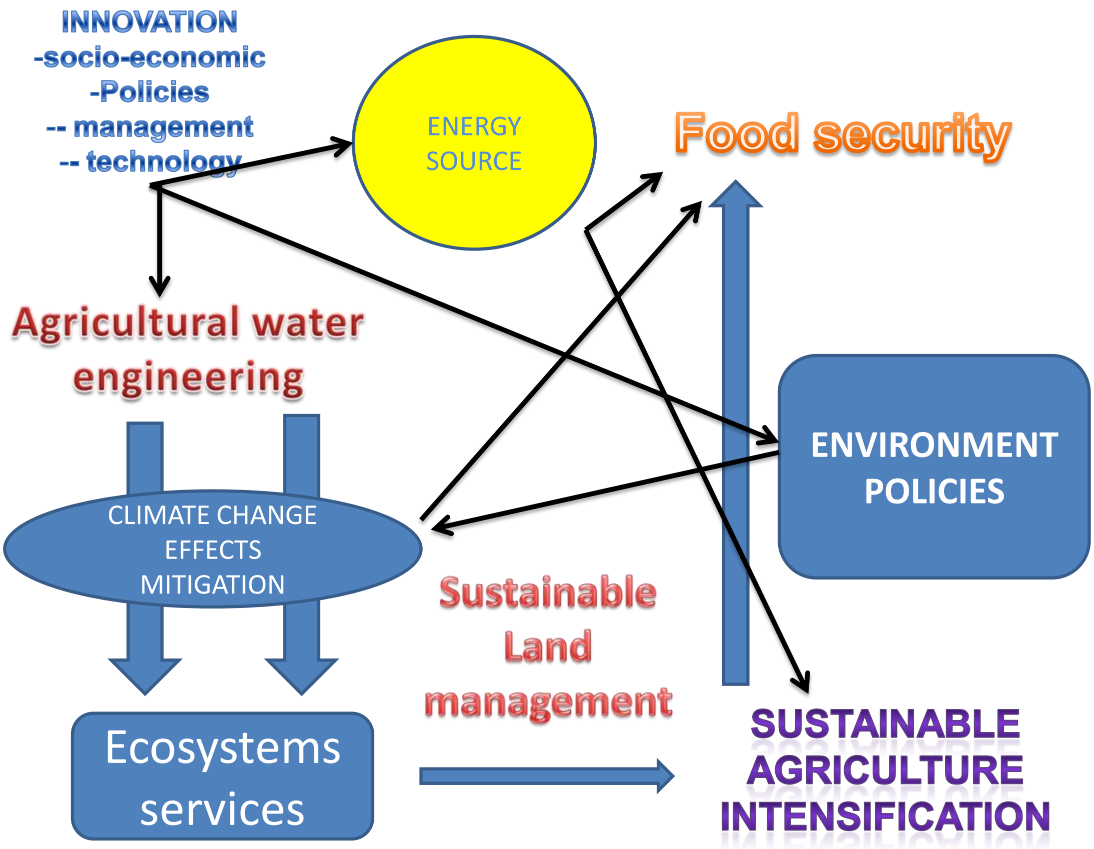

Fig. 2. Agricultural water engineering and climate changes. A conceptual framework

Land reclamation and improvement works are a significant part of agricultural water management and have influences spread in all components of land-water-climate-energy nexus. They provide important ecosystems services including groundwater recharge, flood retention, carbon sequestration, erosion control, accumulation of soil organic matter, recycling of soil nutrients, supporting diversity by providing habitats for flora and fauna (*Wu et al., 2008; Boelee, 2011; IPCC, 2007*). Integrating these different benefits in the framework of agricultural water management requires breaking down disciplinary boundaries between engineers, ecologists, agronomists, economists, hydrologists and climate scientist and the appliance of some reliable climate-energy-economic models as well as land-use models.

An improved understanding of ecosystem services provided by these works and of relations developed in the frame of land-water-climate-energy nexus and the implementation of climate adaptive land reclamation and improvement systems will decrease the pressures on basic resources.

The main objective of these arrangements is to improve agricultural production, to increase the income in rural areas and to minimize the risks generated by drought periods. Irrigated agro-ecosystems tend to maximize the productions of the covered areas but, with an adequate management, they can offer other services as well. The economic value of these services can overrun in some cases the crops values which are served by these land reclamation and improvement works.

At European level is a large quantity of knowledge on land reclamation systems and the degradations they address but this knowledge is dispersed, fragmented and sometimes incomplete especially regarding the complexity, functioning and services of land reclamation works and their interaction with food-climate-energy-ecosystem nexus. Land reclamation and improvement works should also be part of sustainable land management which is defined as the use of land and water resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions *(UN Earth Summit, 1992)*. Understanding regional certainties is a key element for practitioners and policy makers involved in planning, designing and operating climate adaptive land reclamation and improvement systems but also in setting new relevant policies for this sector.

Sustainable irrigation and drainage management is and will continue to be a frontier field in the future. The efficiency and productivity of water use under the circumstance of increasing uncertainties of flooding and drought, reducing the nutrients output from agro-fields and reducing the pollution to groundwater and surface water, alleviating land degradation, increasing the soil carbon pool and soil fertility, reducing the greenhouse gas (methane, nitrous oxide and carbon dioxide) emission from soil and increasing the carbon stock in soil-plant system can be all achieved with a sustainable climate adaptive land reclamation system.

A main challenge for the irrigation systems will be to reach the objective “less drop per crop”. This can be achieved only by implementing some changes regarding water management at basin level and through a careful management of water resources at user level. In the process of modernizing irrigation systems, geospatial systems become more and more present. Because of their technological advance, teledetection systems were integrated in management, monitoring and control activities of land reclamation and improvement systems, also including precision agriculture *(Lee et al., 2010).* This technology has a wide range of benefits including here:

- Realizing maps with vegetation biophysics parameters used in prognosis models of agricultural production (*Doraiswamy et al., 2005; Ma et al., 2011; Rembold et al., 2013*);
- Water necessary to determine different crops using satellite estimations of biophysics parameters assimilated to some agro-meteorological models (*D’Urso et al., 2010*);
- Nitrogen level monitoring, fertilizers distribution, agronomical variables determination (*Casa et al., 2012; Jego et al., 2012*);
- Actual evapotranspiration determination using surface energy balance method based on satellite data (*Bastiaanssen et al., 1998; Allen et al., 2007; Kustas and Anderson, 2009*). These methods, even they are very useful in analyzing water balance in irrigated areas, they are also presenting some limitations regarding their use in decision support systems due to some constrains of spatial and temporal resolution nature or due to the complexity of the algorithms which are used (*Allen et al., 2005; Osann Jochum et al., 2005; Karimi et al., 2013*).

The technological implementation of solutions which are based on teledetection in water and crops management fields is a process with a high complexity and which needs favourable technical, social and economic conditions (*Baptista and Sousa, 2005*). A critical problem which still affects this domain is the link between new technologies and their inclusion in current practices of final users. Regarding the best practices transfer, current practices and agricultural systems which are in use must be re-considered for their adaptation to innovative aspects.

Water retention and water harvesting improvement as well as water efficient use are fundamental for increasing the production and the adaptability to the increasing of precipitations irregularities. In 2013, from 1.5 billion ha which were cultivated worldwide, 80% were depending on precipitations but contributed to 2/3 of global food production (*FAOSTAT, 2012; Rockstrom et al., 2007; Scheierling, 2011*). Rainfed agriculture is practiced in almost all agro-ecological/ hydro-climatic areas of the world. However, in dry (arid) areas which cover 40% of world surface, most crop productions tend to be low, their values representing between 25% and 50% of their potential. (*Rockstrom et al., 2007*; *Wani et al., 2009*; *Scheierling et al., 2013*).

Water for agricultural production is still a key constraint due to high variability of precipitations, dry seasons extension and water hazards events. A faulty management of water and land resources represents the main cause of a low productivity. The water from an agricultural production system can be lost due to evaporation from soil surface, runoff 'or deep percolation. These losses can be however turned to "green water", productive, meaning water from soil directly used by crops. The losses can be also transformed in "blue water" (*Liniger et al., 2011*). In order to unlock the productive potential of small rainfed exploitations it must be improved the water management from that area, to find solutions which integrate water harvesting in sustainable land management (*Wani et al., 2009*; *Liniger et al., 2011*; *Critchley and Gowing, 2012*).

Water harvesting was defined and classified in many ways. As a synthesis, we can define water harvesting as being water collection and water management from floods or surface runoff resulted from irrigations in order to increase the available water for domestic and agricultural use respectively for maintaining ecosystems. Water harvesting is part of sustainable land management and mainly supposes the collection of water from precipitations which fall in a specific area and their transfer to another area which needs an increase of water availability.

Water harvesting together with water conservation in the field are the pillars of the 3R approach proposed by Van Steenbergen and Tuinhof in 2009. This approach is referring at three processes of water resources management: retention, recharge, re-use. The approach is based mainly on strengthening natural processes of water excess storage, below and above soil level for a future use and for environment benefit.

The wide application of this technology is still at a low level due to several problems like costs, lack of good practices dissemination etc. These problems can be however overrun considering the benefits brought by implementing water harvesting systems. First of all, farmers need to be aware of the benefits which they can get by applying these techniques. On the other side, the farmers will need assistance in adapting water harvesting techniques according to local social and economic, cultural and environmental conditions.

Water re-use in another key option in managing the impact of climate changes on agricultural water management. Water reuse has a significant potential to improve water usage and to contribute at preserving fresh water resources but with the cost of resolving important problems like assessment of environmental and human health risks. Irrigation reuse, groundwater discharge and downstream needs covering by treatment and discharging on surface water bodies are only some forms of wastewater reuse which can be easily identified.

Reuse of treated wastewater can be considered a reliable water supply, quite independent from seasonal drought and weather variability and able to cover peaks of water demand. This can be very beneficial to farming activities that can rely on reliable continuity of water supply during the irrigation period, consequently reducing the risk of crop failure and income losses. Appropriate consideration for nutrients in treated wastewater could also reduce the use of additional fertilisers resulting in savings for the environment, farmers and wastewater treatment (*Salgot and Huertas, 2006*)

According to K. Illungkoo and S. Vigneswaran (2009), agricultural irrigation is the biggest user of recycled waters acknowledging that over 40% of recycled water in Japan and more than the half of the recycled water in California are used in this field. Another country with a significant contribution of reused water in agriculture is Tunisia. There are several factors which diminish or enhance these contributions: legislation regarding wastewater reuse, level and costs of treatment, the types of crops which will be irrigated with this treated water etc. However, best management practices on reclaimed water re-use need to consider a list of environmental performance objectives including: efficient resource utilization, protection of land and water resources (surface and under-surface), reduced impact of communities etc. (*Illungkoo and Vigneswaran, 2009*).

CONCLUSIONS

Climate change and agriculture are interrelated processes, both of which take place on a global scale. Internationally, agriculture is widely regarded as one of the sectors at most risk from a changing climate, due to the impact of increased temperatures, reduced rainfall and increased frequency of extreme events. However, since most agriculture is rain fed, attention is often focused more on modeling impacts on rain fed crops. According to IPCC report from 2007, precipitations are presenting spatial and temporal variability with hardly predictable scenarios. A changing climate will influence irrigated crop growth, development and yield. In addition to the direct impacts, there will also be indirect impacts on the agricultural potential of soils by modifying soil water balances, changing crops and crop calendars, affecting moisture availability and land management practices including trafficability and workability, and energy use for pumping. Rainfall variability and the subsequent increase in frequency of extreme weather events, including droughts and floods, combined with an increasing acceleration of the water cycle through increased evapotranspiration, will have an impact on every element in agricultural ecosystems: crops, livestock, trees, fish, rural communities and physical infrastructure. For this reason, climate change adaptation strategies for agriculture will need to be viewed though a ‘water lens’.

Agricultural water engineering is and will continue to be a frontier field in the future. The efficiency and productivity of water use under the circumstance of increasing uncertainties of flooding and drought, reducing the nutrients output from agro-fields and reducing the pollution to groundwater and surface water, alleviating land degradation, increasing the soil carbon pool and soil fertility, reducing the greenhouse gas emission from soil and increasing the carbon stock in soil-plant system can be all achieved with sustainable, climate adaptive, agricultural water engineering solutions.

A future challenge for applied agricultural water engineering is to provide adaptation measures to climate change using an ecosystem services based approach. A sustainable management of the ecosystem services is based on the assessment of the self-regulation and support capacity of the ecosystem and the use of goods and services within the limits of these capacities.

A major role of agricultural water engineering works will be the ability to enhance, to strength and/ or to protect ecological and evolutionary responses of water-related ecosystem services and biodiversity to hydro-climatic and land use changes and to provide humanity the tools to deal with such ecological and evolutionary responses. The future agricultural water engineering works will require cross-disciplinary approach, connected to a multidisciplinary strength of research at combined landscape and drainage-basin levels.

It is therefore important that researchers working in climate and agriculture water engineering understand these issues, including how irrigation management, engineering, and water resource issues can be integrated into their agricultural systems research.

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CLIMATE CHANGE EFFECTS IN AGRICULTURE ENGINEERING. A REVIEW / *EFECTELE SCHIMBĂRILOR CLIMATICE ÎN INGINERIA AGRICOLĂ. SINTEZĂ*

Asst. Prof. Ph.D. Eng. Halbac-Cotoara-Zamfir R.*, Prof. Halbac-Cotoara-Zamfir C.
[1)]Universities Polytechnic Timisoara, Faculty of Civil Engineering / Romania;
Tel: 0727315750; E-mail: raresh_81@yahoo.com

Keywords: *agriculture engineering, climate changes*

ABSTRACT

Agricultural engineering is the application of engineering principles to any process associated with producing agricultural goods and management of our natural resources. Globally, agriculture is faced with the challenge to achieve food security of a growing and urbanizing population while simultaneously adapting to climate change, lowering emission intensities per output and preserving the natural resource base. This paper will provide a review of climate change effects in agriculture engineering trying to assess the trade-offs and synergies between adaptation, mitigation and ecosystem services.

REZUMAT

Ingineria agricola reprezinta aplicarea principiilor ingineriei in orice proces asociat cu producerea de bunuri agricole respectiv managementul resurselor naturale. La nivel global agricultura trebuie sa faca fata provocarilor generate de obtinerea securitatii alimentare pentru o populatie tot mai numeroasa si mai urbanizata simultan cu adaptarea la schimbarile climatice, reducerea emisiilor pe productie respectiv conservarea resurselor naturale. Aceasta lucrare va oferi o sinteza a efectelor schimbarilor climatice in ingineria agricola incercand sa determine atat schimburile cat si sinergiile dintre adaptare, atenuare si serviciile ecosistemelor.

INTRODUCTION

Agricultural engineering represents the branch of engineering that deals with the design of farm machinery, the location and planning of farm structures, farm drainage, soil management and erosion control, water supply and irrigation, rural electrification, and the processing of farm products.

Agricultural engineering is the application of engineering principles to any process associated with producing agriculturally based goods and management of our natural resources.

Globally, agriculture is faced with the challenge to achieve food security of a growing and urbanizing population while simultaneously adapting to climate change, lowering emission intensities per output and preserving the natural resource base.

This challenge will require a transformation of engineering techniques used in agriculture. In conceiving what such a transformation may entail, it is imperative to consider that agricultural engineering systems are embedded in wider landscapes with complex societal interactions, which can be disentangled as i) the ecosystem services provided by agro-ecosystems to society, and ii) the societal driving forces influencing agricultural development. As a consequence, the assessment of how to transform agricultural engineering will need to take into account multiple scales and involve multiple stakeholders.

In the second decade of the 21st century agriculture in Europe seems to stand at a crucial juncture. Projections are highly complex and, unfortunately, very uncertain due to severe changes in population, consumption patterns and environmental policy. Research and technology have been unusually vigorous and have shed light on so many possible innovations that it appears likely that agricultural engineering will provide more environmentally oriented solutions than almost all other economic activities. Part of this transformation is due to the pressure of agricultural engineering practices and policies to face climate change.

Agriculture is not only the main economic sector influenced by climate change – due to the direct relationship of crop production and climate variables – but it is a sector that may be part of the solution of mitigation of greenhouse gases that are responsible for climate change. The ability of agriculture to respond to future challenges may depend, at least in part, to the potential changes in its adaptive capacity.

The technical options to address climate impacts in agriculture have often been considered as adaptation strategies to climate variability. However, the limits to such approaches need to be better understood and their interactions with the provision of other ecosystem services become more important.

MATERIAL AND METHOD

Agricultural engineering can be defined as the discipline which applies engineering principles to agricultural production and processing. Agricultural engineering combines several disciplines (as of mechanical, civil, electrical and chemical engineering principles) with knowledge of agricultural principles. Agricultural engineering tasks can include planning, supervising and managing the building of dairy effluent schemes, agricultural water management activities (irrigation, drainage, flood and water control systems), environmental impact assessment assessments, interpreting research results and implement relevant practices.

In a current and general context, several drivers (population increasing, energy demands increasing, water demands increasing), emphasized by climate changes, develop more and more intense pressures on agricultural engineering systems. Adaptation and mitigation techniques as well as the use of ecosystem services are key aspects in generating new feasible and sustainable agro-ecosystems able to provide several types of responses options across multiple water-land-energy dependent sectors.

Engineering will act as an enabler for existing agro-ecosystems by providing the necessary tools to optimize the operations in mechanized agriculture, precision agriculture, efficient management of land reclamation and improvement works, land conservation and restoration, operating and exploiting new land-plant links, sustainable mitigation of weed and pest etc. The relation between maximum protection and maximum production can be optimized by being more creative in designing new technological systems for agriculture, by designing adaptation options integrating both demand-side as well as supply-side strategies, by improving the understanding of the role played by natural ecosystems (and their services) in buffering variability of climate *(Johnston et al., 2010; Giordano et al., 2012; Pavelic et al., 2012; McCornick et al., 2013; Smakhtin et al., 2014).*

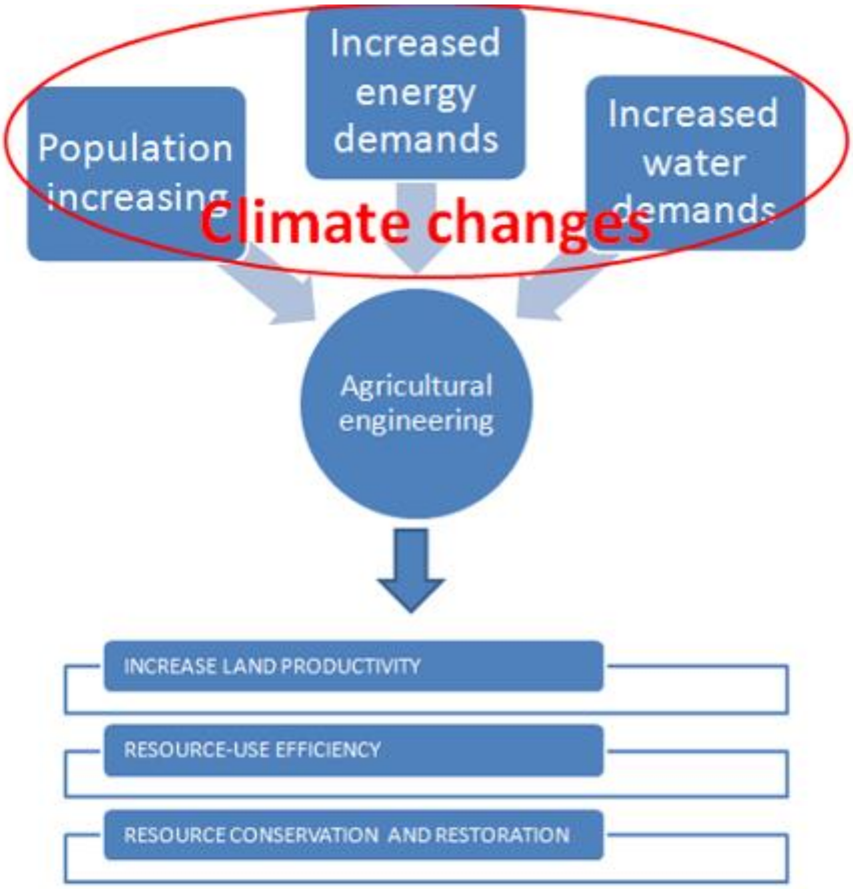

Fig. 1 - Pressures on agricultural engineering and its responses

RESULTS

There are several projected changes in climate which will severely impact agricultural systems: temperatures variability (especially warmer temperatures), the increase frequency of extreme climatic events (droughts, floods, heat waves) and enhanced atmospheric CO_2. Moreover, agricultural sector's vulnerability to climate change is regional climatic dependent, is multi-dimensional and must consider the capacity to adapt to changes, depending on several interacting economic, social and environment factors (*Warren et al., 2006; Field et al., 2007*). Agriculture is a very important economic sector of Europe providing jobs, sustaining food security policies, providing a series of ecosystem services. However, this sector is strongly dependent on water which is an increasingly scarce resource (*Iglesias and Garrote, 2015*).

Competition for land between the energy sector and agriculture (especially related to biofuel production and water supply) is a more recent concern (*Reilly and Paltsev 2009, Wise et al. 2009*). Few studies, however, have accounted for other relevant factors such as changes in agricultural demand, competition over land and water resources for other uses (such as bioenergy production), and the availability and cost of new agricultural technologies in terms of new water and energy sources. Even there is a significant knowledge on new agricultural engineering systems as well as on different types of energy sources which can be used, these advancements were not significantly integrated so far in the current policies leaving this sector under environmental, economic and social pressures generated by lack of fresh water sources, high cost of energy etc.

Climate manipulation experiments can play an important role for understanding the response of agricultural ecosystems to atmospheric and climatic changes (*Rustad 2008*). Meanwhile, the conclusions resulted from these experiments can lead to improvements in designing, operating and maintaining efficient agricultural engineering systems. CO2, temperature and precipitation have different characteristics, which lead to different considerations regarding the design of the experiments and the scenarios to be tested. Atmospheric CO_2 is a continuous variable with a relatively even global distribution and which can be relatively predictable leading to experiments with elevated CO_2 which have focused on a given target providing a constant CO2 concentration (*Ainsworth et al., 2008; Mikkelsen et al., 2008*). Precipitation is temporally and spatially variable with relatively uncertain scenarios for the future (*IPCC, 2007*). As a consequence, several precipitation manipulations have been carried out in many different contexts, different as design and with very different precipitation scenarios leading to a lack of possibilities for comparability (*Beier et al., 2012*). The result is that a general and comprehensive understanding of the impacts of altered precipitation, variability, extremity and threshold exceedance is lacking (*Knapp et al., 2008*) and a new generation of precipitation experiments are needed (*Beier et al., 2012*).

Temperature is a variable characterized by continuity, less variability and more predictable in comparison with precipitation leading this way to experiments which have applied approaches almost entirely focusing on average increases in temperature (*IPCC, 2007; Kreyling and Beier, 2013*). We can also observe that there is a general lack of studies on extremes and temporal variability in temperature change even locally and regionally the global temperature increase will manifest by highly variable changes *(IPCC, 2007; Kreyling and Beier, 2013*). As a conclusion, complexity needs to be stronger and more adequately covered in future temperature change experiments (*Kreyling and Beier, 2013*).

Past and current researches identified a series of benefits associated with warmer temperatures, longer growing seasons and increased CO_2 concentrations, benefits which are anticipated to improve agricultural activities. However, there are other factors that may serve to counteract them: reduced soil moisture, soil degradation, extreme climatic events, heightened presence of pests etc. (*Warren et al., 2004*).

The management of land and soils and their associated ecosystems are inextricably linked to the provision and overall availability of water resources (groundwater and surface). Water availability will become the major driver of future land use, potentially leading to significant land-use changes over the coming decades. Clay (2004) mentioned that globally, the agricultural sector consumes about 70% of the planet's accessible freshwater which represents more than twice that of industry (23%), and dwarfing municipal use (8%). In a report from 2009, EEA states that agriculture only represents 24% of total water use at EU level but its share can reach up to 80% of water use in Southern Europe as a result of the high reliance on irrigation. Concluding, a sustainable managing of water use in agriculture using engineering works represents a key theme in relating to water scarcity and drought.

Agricultural water engineering is mainly based on applied hydrotechnical techniques like irrigation and drainage but also on water management in rainfed agriculture, recycled water reuse, water and land conservation and watershed management. The strategy in implementing agricultural water engineering works presents a transition from controlling water schemes to a more holistic one aiming to mitigate the environmental costs and risks of irrigation (land degradation, salinization, and erosion; reduction or loss of environmental flows; pollution; destruction of natural habitats and livelihoods through drainage of wetlands etc.) (*World Bank, 2006*).

Several agricultural water engineering options were developed to answer current challenges related to water and generated by climate changes in agricultural sector:

- Environmental flows (The establishment of E-Flows will have significant direct or indirect benefits from well-functioning ecosystem services. From another perspective, restoring the E-flows regime will likely add value to a region in terms of qualitatively better ecosystems and services provided by them. This can be done by environmentally friendly agricultural water engineering works.);
- Sustainability of water efficiency targets;
- Implementing sustainable and functional land management to avoid and/or counteract water challenges and achieve water efficiency objectives (Sustainable land management is seen as the key to overcoming many land and water constraints, addressing globally important issues such as climate change adaptation and mitigation, scarcity of land and water etc. A sustainable implementation of a land management system using agricultural engineering works can also provide a wide range of ecosystem services which in return will sustain water regulation, adaptation and mitigation of climate change (including here water scarcity and water excess too) (*Almagro et al., 2013; Howden et al. 2007; Lal 2013*))
- Implementing a sustainable management of the trade-offs and synergies between water use rights and environment.

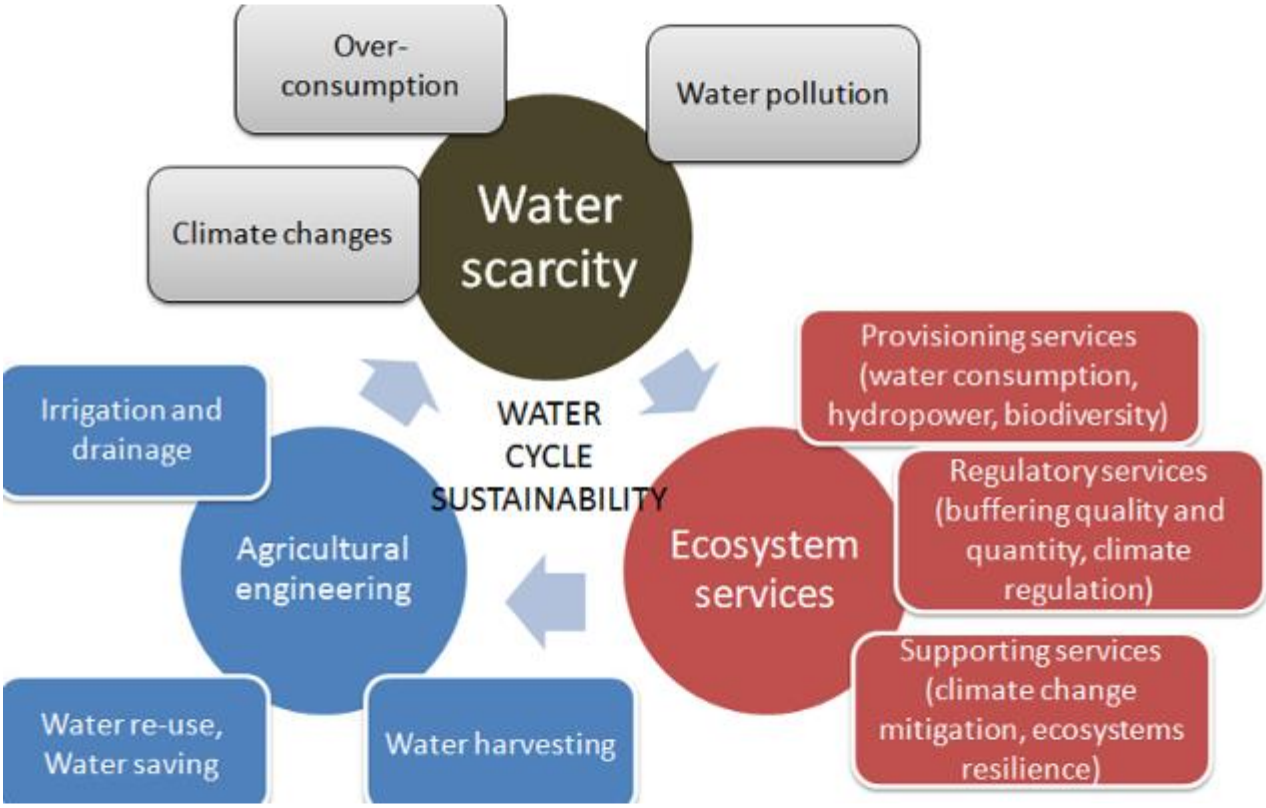

Fig. 2 Conceptual framework: water scarcity – ecosystem services – agricultural engineering

At European level is a large quantity of knowledge on agricultural engineering systems but this knowledge is dispersed, fragmented and sometimes incomplete especially regarding the complexity, functioning and services of different types of agricultural engineering works and their interaction with food-climate-energy-ecosystem nexus. Agricultural engineering works should also be part of sustainable land management which is defined as the use of land and water resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (*UN Earth Summit, 1992*). Understanding regional certainties is a key element for practitioners and policy makers involved in planning, designing and operating climate adaptive agricultural engineering systems but also in setting new relevant policies for this sector.

The relations between applied agricultural engineering works and the concept of sustainable land management are presented in the next figure. This figure is relevant for describing the complexity of applied hydrotechnical works from agricultural engineering field and how these works are interacting with the components of land – energy – climate – food nexus. A special attention in this conceptual framework must be granted to ecosystem services provided by these hydrotechnical works. Applied agricultural engineering works from the sector of land reclamation and improvement, especially irrigation and drainage works, possess the capabilities to provide important ecosystem services mainly from the first three categories: supporting, provisioning and regulating services. The main potential supporting ecosystem services are including soil erosion control, soil nutrients recycling and soil organic matter accumulation.

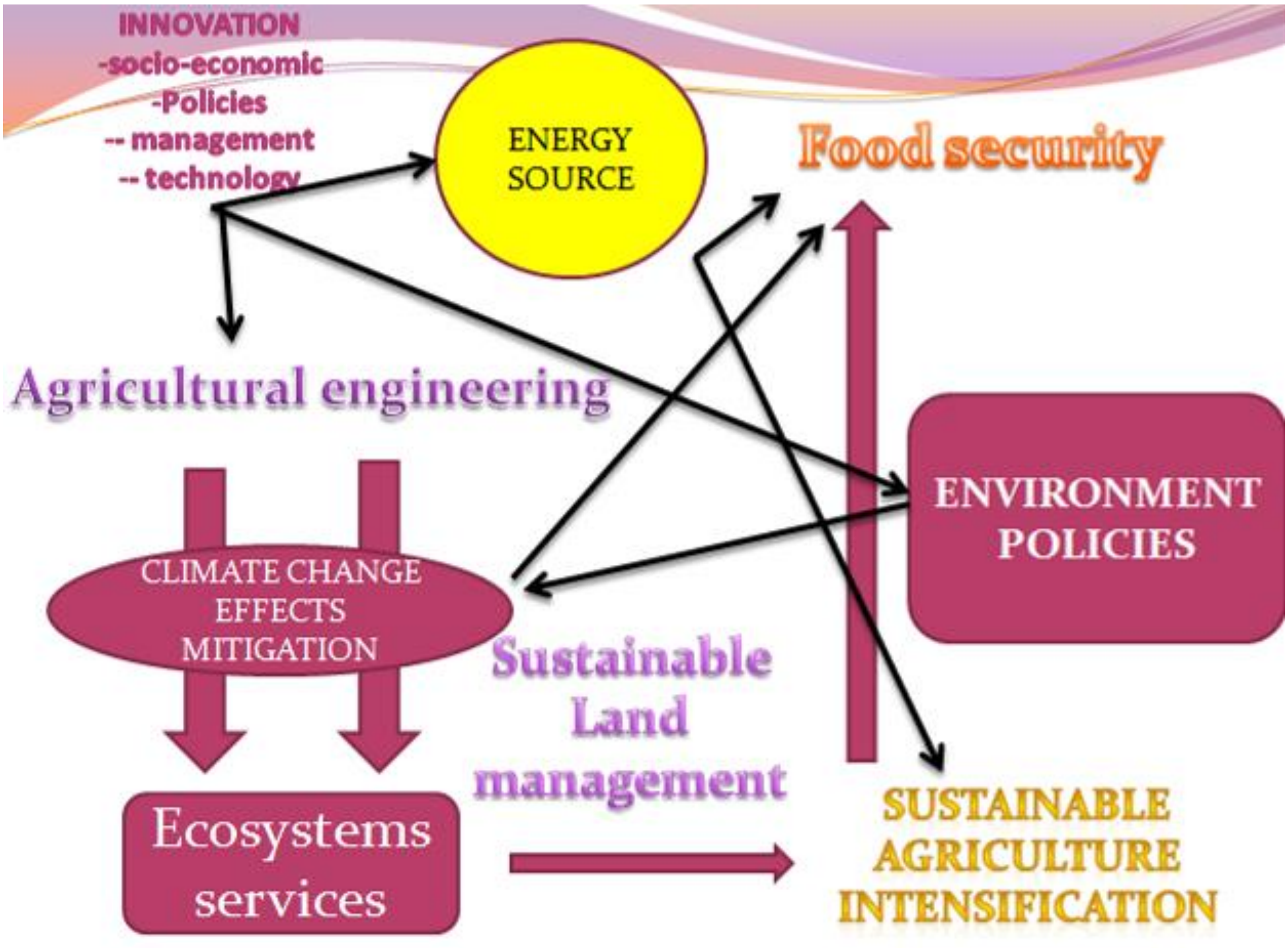

Fig. 3 - Innovation inputs in sustainable design and operation of agricultural engineering works

In the broad concept of applied agricultural engineering works, the emergence is represented by the need to minimize the negative consequences of anthropogenic impacts on land and water resources in order to regulate the energy and matter fluxes in agro-landscapes and to minimize the unproductive losses.

This aim can be achieved by integrating in the planning process both quantitative and qualitative aspects of the impacts generated by applied agricultural engineering works including here the quantification of ecosystem services provided by these works. The problem which must be solved is not very simple due to the way in which applied agricultural engineering measures are integrated in sustainable land management concept.

The need and scope for sustainable land management and food production in relation to cross-sector issues such as innovative agricultural engineering works and regional land – energy – climate – food nexus must integrate in the decision process the concept of production landscapes and trade-offs analysis as well as a framework for linking indicators that provide a measure of the outcomes of sustainable land management. An assessment of these trade-offs must recognize the potential of agricultural engineering works in terms of social and economic benefits, even while leading to possible long term declines in human welfare through altered ecosystem functioning.

The responses of agricultural engineering to climate changes and a series of other drivers (population increase, energy and water demands increasing) in relation to water management in agriculture cover a wide range of activities but may be a challenge for individual farmers, water managers and policy makers.

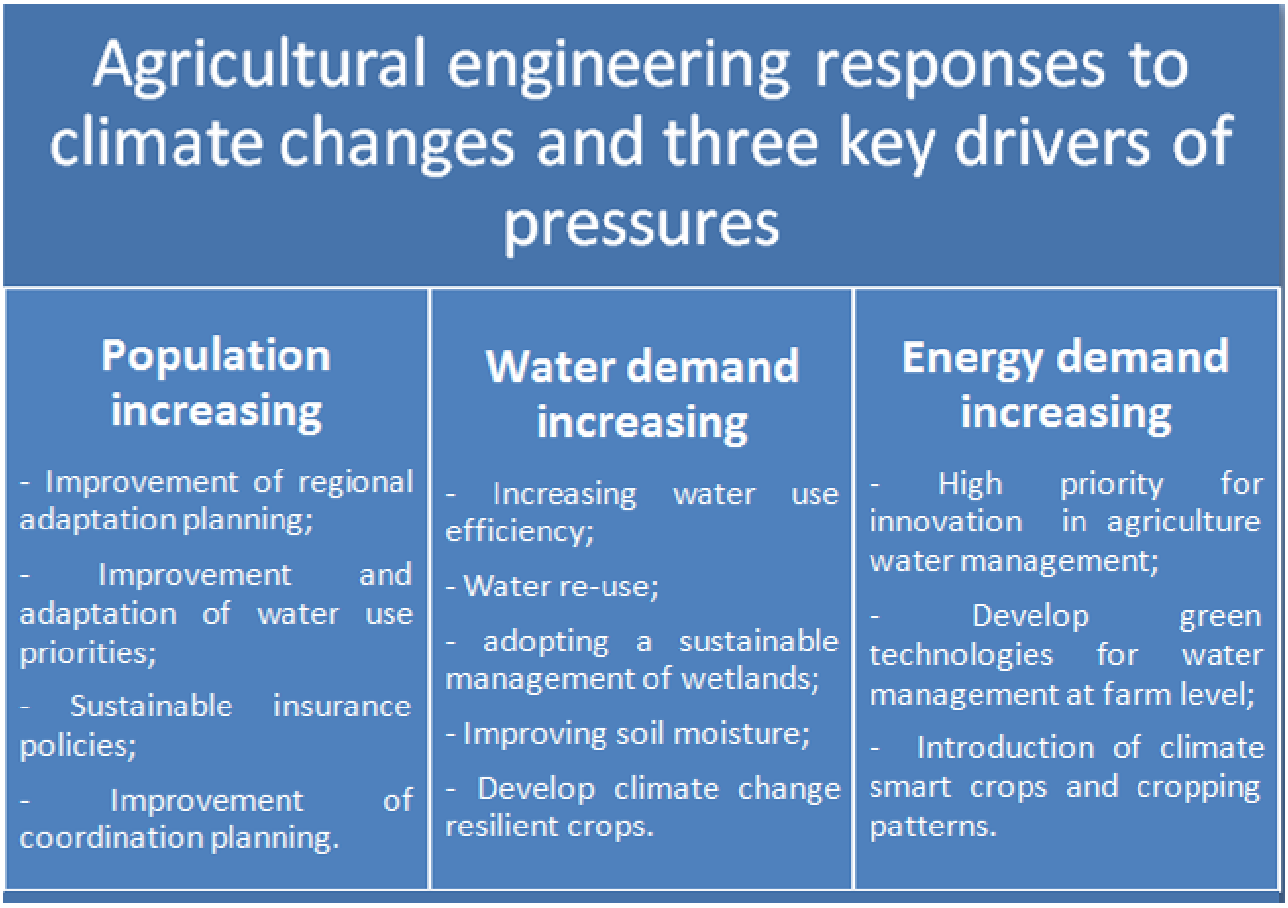

Fig. 4 Responses of agricultural engineering to climate changes and a series of other drivers

CONCLUSIONS

Agricultural engineering is and will continue to be a cross-crossing field in the future. The efficiency and productivity of water use under the circumstance of increasing uncertainties of flooding and drought, reducing the nutrients output from agro-fields and reducing the pollution to groundwater and surface water, alleviating land degradation, increasing the soil carbon pool and soil fertility, reducing the greenhouse gas emission from soil and increasing the carbon stock in soil-plant system can be all achieved with a sustainable climate adaptive agricultural engineering measures using a sustainable land management approach.

Agricultural engineering measures promote the coordinated development and management of water, land and related resources. However, this field of activity requires a shift in the management of water from water for food to sustainable land management for multifunctional agroecosystems, considering the whole ecosystem base of provisioning, regulatory, cultural and supporting services. An integrated approach of multiple ecosystem services of agroecosystems linked with elements of innovative engineering techniques and maximizing their benefits can be a powerful and sustainable response to climate changes and a series of other pressures.

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INTEGRATED USE OF BIOENERGY CONVERSION TECHNOLOGIES IN AGROECOSYSTEMS
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КОМПЛЕКСНЕ ВИКОРИСТАННЯ ТЕХНОЛОГІЙ БІОЕНЕРГЕТИЧНОЇ КОНВЕРСІЇ У АГРОЕКОСИСТЕМАХ

Doctor of Science Engineering Science Golub G.A.[1], Doctor of Science Engineering Kukharets S.M.[2], Ph.D. Eng. Yarosh Y.D.[2], Ph.D. Econ. Kukharets V.V.[2]
[1]National University of Life and Environmental Sciences of Ukraine / Ukraine, [2]Zhytomyr National Agroecological University / Ukraine
Tel:+380676653548, E-mail: saveliy_76@ukr.net

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ABSTRACT
The paper substantiates the mechanical and technological principles of formalizing the structure of agroecosystems on the basis of optimizing the interdependence between the elements of the agroecosystem within a specified range of conditions. The equipment for the production of bioenergy resources is improved by means of minimizing its energy capacity with all qualitative indices of the technological processes preserved.

РЕЗЮМЕ
У статті обґрунтовано механіко-технологічні основи для формалізації структури агроекосистем на основі оптимізації взаємозв'язків між елементами агроекосистеми у визначеному діапазоні умов. Удосконалено обладнання для виробництва біоенергоресурсів шляхом мінімізації його енергоємності при збереженні якісних показників технологічних процесів.

INTRODUCTION
There is no doubt that every measure proposed for implementation in agroecosystems should not only provide soil fertility, but to favour the expanded fertility renewal. Therefore, the important task is to determine the amount of plant biomass, which can be used in heating without any harm to soil fertility recovery.
It should also be taken into account that the use of technological processes with high mechanization level does not always lead to higher economic production indices because of increased deductions in production costs for technical servicing and repair of technical equipment, as well as deductions for depreciation, which are not compensated by additional production profits.

Oil-bearing crop production takes one of the leading positions in the structure of plant growing and in the whole system of agricultural production in Ukraine. In structure of total agricultural output, 35% of total production volumes in all farm categories are due to these crops. The main producers of these products manufacture 60% of oilseed products (Agricultural Ukraine. Stat. Coll.; eds. Y.M. Ostapchuk, 2011). In terms of food security, the volumes of domestic production fully satisfy domestic demands in these products, leaving some bulk for export and raw materials for biofuels.

The experience of using biogas plants was completely analyzed by the Agency for renewable resources in Germany (Guide to biogas. From obtain to using / Renewable resources Agency (FNR). 5th edition, 2012). The authors of the analysis indicate that in the absence of biomass mixing in the reactor, after a while there is a separation of biomass with layer forming due to the difference in density of certain mineral and organic components, as well as to flotation of particles while gas yielding. Thus, the biggest part of the anaerobic bacteria biomass is situated at the bottom of the reactor, and the organic part of the biomass substrate accumulates at the top of the reactor. As a result, the contact zone of anaerobic bacteria with biomass substrate is limited by a boundary layer of mentioned parts of the reactor. Floating crust of solid organic substances also blocks biogas yield. Facilitation anaerobic bacteria contact with substrate biomass is provided by mixing the substrate, but intensive mixing should be avoided, because it can cause stopping of anaerobic fermentation at the expense of disturbance of symbiosis of acetogenic and methanogenic bacteria. In practice, a compromise is achieved by slow rotation of agitators or by their work within a short period of time. Part of the solid mineral inclusions contained in substrates based on manure is released in the process of biological decomposition inside the reactor. Mineral sediment reduces the useful volume of the reactor.

MATERIAL AND METHOD

Structural diagram for the biological conversion of organic material in agricultural ecosystems with production of outputs and biofuels was developed on the basis of typical crop rotation for intensive farming in the Forest-Steppe zone using the calculation of the balance of humus and compost mixture formulation through agrochemical balances. The amount of straw for combustion was calculated as the difference between the total quantity of straw and the priority needs of its use. Heat generation ability of different types of straw was calculated on the basis of DSTU 3581-97 Energy efficiency. Methods of measuring and calculating the heat of combustion. Resources of biodiesel production were determined on the basis of statistical indicators of agricultural sector of Ukraine. Estimated volume of the produced biogas was determined on the basis of the intensity of organic biomass decomposition during its fermentation.

RESULTS

Biological energy conversion. With due regard for well-known regularities and research results (Golub G.A., 2010; Golub G.A., Kukharets S.M., 2015; Golub G.A., 2008) it is developed the structural diagram and simulation model of diversified manufacturing of products with biological energy conversion of organic raw materials for 6-field crop rotation with a total area of 300 hectares (fig. 1).

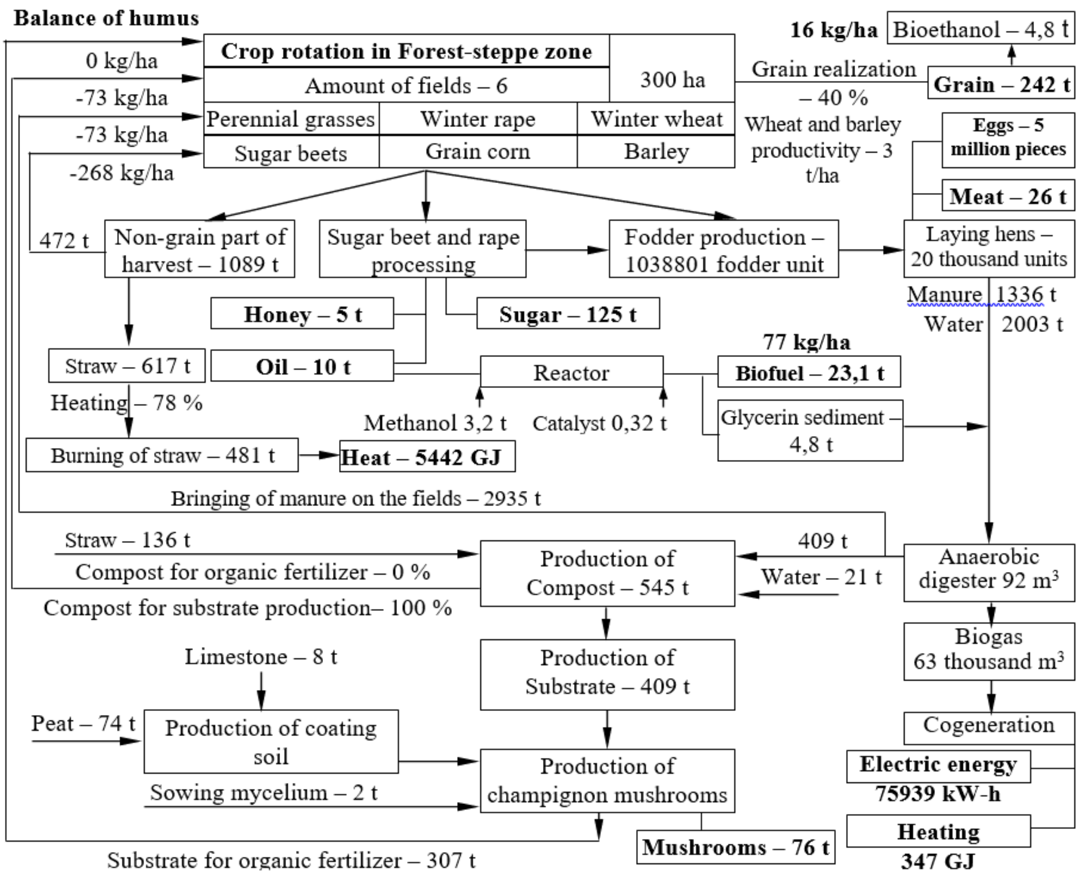

Fig. 1 – Structural diagram for manufacturing of production and energy on the basis of biofuels

Structural diagram of diversified manufacturing of agricultural products and energy envisages: growing of rotation field crops with production of grain and sugar beets; harvesting of crop straw and rape stalks; leaving of shredded corn stalks in the field as mulch; feed production for poultry; manufacturing of poultry products; methane (anaerobic) fermentation of poultry manure with production of heat and electric power from biogas; the preparation and use of grain crop straw and rape stalks for heating needs in the form of briquettes, rolls or chaff; usage of grain crop straw, rape stalks and fermented manure for compost production; production of substrate for champignon growing in compost and champignon production; production of biodiesel from rape seeds; use of glycerine residue for heating needs or its anaerobic fermentation.

On the basis of the introduced scheme it was defined the balance of humus in crop rotation using the well known equation:

$$Б = \frac{1}{\sum_{i=1}^{n} S_i}\left[-\sum_{i=1}^{n} S_i M_i + \sum_{i=1}^{n} S_i У_i k_{CMi} k_{Гi} + \sum_{j}^{m} ОБ_j \left(1 - \frac{W_j}{100}\right) k_{Гj}\right], \qquad (1)$$

where: $Б$ – the annual balance of humus in crop rotation, kg/ha;

S_i – the area under the i rotation crop, ha; M_i – mineralization of humus by the i rotation crop, kg/ha;

$У_i$ – the productivity of the i rotation crop, kg/ha;

k_{CMi}, $k_{Гi}$ – output coefficients of dry weight of residues and their humification for the i rotation crop, rel. units.;

$ОБ_j$ – annual organic biomass volume of the j species (non-seed biomass of agricultural crops remaining in the fields, manure, compost, substrate and biomass of weeds, green manure, etc.), which enters the field during a year, kg;

W_j – relative humidity of organic biomass of the j species, %;

$k_{Гj}$ – humification coefficient of dry organic biomass of the j species, rel. units.;

n, m – the number of rotation fields and the number of organic biomass species respectively, units.

The biggest influence on the balance of humus has grain crop capacity, as it in the biggest extant forms organic material revenues on fields and in lesser extant – the level of grain realization, as it affects the value of poultry fodder. Using all collected straw and rape stalks (losses are expected to be equal to 25%, including 10% of stubble and 15% of losses during harvesting, transportation and storage) for heating needs, the balance of humus in crop rotation can be approximated by the following linear equation of regression:

$$Б=(-0,0537P + 33,123)Y - 975 \qquad (2)$$

where: P is the level of grain realization (of the total number of grown grain), % ;

Y – the average wheat and barley capacity, kg/ha.

Computer simulation model allows determining the quotient of straw, which can be used for heating needs individually for separate farm. Thus, under the conditions shown in the figure, it can be reserved 78 % of straw for heating needs, and the part of the gathered straw in amount of 136 tons should be used for humus deficiency compensation in order to compensate humus losses completely. This can be done by two methods – either to leave some chopped straw in the fields or to develop on its basis compost or substrate for growing champignons.

Straw combustion. On the basis of existing indicators, which characterize agricultural production in Ukraine during recent years, in general, there were also made the calculations on defining the straw volume limits, used for heating needs (Golub G.A., 2011). This dependence defined as a percentage of the total amount of straw is as follows:

$$C^{\%} = -0{,}57D + 48{,}66 \qquad (3)$$

where: $C^{\%}$ is the straw amount limit from the total amount which can be used for heating needs, %;

D – annual humus deficiency, kg/ha.

It should be mentioned, that in the case of the total humus deficiency in the range of 80 to 90 kg/ha, the use of straw for heating needs is impossible because of soil fertility preserving terms. The maximum amount of straw which can be used for heating needs with zero humus balance is about 50%.

To ensure use of corn and sunflower tops for heating needs, as well as of rape stems, there remain unsolved technical issues of this plant biomass storage, that's why nowadays it is usually crushed and left in the fields.

To ensure the process of straw burning, we have determined the heat of straw combustion. These calculations were performed by the empirical formula, which connects the lowest calorific value $Q^p_н$ in kilojoules per kilogram of solid fuel and its elemental composition:

$$Q^p_н=339C^p+1030H^p-109(O^p-S^p)-25W^p \qquad (4)$$

where C^p, H^p, O^p, S^p, *ma* W^p are mass fractions of carbon, oxygen, sulphur and moisture in the working mass of fuel, %.

When summarizing the data of chemical composition of straw it was assumed that the nitrogen-sulphur ratio in cereal straw is 5 units (in legume straw – 10 units), and the hydrogen-sulphur ratio is 56 units, which correspond to the averaged data according to (Barotfy I., Rapan P., 1988). The carbon-nitrogen ratio was taken as medium in volume, according to the data in (Shkarada M., 1985). On the basis of the generalized data, introduced in table 1 (Golub G.A., Lukyanets V.O., Subota S.V., 2009), there were received empirical calculation dependences for determination of heat of different types of straw combustion.

These dependencies can be used in feasibility study of certain straw combustion efficiency. While calculations performed to prove the use of plant biomass for specific region or whole country, the heat of straw combustion should be determined by the equation, which takes into account the importance of the volumes of a particular straw type. For example, it is known that the main volumes of grain crop straw in Ukraine are presented by wheat straw (from 40 to 60%), barley straw (from 20 to 30%), rye straw (from 3 to 6%) and legume straw (from 2 to 8%). In recent years, it began to increase specific weight of rape straw, which reached values from 4 to 6%.

With regard to the weight of straw yield above-mentioned crops, the lowest heat of its combustion Q^{p}_{H}, should be determined by the equation:

$$Q_H^p = 16{,}544 - 0{,}19W \tag{5}$$

where: Q_H^p is the average lowest heat of straw combustion, MJ/kg;

W is straw humidity, %.

Table 1

Composition and calculation of straw combustion heat

Field crop – the straw producer	Content of dry weight, %								Calculation formula, MJ/kg
	Ash	Organic matter	Nitrogen, N	Carbon, C	Hydrogen, H	Oxygen, O	Sulphur, S	C/N	
Wheat	4,65	95,35	0,52	44,43	5,86	44,43	0,11	85	$Q_H^p = 16{,}261 - 0{,}1876W$
Rye	4,65	95,35	0,43	45,02	4,80	45,02	0,09	105	$Q_H^p = 15{,}309 - 0{,}1781W$
Barley	4,65	95,35	0,59	44,03	6,58	44,03	0,12	75	$Q_H^p = 16{,}914 - 0{,}1941W$
Oats	6,98	93,02	0,51	43,35	5,71	43,35	0,10	85	$Q_H^p = 15{,}865 - 0{,}1836W$
Corn	4,65	95,35	0,63	43,80	7,01	43,80	0,13	70	$Q_H^p = 17{,}304 - 0{,}1980W$
Rape	5,88	94,12	0,66	42,96	7,40	42,96	0,13	65	$Q_H^p = 17{,}520 - 0{,}2002W$
Grain legumes	6,98	93,02	1,64	41,02	9,19	41,02	0,16	25	$Q_H^p = 18{,}915 - 0{,}2141W$

It is well-known that grain crops, vegetative mass major producers, traditionally occupy from 40 to 55% in the structure of sowed crops. It should also be mentioned that with livestock decrease straw consumption for feeding and litter decreased as well, and the surplus straw is usually burned in fields (fig. 2).

Using straw in existing volumes would allow natural gas saving in the range from 4.5 to 14.3 billion m³. It is necessary to mention the appropriateness and availability of rolled straw storage, because this technology allows quick removal of straw from fields and is realized by means of simple and reliable technical equipment.

According to our estimations, while annual volume of straw combustion at the rate of 30 million tons, the total amount of natural gas yielded will be 10.9 billion m³. In these conditions, additional investments for preparation and combustion of straw will be 14.6 billion UAH, and their payback period will be from 1.2 to 1.3 years.

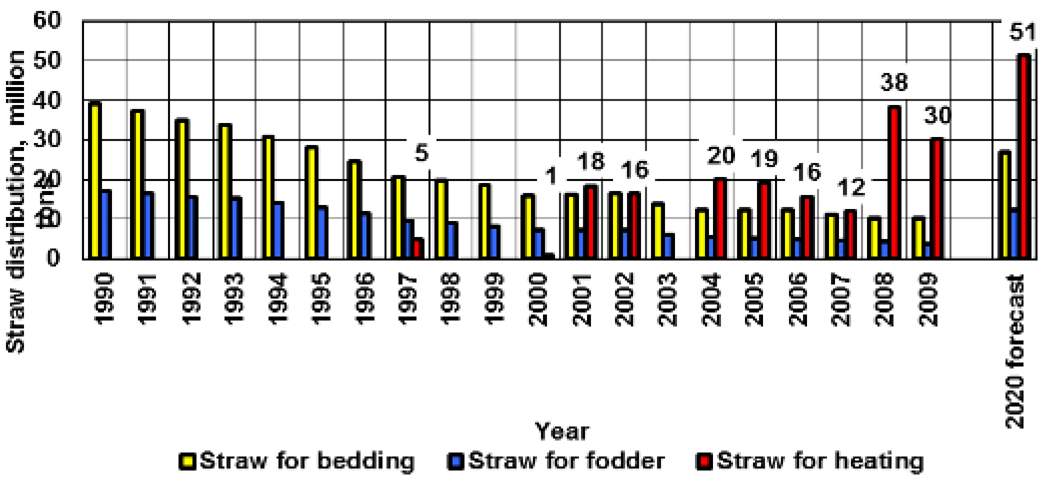

Fig. 2 – Straw distribution according to usage by years

The calculations of straw combustion effectiveness on the basis of comparison to heat generation by natural gas burning have established the dependence of heat production efficiency on straw when compared to gas heating in terms of changing of straw cost (fig. 3).

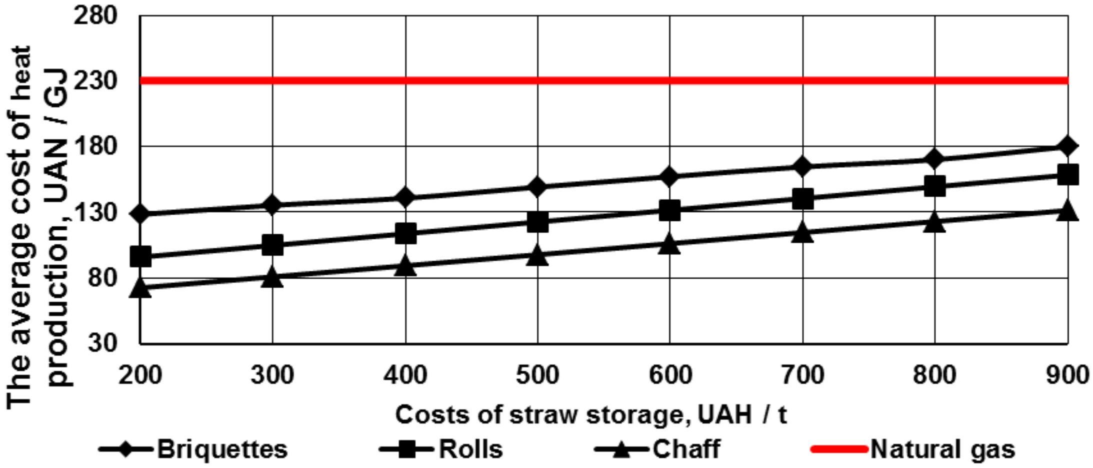

Fig. 3 – Efficiency of heat production from straw compared to gas heating by changing of straw value

Biodiesel. In Ukraine there are many cases of usage by agricultural producers of rapeseed oil in mixture with diesel for diesel tractors which have exceeded their service life.

We found that rapeseed oil production for usage as biodiesel can be economically reasonable in terms of agricultural production, when compared to rapeseed selling if the total cost of production is high and close to the average selling price of rapeseeds, or if the price of realization is low and similar to the total cost of rapeseeds.

Using biodiesel to replace diesel, it is necessary to heat biodiesel in the fuel lines of low pressure up to the temperature which provides the determined level of biodiesel filtration. To increase efficiency and temperature range of biodiesel use, we have designed and made a two-stage heating system (fig. 4), which allows using biodiesel under any values of environment temperature and provides an increase in completeness of fuel combustion. The second stage of fuel heating is made in the fuel pump-injector section for its better spraying and increase of speed and combustion completeness (Golub G.A., Chuba V.V., 2012).

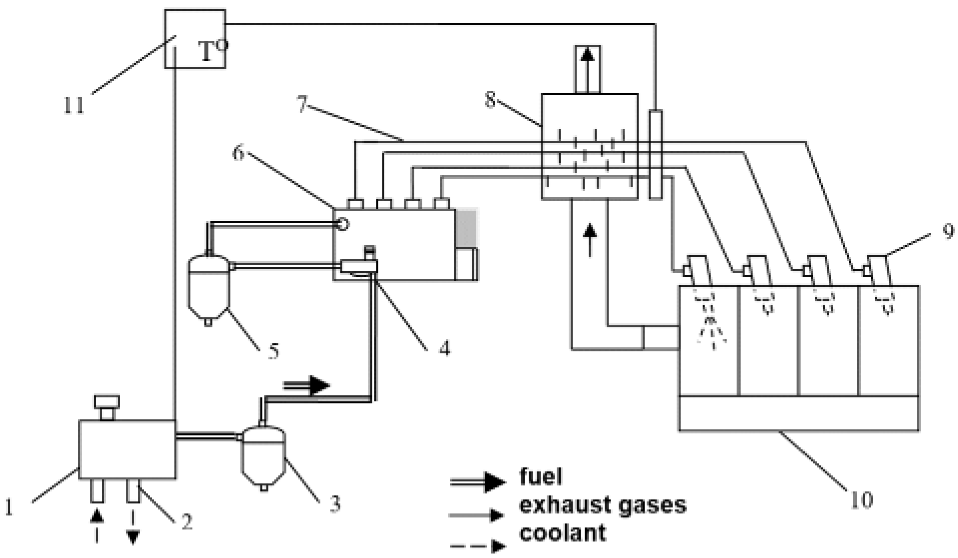

Fig. 4 – Scheme of the dual stage heating of biodiesel for motor and tractor engines

1 – fuel tank, 2 – heat exchanger, 3 – coarse filter, 4 – booster pump, 5 – fine filter, 6 – fuel channel of the high- pressure pump, 7 – fuel injection pipe, 8 – heating chamber, 9 –engine injectors 10 – engine 11 – temperature control unit

Fuel prices are constantly increasing, and faster than those for agricultural products, which significantly affects production cost, realization price and farmers' profit. The analysis shows (fig. 5) that in 2000 farmers had to sell 4.6 tons of wheat to buy 1 ton of diesel, in 2006 it was necessary to sell 8.1 tons of wheat, in 2008 – 9.1 tons. Over the past 11 years the price of wheat increased 2.74 times and of diesel – 4.73 times.

On the basis of statistical data about consumption of diesel in agriculture and rape gross harvest, we have evaluated the capacity of replacing diesel to biodiesel while processing of whole rape harvest (fig. 6).

The largest consumption of diesel in agriculture for the observed period was observed in 2001, 2002, 2000, and the lowest – in 2006, 2007, 2008; in 2011 it was observed the tendency of diesel use increase when compared to 2010 from 1201.4 thousand tons to 1349.7 thousand tons. Rape gross yield increase is being observed since 2004, and in 2009 was observed production decline. The volume of biodiesel production while processing of the whole rape harvest was to be the highest for the investigated period in 2008 – 900.6 thousand tons of biodiesel, in 2009 – 587.3 thousand tons, in 2010 – 460.8 thousand tons, in 2011 – 387.9 thousand tons, and the lowest – in 2003 – 15.8 thousand tons, as well as in 2002 – 19.1 thousand tons. The quotient of diesel which can be substituted to biodiesel while processing of whole rape harvest was the largest in 2008 – 64.7%. At the same time, as it is predicted, production and use of biofuel in 2020 will not exceed 100 thousand tons per year (Geletukha G.G., Zheleznaya T.A., 2012).

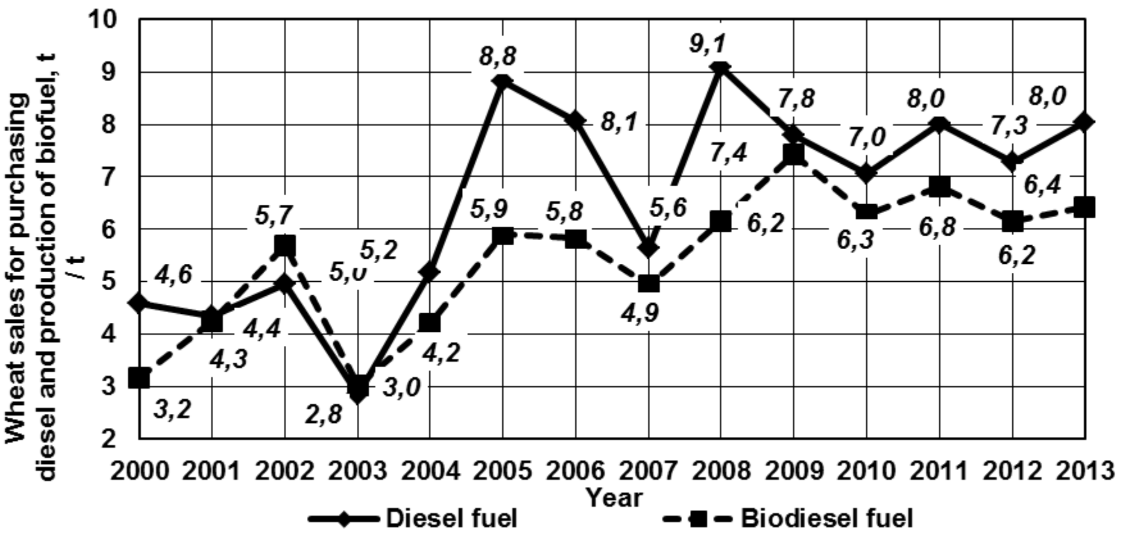

Fig. 5 – Change dynamics of required sale volumes of wheat to buy diesel or produce biodiesel

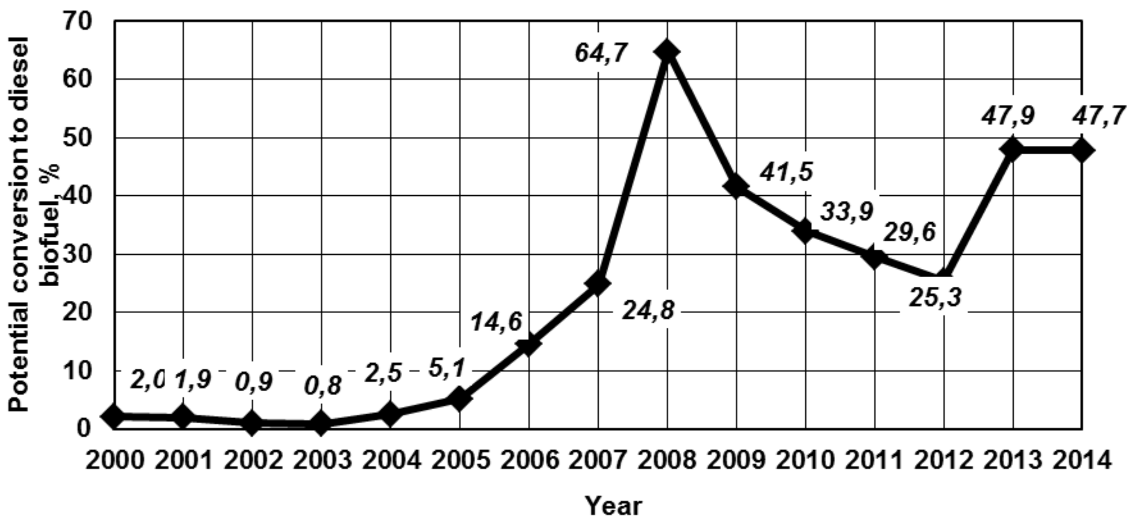

Fig. 6 – Change dynamics of potential transition to biodiesel while processing of whole rape harvest

Farms can produce biodiesel after harvesting of oilseeds, i.e. in autumn. In autumn-winter period diesel is limitedly used in agricultural production –in animal husbandry only. The produced biodiesel is stored in warehouses for oil products till the beginning of spring field work. When stored in sealed containers, biodiesel does not lose its properties during the year, unlike rapeseeds and rape oil. Prices for fossil diesel are constantly increasing, especially at the beginning of spring, but the cost of produced biofuels in the previous year remained unchanged, that is one of the cost saving provisions in agriculture.

The profitability of production of rapeseeds, rapeseed oil and based on it biodiesel is affected by a number of factors including: the cost and selling price of rapeseeds, production capacity of equipment which was used for production of oil and biofuels, the price situation in the diesel market. Taking these factors into consideration, we have analyzed the indices for 2000-2013 (fig. 7). Profitability of rapeseed oil production was higher than the one of rapeseed production for the entire studied period, except of 2001, 2002 and 2010. Profitability of biodiesel production was lower than the one of oil and rapeseeds in 2000-2004, 2006, 2008, 2009, 2011 and 2012. Profitability of biodiesel production in 2005, 2007, 2010 and 2013 was greater than the one of rapeseed production, which can be explained by reducing of rapeseed realization cost (Golub G.A., Lukyanets S.V., 2013).

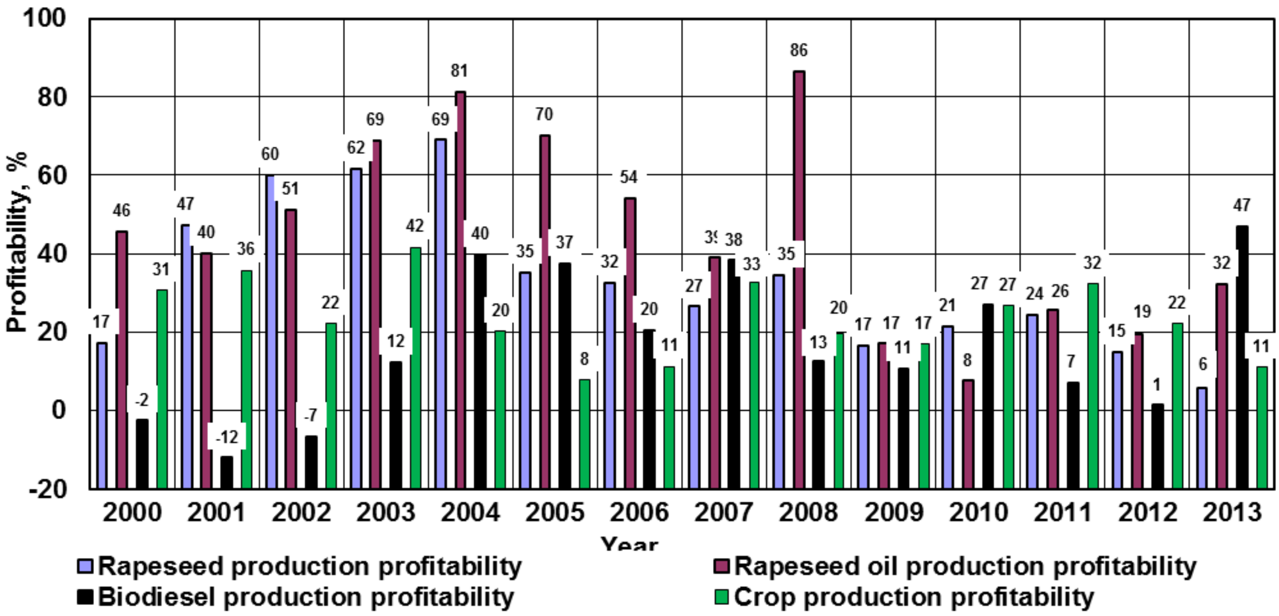

Fig. 7 – Indicators of profitability of crop production, rapeseeds, rapeseed oil and biodiesel on its basis

Stable high demands, formed by the world market, and high prices provide highly profitable rapeseed production and are very attractive to investors. Profitability of rapeseed production was increasing till 2004 and reached 69%, and starting from 2005 up to 2007 it tended to decrease, and stabilized at 17-35%. Profitability of rapeseed oil production was increasing till 2004 and reached 81%, from 2005 to 2010 – it was decreasing (except in 2008, when there was the highest index – 86%) and stabilized at the level of 8-17%. Analyzing the profitability of biodiesel production, it should be mentioned, that by 2002 biodiesel production was not profitable, due to the relatively high cost of its production and a fairly low price for diesel. However, with the rising cost of fossil fuels, the profitability of biodiesel production has increased significantly, and from 2004 to 2007 exceeded even the profitability of crop production, confirming the effectiveness of investment and the need to develop the biofuel production branches.

The analysis of interest rates on deposits of banks of Ukraine shows that for the 2000-2011 the interest rate for individuals ranged from 12.6 to 20.4%, for legal entities – from 6.6 to 13.8% (National Bank of Ukraine). However, investing money into biodiesel production, investor derives much greater profit. So, in 2004 the average interest rate on bank deposits for individuals was 15.7%, for entities – 8.9%, while the profitability of biofuel production was 40%, in 2007 respectively – 14.1 and 8.9%, and biofuel profitability – 38%, in 2010, rates of banks – 18.8% and 13.7%, while biofuel production – 27%. Raising funds to produce biodiesel, it is probable not only to improve the efficiency of invested capital, but also to make contribution into improving the environmental situation of the country, and into ensuring of power independence industry, as well as of the country as a whole.

Biogas. Experience of using biogas reactors showed that there are reactors already half-filled with mineral sediment, which can be removed only with an excavator after total stopping of fermentation process. Floating layers, especially based on fibrous substrates, often form a crust and if it is not mixed, the reactor must also be stopped to remove it.

Thus, the improvement of biogas reactor work to ensure the mixing of biomass substrate layers requires new technical solutions, one of which is mixing by rotation of the suspended reactor submerged into water.

We have developed and patented several designs of modular anaerobic digesters of rotational type (Golub G.A., Kukharets S.M., 2015), the design of one of which is shown in fig. 8.

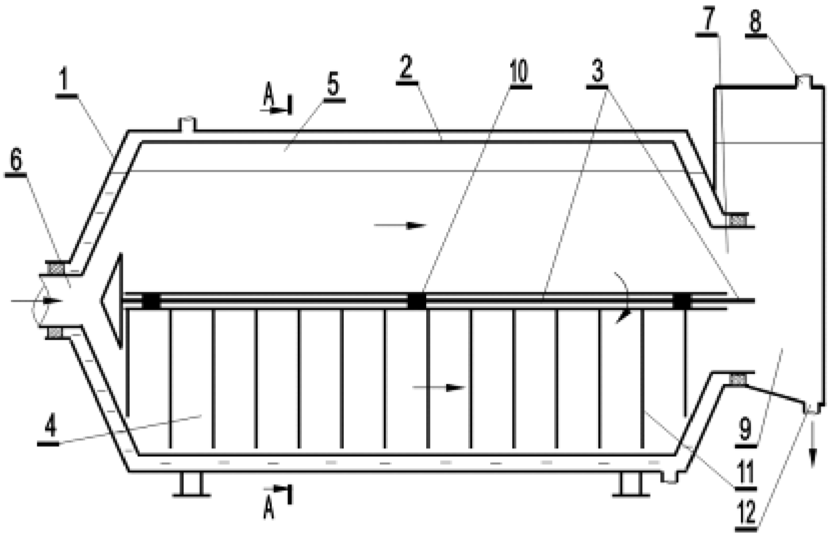

Fig. 8 – Construction of anaerobic digester immersed into thermostatic liquid

1 – horizontal outer casing, 2 – cylindrical reactor 3 – longitudinal bulkhead, 4, 5 – fermentation chambers, 6, 7 – tubes for cart and removal of organic matter, 8 – pipe for biogas runoff, 9 – unloading camera, 10 – joints 11 – mixing fingers, 12 – pipe for organic matter removing

Our calculations showed the microbiological decomposition while anaerobic fermentation of 1 kg of organic matter is accompanied by about 0.4 kg of methane yield and by 0.7 kg of carbon dioxide yield. Adopting the assumption that the volume of produced biogas is determined by the intensity of organic matter decomposing during organic biomass fermentation, biogas yield while fermentation in terms of normal conditions can be defined as follows:

$$V_{БГ} = \rho_{БМ}\left(1 - \frac{W_{БМ}}{100}\right) k_{ОМ} k_{ОМ}^{Р} \frac{m_{БГ}}{\rho_{БГ}^{Н}}, \tag{6}$$

where: $V_{БГ}$ is a specific biogas yield from the reactor under normal conditions, $м_{БГ}^3/м_{БМ}^3$ per day;

$\rho_{БМ}$ – biomass density, $кг_{БМ}/м_{БМ}^3$;

$W_{БМ}$ – biomass dampness, %;

$\left(1 - \frac{W_{БМ}}{100}\right)$ – dry matter content in relation to the total biomass, $кг_{СМ}/кг_{БМ}$;

$k_{ОМ}$ – organic matter content in relation to the volume of the total dry weight in fermenting biomass, $кг_{ОМ}/кг_{СМ}$;

$k_{ОМ}^{Р}$ – the number of decomposed organic matter per day in relation to the total organic mass, $кг_{РОМ}/кг_{ОМ}$ per day;

$m_{БГ}$ – biogas yield per unit of decomposed organic matter, $кг_{БГ}/кг_{РОМ}$;

$\rho_{БГ}^{Н}$ – biogas density under normal conditions, $кг_{БГ}/м_{БГ}^3$.

Table 2

Calculation of the specific release of biogas and biomethane

Indicator	Measurement	Values
Manure density	$kg_{БМ}/м^3_{БМ}$	1062
Humidity	%	90
Water content	$kg_{В}/kg_{БМ}$	0,9
Dry weight	%	10
	$kg_{СМ}/kg_{БМ}$	0,1
Organic matter content	%	80
	$kg_{ОМ}/kg_{СМ}$	0,8
The intensity of organic matter decomposing	**% per day**	**3,0**
	$kg_{РОМ}/kg_{ОМ}$ per day	**0,03**
	$kg_{РОМ}/м^3_{БМ}$ per day	**2,55**

Biogas yield from decomposed organic matter under normal conditions	kg$_{БГ}$/kg$_{РОМ}$	1,1
	м$^3_{БГ}$/kg$_{РОМ}$	0,92
Biogas yield from the reactor under normal conditions	**м$^3_{БГ}$/м$^3_{БМ}$ per day**	**2,34**
Biomethane yield under normal conditions	**м^{3}CH$_4$/м$^3_{БМ}$ per day**	**1,666**
The maximum level of organic biomass decomposing	%	38
	кг$_{РОМ}$/м$^3_{БМ}$	32,5
Fermentation time	**days**	**12,74**

At the same time, specific biomethane yield will be:

$$V_{CH_4} = V_{БГ} k_{CH_4}, \quad (7)$$

where: V_{CH_4} – is specific biomethane yield from the reactor under normal conditions, $м^3_{CH_4}/м^3_{БМ}$ per day;

k_{CH_4} – volume biomethane content in biogas, $м^3_{CH_4}/м^3_{БГ}$.

With the parameters introduced in table 2, the relationships between the intensity of organic matter decomposing and specific biomethane and biogas yields, and fermentation time, will take the form shown in fig. 9.

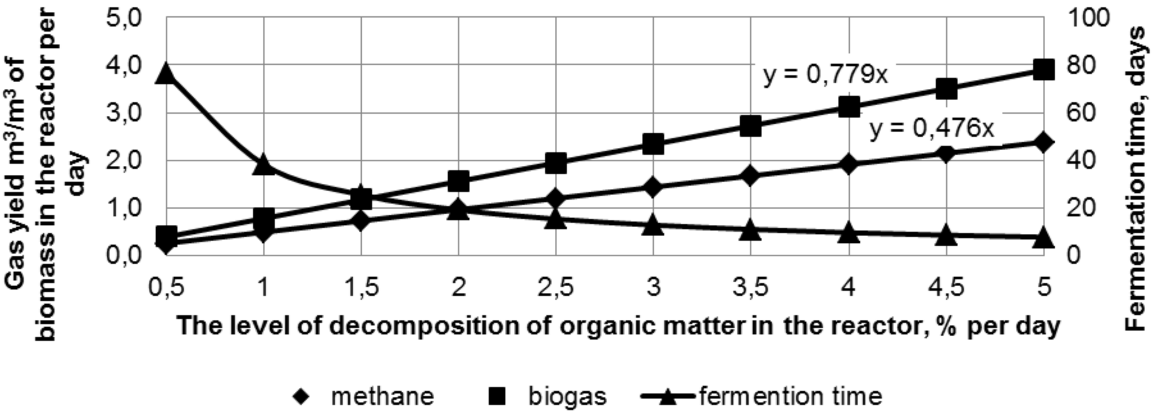

Fig. 9 – The effect of organic matter decomposing intensity on the specific yield of biomethane, biogas and fermentation time

Biogas and biomethane yields increase proportionally with increasing of level of organic biomass decomposing in the reactor, and the fermentation time decreases exponentially till it achieves 38% fermentation level.

CONCLUSIONS

Biological and energetic conversion of organic agrocenosis raw materials with energy production can ensure energy autonomy of agroecosystems in total energy balance. Though, it is impossible to do it according to the types of fuels and energy, since there is a limit on the possibility of autonomous production of electric power and gasoline. However, production of biodiesel and heat energy can be redundant. Source of raw materials that would meet the needs of agricultural production under centralized bioethanol production is sufficient. At the same time, to implement such systems, first of all, it is needed to change the basic principles of society existence, regarding manufacturing of environmentally friendly production and biological diversity preserving.

The heat of straw combustion reduces down to 0.18 to 0.21 MJ/kg for each percent of its humidity increase. Energy efficiency is increased while burning straw in the compressed form (briquettes, pellets). Baled straw should be burned in boilers equipped with cameras for post-combustion of volatile compounds. Non-pressed straw should be burned in crushed form with use of eddy chambers.

Following the scientific-based structure of crop rotation, biofuel production can solve a number of problems and bring in returns to agricultural enterprise.

Oil mass has fully exfoliated during 4 days, allowing the following use of the received product for biodiesel manufacturing. It was found that temperature has no significant influence on sedimentation, while acid number together with content of moisture and volatile matters range in acceptable norms.

The main direction in manure fermentation process intensification is increase of organic matter decomposition at the cost of creation of appropriate conditions for the development of anaerobic microflora. This can be achieved by creating stable fermentation temperature conditions and, what is more important, by providing quality biomass mixing, which, on the one hand, must not to disturb the symbiosis of acetogenic and methanogenic bacteria, and, on the other hand, to prevent the exfoliation of biomass in the reactor to mineral sediment and floating organic layer.

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TECHNOLOGY OF DRAINING AND PROCESSING THE LEVIGATE FROM LANDFILLS IN ORDER TO REDUCE POLLUTION LEVEL
/
TEHNOLOGIE DE COLECTARE ŞI TRATARE A LEVIGATULUI DIN DEPOZITELE DE DEŞEURI NEAMENAJATE ÎN VEDEREA REDUCERII NIVELULUI DE POLUARE

Ph. D. Toth L., Ph.D. Călămar A., Ph D. Pupăzan D., Ph. D. Găman G. A., Ph. D. Kovacs M., Ph. D. Simion S.
[1)] National Institute for Research and Development in Mine Safety and Protection to Explosion
Tel: 0731390803; E-mail: lorand.toth@insemex.ro

Keywords: *pollution, environment, levigate, landfill*

ABSTRACT:

Human society has several major problems and the most acute is the unwanted consequences of environment pollution. The intense use of natural resources and the great amount of generated waste tend to change the natural environment and its self adjusting reactions tend to affect life and the healthy ambient. The house waste represents one of the best indicators who measures the economic vitality and the way of life of the society. The economic growth and development encompass a quantitative growth and a diversification of types of house wastes, obtained for the community facilities.

Nowadays, in our country the management and the treatment of house waste is a real issue for the ensurance of sustainable development. A non-ecological landfill if it doesn't have water-proof base and side walls, draining system and levigate collector, basins or special places to deposit and store toxic waste, can be appropriately set by a good exploitation of the landfill thus influencing positively the environment.

As most city landfills have not water-proof base, levigate may drain in the soil, under soil and in underground waters causing pollution of environmental factors. This paper deals with the problems of drain and processing the levigate from the non-ecological landfills.

REZUMAT:

Societatea umană se confruntă cu o seamă de probleme majore, dintre care se evidenţiază din ce în ce mai mult, consecinţele nefaste ale poluării mediului. Ritmul intens de utilizare a resurselor naturale şi cantitatea mare de deşeuri generate tind să transforme cadrul natural din mediu care înconjoară, in mediu înconjurat, reacţiile sale de autoreglare devenind nefaste atât vieţii cât şi ambientului constructiv creat. Deşeurile reprezintă unul din cei mai buni indicatori care măsoară vitalitatea economică şi modul de viaţă a unei societăţi. Creşterea şi dezvoltarea economică generează, de cele mai multe ori, o creştere cantitativă şi o diversificare a naturii deşeurilor, care se obţin în urma proceselor de realizare a utilităţilor comunitare.

La ora actuală, gestiunea şi tratamentul deşeurilor au devenit probleme cruciale şi complexe pentru asigurarea unei dezvoltări durabile. Datorită faptului că majoritatea depozitelor de deşeuri municipale nu au un fundament perfect impermeabilizat, pot avea loc infiltraţii de levigat în sol, subsol şi ape subterane producând poluarea acestor factori de mediu.

În acest scop lucrarea îşi propune să etaleze problema colectării şi tratării levigatului din depozitele necontrolate de deşeuri municipale prin prezentarea unei tehnologii moderne de colectare şi tratare a levigatului provenit de la depozite necontrolate de deşeuri municipale.

INTRODUCTION

Considering that environment can only bear so much as well as the major effects of environmental pollution, we certainly need to act with full responsibility to promote environmental protection as part of human society development.

In past decades the cheapest way to solve the waste problem was that of storage. At present, singular approaches in waste management are no longer accepted.

Considering a non-ecological spoil dump, whith no base and side walls sealing, no levigate drainage and accumulation system, no reservoirs or designated places for storage of liquid toxic or less toxic and / or dangerous waste, no appropriate operation of activities taking place in a warehouse, the impact on the environment is significant.

Because most municipal spoil dumps do not have a perfect waterproofed foundation, levigate infiltration into the soil, subsoil and groundwater may occur, causing pollution of these environmental factors.

To this purpose, the paper aims to present the issue of collection and treatment of levigate from uncontrolled municipal spoil dumps in order to reduce pollution levels by developing a modern technology and an experimental model for collection and treatment of levigate resulted from uncontrolled municipal spoil dumps.

MATERIAL AND METHOD

In this chapter are presented issues regarding the present state of spoil dumps and technical considerations on levigate.

Due to accorgance of national legislation to that of the European Union, part of the legislation was adopted.

Thus, levigate collecting methods presented in the current national legislation only refer to controlled spoil dumps.

Currently there is no standard method for collecting levigate to reduce pollution of soil, subsoil and groundwater.

According to the legislation in force, levigate treatment can be performed in two plant types, namely:

- Deposit's own treatment plant, allowing for discharge of levigate directly into the natural receiver, observing the legislation;
- Levigate pre-treatment plant, to be discharged to a domestic wastewater treatment plant, in compliance with the effluent quality parameter values.

When it comes to uncontrolled deposits (preponderant in Romania) there are no facilities for collection and treatment of levigate.

In this respect, at uncontrolled municipal where there are neither collecting facilities nor levigate treatment stations, a collecting and pretreatment technology can be applied to lower concentrations of salts, heavy metals and organic substances.

Without using water in the technological process at spoil dumps, it results in wastewater or so-called leach or levigate.

In proportion of 20-30% it results from moisture of waste deposited on the ramp (in this case household waste and vegetal waste), the remaining 70-80% coming from:

- Rainwater falling on the ramp surface and, on its way, solubilizing and carrying along a variety of organic and inorganic compounds, depending on the nature of waste;
- Rainwater leaking from the slopes.

In conclusion, levigate is a result of waste being leached by rainwater and resulting from waste moisture – by free downstream leakage - by infiltration producing groundwater pollution, namely of the phreatic surface and surface water in which it is discharging.

Main physical-chemical characteristics of a medium levigate have been determined by physical-chemical spectrophotometric and gas chromatography methods, and are listed below:

Table 1

Physical-chemical characteristics of a medium levigate

Marker	Values	Pollution type
PH	6,1	Acid
Total organic Carbon	1700 mg/l	Organic pollution
CBO_5	2500 mg/l	
Organic substances	5000 mg/l	
Na;K;	3000 mg/l	Mineral pollution
Ca;Mg;	2000 mg/l	
Cl;SO_4;	5000 mg/l	
NH_4	700 mg/l	
Total Phosphor	6 mg/l	
Fe	900 mg/l	Metal and non ferrous pollution
Mn	25 mg/l	
Zn	10 mg/l	
Other metals such as: Co, Ni, Cu, Cr, Pb, Mo, As, Hg	10 mg/l	

Two important features to note are:

- CBO_5/CCO ratio, that defines the organic character of a dump, should be 0.5 for young dumps, the ratio decreasing to zero for the old ones;

- If on long term CBO_5 can reach values near zero, it will not keep up with CCO, which can remain notable, in the range of g/l.

RESULTS

As mentioned above in the following is the presentation of levigate drainage and treatment flow sheet. The collecting / drainage of levigate from uncontrolled municipal spoil dumps will be achieved by lowering the hydrostatic level of underground water, if groundwater is contaminated by leach, the conducting drills thus obtaining so-called cones of depression.

Ground water contaminated with leach is extracted from boreholes using a submersible pump. Boreholes (from which polluted water will be extracted) will be performed into the grid, to determine groundwater flow gradient. Also, a barrier of cones of depression will be established, acting as wastewater drainage.

The waste water extracted with the submersible pump is placed into a water aerator intended to dissolve air into the waste water.

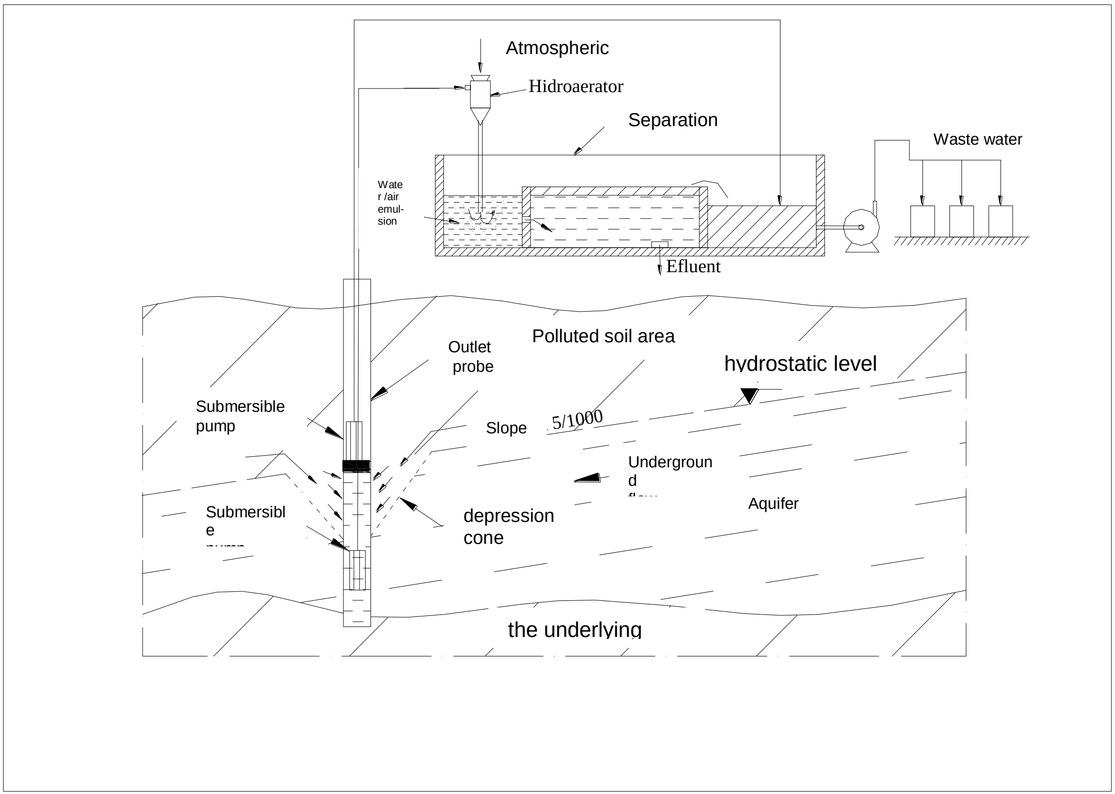

Fig.1 - Waste water drainage and treatment technology flow in a spoil dump

By leach dilution into the groundwater it results waste water which, by a single physicochemical purification step can be discharged into the sewage networks.

The water aerator is a static equipment operating on the principle jet pumps, used to reduce chemical and biochemical oxygen content of wastewater.

Following shutting off spoil dumps remains the issue of territorial rearrangement of the space formally occupied by them. Thus, certain re-greening measures for the affected areas are required.

There are three types of interventions for environmental recovery of the affected territory; the first type requires reconstruction of the landscape as it was before degradation; the second type searches for new use purposes, finding new way of using the space or trying to meet demands advanced by the community; the last type refers to provisional systematization of the affected areas, pending final decisions taken by appropriate bodies.

For reusing the ground surface after its storage capacity is exhausted, the following measures are recommended:

- Evening out works, so as to create the conditions necessary for the regeneration of soil fertility and crop plants or conditions for constructions. Leveling will be performed using bulldozers and both on longitudinal and transversal level.

- Grounding vegetable soil for biological re-cultivation. Areas returned to agricultural use, must have loam or sandy-loam structure on a depth of at least 50 cm, with 15% clay, materials able to retain moisture and have permeability to water and air, as well as a good absorption capacity, are rich in P, K, Ca, S, Mg without containing, however, dangerous substances.

- Drainage works in areas with slopes of 2-3%, after placing the required thickness of vegetable soil.

- Biological re-cultivation works, as the most widely used solution for rendering degraded land areas into use. During the first 4-5 years after closing the spoil dumps it is recommended that the land is cultivated with plants used as green manure and after this period we can proceed to performing usual cultivations.

CONCLUSIONS

Human society is facing a number of major issues, among which detrimental consequences of environmental pollution stand out increasingly more.

Waste represents one of the best indicators measuring economic vitality and a society's way of life.

Currently, waste management and treatment have become crucial and complex issues for achieving sustainable development.

Levigate is a result of waste being leached by rainwater and resulting from waste moisture – by free downstream leakage - by infiltration producing groundwater pollution, namely of the phreatic surface and surface water in which it is discharging.

Following shutting off spoil dumps remains the issue of territorial rearrangement of the space formally occupied by them.

Biological re-cultivation works are the most widely used solution for rendering degraded land areas into use.

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ESTABLISHING BY EXPERIMENTAL RESEARCHES THE AERODYNAMICS RESISTANCE COEFFICIENTS OF GREENHOUSES PLACED ON BUILDING ROOFS
/
STABILIREA PRIN CERCETĂRI EXPERIMENTALE A COEFICIENŢILOR DE REZISTENŢĂ AERODINAMICĂ PENTRU SERELE AMPLASATE PE ACOPERIŞURILE CLĂDIRILOR

Prof. PhD. Eng. Brătucu Gh., Eng. Badiu E.C., PhD. Eng. Păunescu D.D.
[1)]Transylvania University of Brasov / Romania
E-mail: gh.bratucu@unitbv.ro

Keywords: *roof greenhouses, aerodynamics resistance coefficients*

ABSTRACT

Experimental researches were performed on 5 models of constructively similar greenhouses which differ in terms of number of roof slopes (2 or 4) and angles that the slopes form. For researches, a high performance wind tunnel was used, where the air flow velocity values were of 10, 15, 20, 25, 27.5 and 30 m/s. Models were placed on frontal and lateral direction of the air flow, according to provisions of the design code CR-1-1-4/2016, regarding the evaluation of wind action upon buildings. The results obtained have emphasized the influence of model constructive characteristics on their aerodynamics resistance coefficients, as well as the differences from the provisions of design code.

REZUMAT

Cercetările experimentale s-au efectuat pe 5 modele de sere asemănătoare constructiv, care se deosebesc prin numărul de pante ale acoperişurilor (2 sau 4) şi prin unghiurile pe care le formează aceste pante. Pentru cercetări s-a utilizat un tunel aerodinamic performant, în care vitezele curentului de aer au fost de 10, 15, 20, 25, 27,5 şi 30 m/s. Modelele au fost poziţionate pe direcţia frontală şi laterală faţă de curentul de aer, în conformitate cu prevederile codului de proiectare CR-1-1-4/2016, referitoare la evaluarea acţiunii vântului asupra construcţiilor. Rezultatele obţinute evidenţiază influenţa caracteristicilor constructive ale modelelor asupra coeficienţilor de rezistenţă aerodinamică ai acestora, precum şi deosebirile faţă de prevederile codului de proiectare precizat.

INTRODUCTION

Nowadays society is facing several worrying phenomena such as global warming, explosive population growth, accelerated and uncontrolled urbanization, etc., that endanger people health and well-being of future generations (https://rowikipedia.org/wiki/Încălzirea_globală). The effects of the phenomena mentioned above are more and more obvious in urban agglomerations in developing countries, where the statistics have shown that health of 9 out of 10 inhabitants is largely affected by noise, air pollution, sudden temperature changes, draught or violence of certain phenomena of the atmosphere (*http://www.descopera.ro/incalzirea-globala)*. Being worried of these phenomena which led to an unsustainable development of world economy in the last century, many international organisms, governmental organizations or civil society organizations, even well-known personalities involved in science, politics or economy are proposing a series of solutions aiming to diminish their negative effects and re-establish the planet normal environment conditions.(*https://ro.wikipedia.org /wiki/Dezvoltare_durabilă)*. One of the respective solutions related to improving the environment in big cities refers to "greening" them, namely to ensure a minimum green/blue surface for each inhabitant *(http://www.academia.edu/.../SPAŢIILE; http://www.dreptonline.ro/legislatie/lege _spatii_verzi.php)*. For EU countries, this surface must be of 26 m^2/inhabitant, and WHO recommends even 50 m^2/inhabitant (in Bucharest, the green surface is of 9.67 m^2/inhabitant) (*http:// www.legalis.ro/.../legea-24_2007_reglementare_admi*). Having in view that green/blue areas cannot be extended (in fact, they are being reduced in systematic manner over certain occult interests), it was proposed and is successfully being implemented the big towns "greening" by creating green roofs and recently, by placing greenhouses on building roofs. These aspects began to be properly regulated in terms of law in many developed European countries or in US, Japan, etc. *(Despommier D., 2011)*.

While for greenhouses placed on soil a very definite legislative framework has been created (dimensional standardization and calculation systems standardization), in case of roof greenhouses, the building shapes are eventually imposed by urban architects *(Badiu E.C. et al., 2014)*. For these greenhouses, which must not be confused with normal building roofs, the national legislations are recommending the individual research of stress undergone, by modern theoretical numerical methods and on models placed in aerodynamics tunnels, where velocity and direction of air flow should meet the requirements resulted from the practice referring to relevant buildings *(Castelano S., 2007)*.

In Romania, Code CR1-1-4/2012 is used in this respect, where are exemplified, by types of roofs, aerodynamic aerodynamics drag coefficients that design engineers should use in drag calculations *(https://ro.wikipedia.org/wiki/Dezvoltare_durabilă)*. This paper presents the results of experimental research in wind tunnel of classical greenhouse models (for which theoretical research by finite elements method were made) so that additional data be provided to designers, based on which to improve the functionality and safety of greenhouses located on the roofs of buildings in big cities**.**

MATERIAL AND METHOD

The main objective of the experimental research in this paper was to measure, in the wind tunnel, pressures/depressions and thrust forces exerted on frontal, lateral surfaces and on the roofs of some greenhouse models that can be located on building roofs, to frontal and lateral action of the wind blowing at different speeds.
In order to achieve the main objective of this research it was necessary a sequential approach and solving of several subsidiary objectives, such as:

- correct determination of the number of greenhouse models and their forms, according to construction requirements imposed by plant environmental factors, classification in urban development legislation, climatic parameters specific for the geographical area, etc.;
- practical realization of five greenhouse models, with equal bases surfaces and heights, but with different roof slopes number, tilting angles and adaptation to the requirements of the study in the wind tunnel used;
- Establishing a rigorous program (method) of experimental research in order to study pressure and pressure forces exerted by wind on models, according to the provisions in Code CR 1-1-4/2012 *(http://www.descopera.ro/incalzirea-globala)***,** that would confer the guarantee that the results obtained in the research are correct;
- determining pressures/depressions exerted by the wind blowing at different speeds on models frontal, lateral surfaces, but also on roofs with different tilting slopes.
- determining pressure forces exerted by the wind blowing at different speeds on frontal and lateral walls of the five models;
- calculating drag global coefficients of the greenhouse models researched and comparing them to those stipulated in CR 1-1-4/2012;
- Processing, analysing and interpreting experimental research results and comparing them to the ones obtained in theoretical research.

The experimental research objects are five greenhouse models (Fig. 1), made of plastic material, 2.5 mm thick. In order to compare the results of experimental research between them, it was established that base surfaces and heights of all the models be identical, the differences between them consisting in the number of roof slopes, their tilting angles and the useful volumes.

Fig. 1 – Greenhouse models for experimental research

Models 1, 2, and 3 have two-slope roofs; model 4 has a roof made of four slopes forming a ridge, while model 5 has a roof made of four identical slopes forming a roof top. For models to have enough rigidity to wind action, the plastic panels were fixed with screws on profiles shaped of 1.5 mm metal sheets.

Since the wind tunnel is provided with 16 tubes, with outer diameters of 3 mm, used to measure the pressure exerted by the wind on frontal and lateral vertical walls as well as on roof slopes, several holes with 3 mm diameter were made in places considered to be representative. The holes that were not used to measure pressures were covered with adhesive tape. When measuring the thrust forces exerted by the wind on the models, all the holes were covered.

Also, in all models, a hole with a diameter of 30 mm was made in the bottom plate to introduce and fix, in the holes made in the walls and roofs, the tubes measuring wind pressure/depression. The hole in the bottom plate was also used to fix, with the help of adequate clamps, the models in the wind tunnel and the device supporting the calibrated stem measuring the air flow thrust force exerted on greenhouse models.

Table 1

The geometrical characteristics of the greenhouses models used in the experimental research

Model no.	α_1^0	α_2^0	A_b [cm²]	H [cm]	V [cm³]	A_{fv} [cm²]	A_{fac} [cm²]	A_{lv} [cm²]	A_{lac} [cm²]	A_t [cm²]
1	110	-	400	20	6600	330	-	260	240	1660
2	120	-	400	20	7000	350	-	300	220	1740
3	90	-	400	20	6000	300	-	200	280	1560
4	115	120	400	20	5600	250	80	250	180	1520
5	100	100	400	20	5200	250	120	250	120	1480

The geometrical characteristics of the greenhouses models used in the experimental research are mentioned in Table 1, where notations have the following significance: α_1 – angle formed by roof main slopes; α_2 - angle formed by roof secondary slopes; A_b – base area, equal in all models; H – model height, equal in all models; V – model internal volume; A_{fv} – vertical frontal wall area; A_{fac} – frontal roof surface area; A_{lv} – lateral vertical wall area; A_{lac}- lateral roof surface area; A_t – walls and roof total surface.

It is to be mentioned that the forms of the 5 greenhouse models were not chosen by chance; they are the result of analysis of most greenhouse forms that are currently used on the ground or on rooftops. These forms not only meet the environmental requirements for a large number of plants, but also the economic ones, meaning that they use materials and equipment affordable in terms of reliability/price ratio, being verified in practice.

In order to achieve the main objective and the subsidiary ones of experimental research, a *general method* was created and followed, in which the main elements set out in Code 1-1-4 CR / 2012 *(http://ugir.ro/wp-content/uploads/2012/06/CR-1-1-4-2012.pdf)* were observed.

Therefore, the greenhouse models have roofs with two or four slopes and the aerodynamic resistance coefficients in the specified Code take into account frontal and lateral directions the wind blows from. Thus, the results of experimental research on these models can be compared with those specified in the respective norms. On the other hand, the maximum air flow velocity in the wind tunnel available for experimental research is 30 m/s, satisfactory for climatic conditions in Romania.

The main equipment used in the experimental research was the wind tunnel HM170 Educational Wind Tunnel G.U.N.T. Gerätebau GmbH. Barsbüttel, Germany ***(**** *Equipment for Engineering Education. Operating Instructions. HM170.23 Pressure Cylinder. G.U.N.T. Gerätebau GmbH. Barsbüttel, Germany)*, from in the Laboratory of Wind Energy Study within Product Design, Mechatronics and Environment Department of Transylvania University in Brasov; its general view is presented in Figure 2.

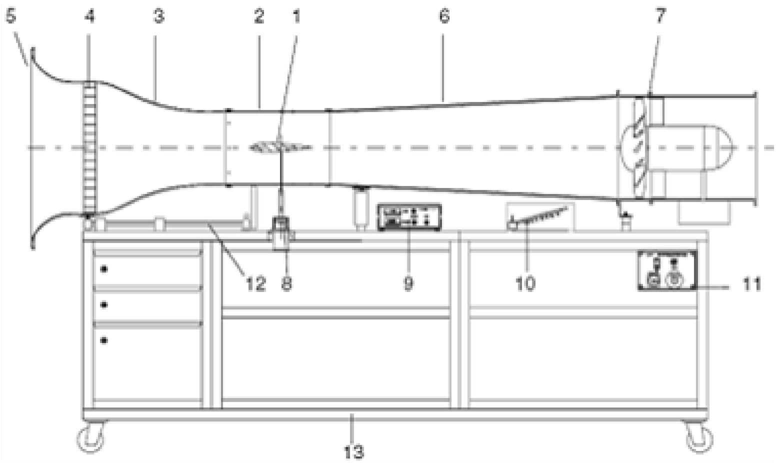

Fig. 2 – HM170 Educational Wind Tunnel G.U.N.T. Gerätebau GmbH. Barsbüttel, Germany [4]

This is a subsonic tunnel (air velocity reaches a Mach number of about Ma = 0.1), open circuit (air is drawn in from outside and blown back out into the open, with increased velocity). The measurement area has a 287 mm x 287 mm section and 365 mm length; it is made of transparent Plexiglas and the superstructure moves longitudinally so that the objects under experimental researches be inserted and removed.

The experimental model 1 is fixed in measurement section 2. The air is drawn in from the atmosphere via the funnel 5, the parallel flow being ensured through section 4 (any transverse air flow components are reduced to zero). The parallel flow is accelerated to roughly 3.3 times its original velocity, in section 3, while in section 6 the flow is decelerated and the air is drawn out through the axial fan 7 *(*** Equipment for Engineering Education. Operating Instructions. HM170.23 Pressure Cylinder. G.U.N.T. Gerätebau GmbH. Barsbüttel, Germany)*.

- The equipment for measuring the forces consists of the force transducer 8 which is integral with the experimental model 1. This transducer can perform, inside the tunnel, measurements (in two directions: drag and lift) on the forces, speeds, pressures, drag and lift coefficients. Force values can be viewed on measurement amplifier with force display 9.

Air speed in measurement section 2 is indicated at the inclined-tube manometer 10. The control panel 11 has a main ON/OFF power supply switch, emergency stop, speed control (a frequency converter) and an ON/OFF fan switch. The sliding guide 12 permits moving the lateral wall of measurement section and the access inside the section. The system is installed on a trolley 13.

Pressures measurement is made using a multitube manometer (Fig. 3) attached to the tunnel *(***Equipment for Engineering Education. Experiment Instructions. HM170.50 Multi-Tube Manometer Panel. G.U.N.T. Gerätebau GmbH. Barsbüttel, Germany)*, having 16 Prandtl tubes with differential pressure gauge 2, installed on an inclinable panel 1. Each manometric tube is provided at the top with a connection jet 3. Water supply is achieved by means of tank 4, connected to the connecting tube 5. By construction, the multitube manometer offers the possibility to measure absolute or relative air pressure, static or dynamic air flow pressure. The panel can be oriented in 3 inclination positions with the help of lever 6, thus offering the possibility to measure very low pressures. Panel inclination can be read on indicator 7: 1:2 (63.4^o), 1:5 (78.7^o), 1:10 (84.3^o). Fixing the panel on vertical direction is made using screws 8, taking into account indicator 10. Fixing the panel on stand 11 is made using fastening screws 9.

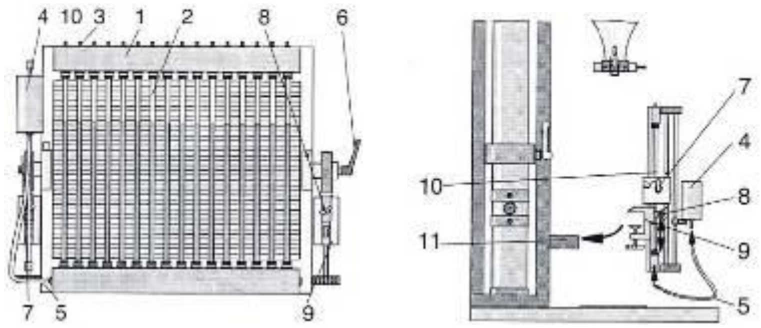

Fig. 3 – Structure of multitube manometer for pressure measurement [5]

During water supply, upper jets of manometric tubes are not connected and according to communicating vessels principle, the water level is the same in the tank and in all tubes, taking into account atmospheric pressure.

- Thermal anemometer (Fig. 4) is part of the equipment necessary for using the wind tunnel; it helps adjusting and checking air flow speed during the experimental research *(Lates M.T., 2012)*.

Fig. 4 – Thermal anemometer attached to the wing tunnel [13]

Thermal anemometer has the following structure and facilities: 1 – strain gauge-type sensor; 2 – on button; 3 – off button; 4 – backlight screen button; 5 – button for calculating the average value measured; 6 – setting the measurement unit; 7 – calibration button; 8 – memory button; 9 – button for deleting the memorised value; 10 – button for displaying minimum, maximum, average value measured since the "on" button has been activated; 11 – button for displaying the temperature measured; 12 – button for displaying the wind speed measured; 13 – scroll down button; 14 – scroll up button; 15 – display of temperature value measured; 16 – display of wind speed measured.

Experimental research conduct

Experimental researches were conducted in the Laboratory of Wind Energy Study within Product Design, Mechatronics and Environment Department of Transylvania University in Brasov. Preparations for carrying out experimental research aimed at checking the technical condition of models and their adjacent devices, operation at the rated parameters of wind tunnel, anemometer and other equipment included and necessary for these researches.

- Measurement of wind pressure on models

Because the test equipment has only 16 tubes for pressure measurement, their judicious distribution on the surfaces exposed to the wind was necessary. At models no. 1, 2 and 3, 5 tubes were installed on the frontal vertical wall, on a lateral vertical wall and on a roof slope. At models no. 4 and 5, the pressures on four surfaces were studied, namely, two vertical walls and two roof slopes. The other holes in the walls and roof of the model were covered with adhesive tape. It has also been considered that on the vertical lateral wall and the roof slope from the opposite side, the action of the air flow is symmetric.

Fig. 5 – Preparing model 1 for measuring wind pressure

For fixing the ends of the tubes in the holes established as representative by their positions for measuring pressure, models superstructure was removed from the bottom plates, tubes were inserted through the 30 mm diameter holes in the middle of them and they were sealed onto the walls and the roof of each model. The model superstructure was fixed on the bottom plate and the entire assembly was fixed with three metal clamps on the tunnel floor. The edges of the models were then sealed against the tunnel floor with adhesive tape.
Figure 5 presents model 1 prepared to be introduced in the wind tunnel in order to measure air flow pressure on its walls and roof.

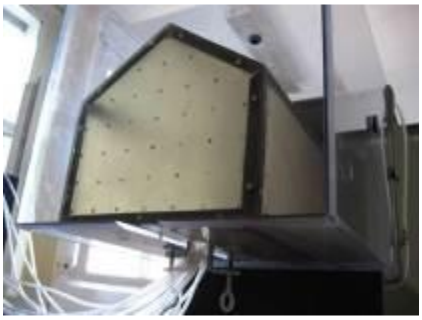

Fig. 6 – Introducing model 1 in the wind tunnel

Fig. 7 - Model 1 fixed in the wind tunnel to measure pressures

Figure 6 presents the model placed on the floor of tunnel measurement area, while figure 7 presents the adjustment of a wind speed value by using the anemometer probe.

It is to be mentioned that each model was set in the wind tunnel in two positions reported to air flow direction, namely frontal and lateral, as it is mentioned in Code CR 1-1-4/2012 *(http://ugir.ro/wp-content/uploads/2012/06/CR-1-1-4-2012.pdf)*.

- Measurement of thrust force wind exerts on models

Adapting the models to measure the drag forces the air flow exerts with speed of 10 m/s, 15 m/s, 20 m/s, 25 m/s, 27.5 m/s and 30 m/s started from the shape and dimensions of the force transducer 8 where model 1 is fixed for experimental research (Fig. 2).

There was an important issue regarding the correct positioning of the models on the calibrated stem of the device for measuring wind thrust forces exerted on them. To this end it was designed and built the support in Figure 8. The calibrated stem is supplied by the company producing the wind tunnel so its size should be taken into account in designing and producing the support.

Fig. 8 – Construction of the support for calibrated stem used to measure thrust forces

Fig. 9 – Assembling calibrated stem support in one of the models to measure air flow thrust force

The support is made of a plastic material tube, with 30 mm outer diameter, inside of which two wooden discs were introduced and fastened with screws. The first one is fixed at the end of the tube and is shaped so as to be correctly placed reported to roof sides (for each model the adequate support was made). With a screw operated from the outside, the disc is positioned and set perpendicular to the bottom plate. A second disc, with a 10 mm thickness, is fixed with a screw at a 90 mm height (the same for all supports), which is essential for determining the values of wind thrust forces. A hole with a 4 mm diameter was made in the middle of the disc through which the calibrated stem of the thrust force measurement system passes. The discs are fixed to the stem with an adequate screw. At the lower end, the support has a 3 mm thick disc which is pressed on the tube and fixed with three screws on the bottom plate of each model.

Figure 9 shows how the described assembly is mounted in each model. All models were introduced, by turn, in the wind tunnel and were subjected to the air flow action on the frontal and lateral directions, at speeds specified above.

RESULTS

- Results of the measurements of wind pressure on greenhouses superstructure

As stated earlier, pressure measurements were made for each model for two air flows (wind) directions namely frontal and lateral (as defined under the Code CR 1-1-4 / 2012). Depending on the number of each model roof slopes (two or four), the 16 Prandtl tubes were placed on two vertical walls and on one or two roof slopes.

Measurement results for each tube is presented in a table, for each greenhouse model, wind direction and vertical wall or roof slope affected by the air flow. Hole numbers in the tables correspond to the numbers written on the models walls and roofs holes.

The reference value of water level in the multitube manometer tubes was 21 mbar (offset 21 mbar to 0, which is considered the normal atmospheric pressure). When drawing the pressure variation graphs to air flow frontal, respectively lateral actions in the wind tunnel, the reference value mentioned became abscissa origin, on which were considered, in mmH_2O, the pressures and depressions (suction) specified in the case of each model for vertical walls and roof slopes.

- Results of the measurements of wind pressure on model 1 superstructure

In the case of this model it was considered that one must observe the simultaneous action of the air flow on three representative surfaces, namely on frontal and lateral vertical walls and on one of the two symmetrical roof slopes, 5 Prandtl tubes having been fixed on each to measure pressure variations.

When choosing the position of each tube its representativeness was taken into consideration, meaning that they were placed both in the centre and on the edges, that is why small variations of the pressures registered on the same surface of the model were registered. Instead, the averages of the 5 values lead to credible results.

According to the experimental research method (program), each greenhouse model was exposed to air flow frontal and lateral actions at all speeds established before. Tables 2, 3 and 4 present the pressure variations on the three surfaces to frontal air flow direction.

Table 2

Model 1: The measured values of the pressure on the vertical frontal wall to the air flow frontal action

The speed of wind/ Aperture	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s[	30 [m/s]
1	21.1	20.7	20.5	20.2	19.4	18.9
2	20.9	20.6	20.0	19.6	19.1	18.8
3	20.6	20.3	19.4	18.8	18.2	17.9
4	20.7	20.4	19.8	19.2	18.9	18.6
5	20.8	20.4	19.8	19.1	18.6	18.3
Average	**20.8**	**20.5**	**19.9**	**19.4**	**19.0**	**18.7**

Table 3

Model 1: The measured values of the pressure on the vertical lateral wall to the air flow frontal action

The speed of wind/ Aperture	10 [m/s[	15 [m/s[	20 [m/s[	25 [m/s]	27.5 [m/s[	30 [m/s]
1	21.4	22.6	23.2	24.9	25.8	26.9
2	21.5	22.7	23.4	24.8	26.1	27.3
3	21.6	22.5	23.3	25.8	26.9	27.9
4	21.3	22.5	23.2	24.6	25.9	27.1
5	21.2	22.7	23.4	23.7	25.0	26.3
Average	**21.4**	**22.6**	**23.3**	**24.7**	**26.0**	**27.2**

Table 4

Model 1: The measured values of the pressure on the lateral roof to the air flow frontal action

The speed of wind/ Aperture	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]
1	21.5	21.9	22.6	23.6	24.5	25.3
2	21.6	21.8	22.8	23.5	24.0	24.5
3	21.3	21.7	22.9	23.3	23.8	24.2
4	21.2	21.5	22.6	23.3	23.8	24.3
5	21.4	21.4	22.3	23.3	23.7	24.1
Average	**21.4**	**21.7**	**22.7**	**23.4**	**23.9**	**24.4**

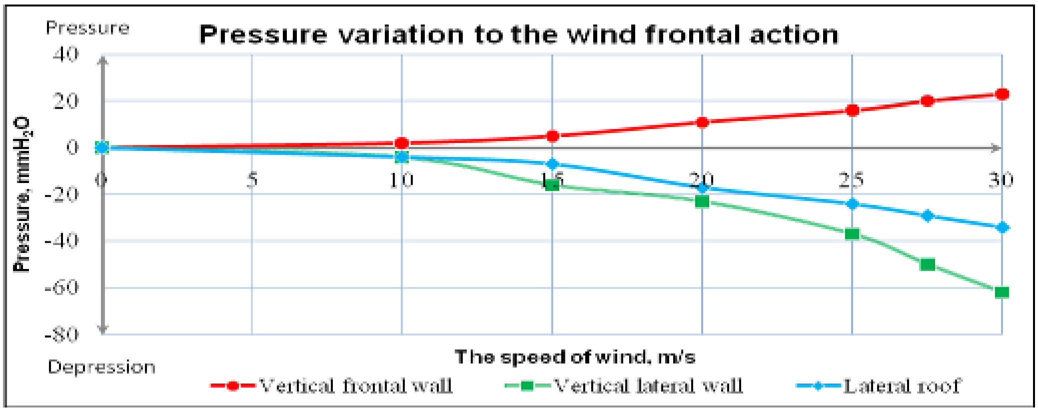

Fig. 10 - Pressure variation on M1 model superstructure, to frontal action of air stream

From tables 2, 3 and 4 and their graphical representation in figure 10 can be observed:

- air flow causes a pressure (pressure) only on the frontal vertical wall, while on the lateral vertical wall and roof it causes depression (suction);

• to increase the speed of the air flow up to 30 m/s the pressure exerted on frontal vertical wall increased by 23 mmH_2O, while the depression on the lateral vertical wall had a value of - 62 mmH_2O, and on the lateral roof slope it fell to - 34 mmH_2O;

In tables 5, 6 and 7 are presented pressure variations on the three walls of the model no.1, when direction of the air flow is lateral compared to respective model; in figure 11 are designed the graphs of pressure variations and depressions depending on air flow speed.

Table 5

Model 1: The measured values of the pressure on the vertical lateral wall to the air flow lateral action

The speed of wind/ Aperture	10 [m/s[	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]
1	20.9	20.8	20.7	20.6	20.5	20.4
2	20.8	20.6	20.2	19.6	20.1	19.0
3	21.0	20.6	20.0	19.3	19.1	19.0
4	20.9	20.4	19.8	19.2	18.9	18.8
5	20.8	20.1	19.3	18.1	17.9	17.8
Average	**20.8**	**20.5**	**20.0**	**19.4**	**19.1**	**18.9**

Table 6

Model 1: The measured values of the pressure on the lateral roof to the air flow lateral action

The speed of wind/ Aperture	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]
1	21.0	21.2	21.5	21.6	21.9	22.2
2	21.2	21.3	21.7	22.1	22.3	22.4
3	21.4	21.8	22.3	22.8	23.4	24.1
4	21.0	21.1	21.7	22.3	22.5	22.6
5	21.1	21.3	21.3	22.2	22.3	22.3
Average	21.1	21.4	21.6	22.2	22.4	22.5

Table 7

Model 1: The measured values of the pressure on the vertical frontal wall to the air flow lateral action

The speed of wind/ Aperture	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]
1	21.8	23.0	24.2	25.0	26.4	27.8
2	22.2	23.1	24.3	25.2	26.6	28.3
3	22.0	23.2	23.8	25.2	26.8	28.2
4	21.8	22.9	24.0	24.9	26.4	28.1
5	22.2	22.8	24.1	24.9	26.1	28.4
Average	**22.0**	**23.0**	**24.2**	**25.1**	**26.5**	**28.2**

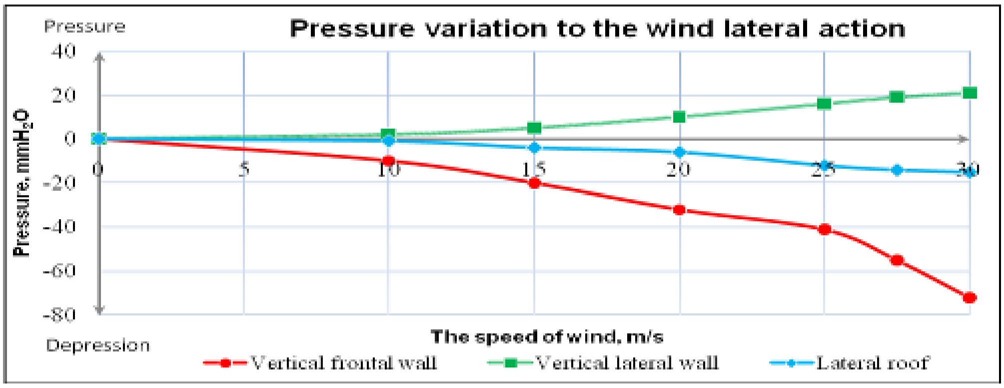

Fig. 11 - Pressure variation on M1 model superstructure to wind lateral action

It is noted that this time the pressure is exerted only on the vertical lateral wall (21 mmH_2O), while on the vertical frontal wall and the roof slope exposed to the air flow depressions occur. The most pronounced depression is found on the vertical frontal wall, where at air flow speed of 30 m/s, the depression was -72 mmH_2O. On the lateral roof side depression was of -15 mmH_2O.

The same thing was done with all the models; it is to be mentioned that in the case of models M4 and M5 with four-slope roofs, the 16 tubes of multitube manometer were uniformly distributed on two vertical walls and two roof slopes.

- Results of the measurements of wind force on greenhouses superstructure

For each model and for each predetermined speed of air flow within wind tunnel were recorded thrust forces to its frontal, respectively, lateral action.

As thrust forces wind exerted on the models within wind tunnel would be real only if their contact point with the calibrated stem of the measurement system is located at a height of 302 mm their correction was necessary, as specified by the equipment supplier, by which to take into account that for all models the contacts with calibrated stems have been made at the height of 150 mm, namely:

$$Fcor = Fm\frac{302}{150}, \quad (1)$$

Fm is the force value measured and read at specialized equipment no 9 of wind tunnel, [N];

Fcor is the corrected (real) value of air flow thrust force exerted on models within the wind tunnel, [N].

Corrected values of these thrust forces are presented in tables 8 and 9.

Table 8

The corrected values of the drag force against the models, to the wind frontal action, N

Model\ The speed of wind	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]
1	4.0	9.0	11.6	13.2	14.4	15,9
2	4.0	8.6	11.4	13.2	14.2	15.8
3	3.6	7.8	11.8	13.0	14.8	16.0
4	3.4	7.0	10.2	12.6	13.0	14.4
5	3.4	7.4	11.2	12.8	13.6	15.2

Table 9

The corrected values of the drag force against the models, to the wind lateral action, N

Model\ The speed of wind	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]
1	5.0	11.0	12.6	15.0	16.2	17.8
2	5.2	10.6	12.4	14.6	15.8	17.6
3	4.6	10.0	11.8	13.8	15.2	17.0
4	4.0	8.6	11.4	13.4	14.4	16.0
5	3.4	7.4	11.2	12.8	13.6	15.2

It is noticed that at frontal air flow action, models 1, 2 and 3 oppose drag forces quite close, especially at high wind speeds. The lower the drag resistance force was recorded, in the case of wind front action, at model no. 4, which was about 12% lower than that at model no. 3. At model no 5, thrust force of frontal air current registered an average value between thrust forces of the first three models and the thrust force of model 4. In the case of air flow lateral actions, it is noticed an increase by 10 ... 13% of thrust forces at the models 1, 2 and 3, the highest value being recorded at model 1. Increasing thrust force is manifested to model 4, but also to lateral action of the air flow. This is smaller compared to the forces recorded at the three models by more than 10%.

The special aspect is found in case of lateral action of air flow at the model no. 5, where pushing resistance forces are similar to those found to the frontal action of this air flow and are by 15-18% smaller than measured forces at the first three model forms.

- The aerodynamic resistance coefficients to wind thrust action

To calculate the aerodynamic resistance coefficients to wind thrust action, the following relation was used:

$$F_d = \frac{1}{2}\cdot\rho\cdot c_d\cdot A\cdot v^2, \quad (2)$$

ρ is the air density, [kg/m^3];

A is model surface area exposed to wind, [m^2];

c_d – aerodynamic resistance coefficient of the models to air flow action;

v – air flow speed (wind), [m/s].

For an air temperature T = 18°C, barometric pressure p = 1026 mbar and air relative humidity of 60%, the air density value is $\rho = 1225$ kg/m^3.

Aerodynamic resistance coefficients c_d, calculated using relation (2), also recommended by wind tunnel provider, and corrected thrust forces in tables 8 and 9 are shown in table 10 for each model and predetermined wind speed to the frontal action, respectively in table11 to its lateral action. In figures 12 and 13 the variations of these coefficients depending on air flow speed are graphically represented.

Table 10

The values of the aerodynamic resistance coefficient to the wind frontal action

Model\ The speed of wind	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]	Average value
1	1.98	1.98	1.44	1.05	0.94	0.88	**1.38**
2	1.87	1.78	1.33	0.99	0.89	0.82	**1.28**
3	1.96	1.89	1.60	1.13	0.99	0.92	**1.41**
4	1.68	1.54	1.26	1.00	0.85	0.79	**1.19**
5	1.50	1.45	1.24	0.90	0.79	0.75	**1.10**

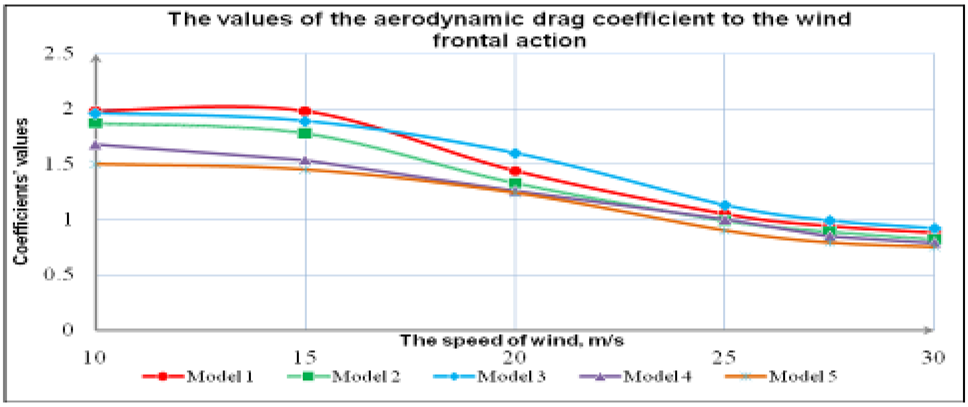

Fig. 12 – The variation of models aerodynamic resistance coefficients to wind frontal action

In tables 10 and 11 are also presented the average values of the aerodynamic resistance coefficients for each model, which offer a performances complete imagine of different constructive solutions of greenhouses placed on building roofs, with respect to their behaviour to wind action.

Table 11

The values of the aerodynamic resistance coefficient to the wind lateral action

Model\ The speed of wind	10 [m/s]	15 [m/s]	20 [m/s]	25 [m/s]	27.5 [m/s]	30 [m/s]	Average value
1	1.63	1.60	0.98	0.78	0.70	0.65	**1.05**
2	1.63	1.48	0.97	0.74	0.66	0.62	**1.02**
3	1.56	1.51	1.00	0.75	0.68	0.64	**1.03**
4	1.51	1.45	1.08	0.81	0.72	0.68	**1.04**
5	1.50	1.45	1.24	0.90	0.79	0.75	**1.10**

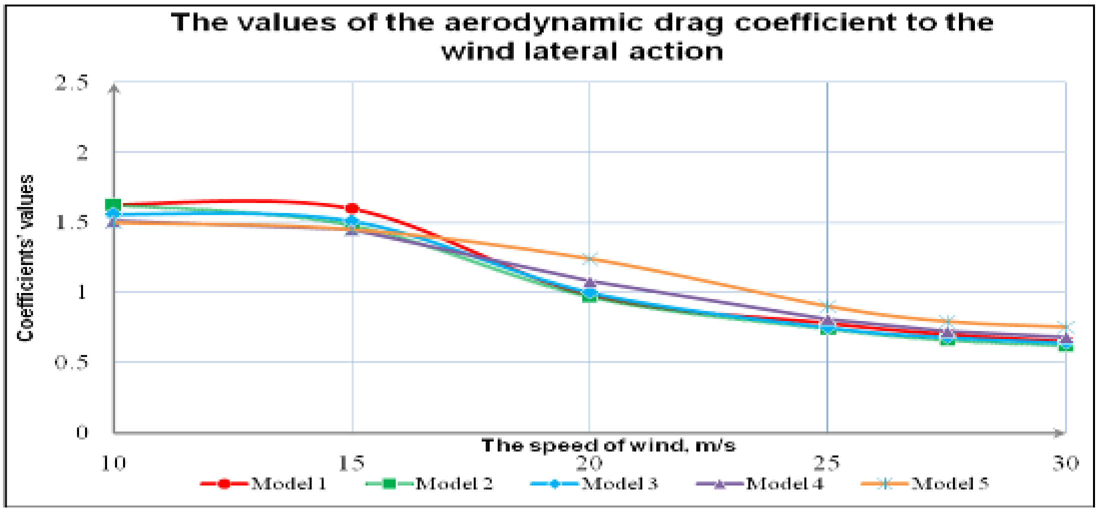

Fig. 13 - Variation of models aerodynamic resistance coefficients to wind lateral action

It is noticed that at different wind speed values, the aerodynamic resistance coefficients have different values. However, the shapes relatively similar of the five greenhouse models which were subject of experimental research, lead to sensitive grouping of aerodynamic resistance coefficient values, both to the frontal and lateral wind action, for its specified speed. In fact, for practical applications researches should be done only for wind maximum speeds where is placed the building on which a vegetable or flower greenhouse is going to be build, namely to determine an aerodynamic resistance coefficient on air flow frontal and lateral directions.

From the results listed in tables 10 and 11 and from graphical representations in figures 12 and 13 the following are noticed:

- aerodynamic resistance coefficients of the models subjected to experimental research are in limits presented in tables 4.2, 4.4, a, b and 4.5 according to provisions of the design code CR-1-1-4/2012, regarding the evaluation of wind action upon buildings, on the recommended values for two-slope roofs (1.98…0.75 on models, 1.5…0.6 in tables), respectively with 4 slopes (- 1.51...0.63 on models; - 1.2…- 0.5 in tables);
- for all researched models, aerodynamic resistance coefficients to wind frontal action are higher by 20..25% compared to the calculated ones to wind lateral action. An exception is done by model 5, where the four-slope roof is symmetric, so, no matter of wind direction the aerodynamic resistance coefficients have the same value;
- in case of models 1, 2 and 3, with two-slope roofs, the lowest aerodynamic resistance coefficients to lateral wind action are registered for model 2, to which the angle made by roof slopes is the largest (120°). In increasing order are located models 1 and 3, where the slope angles are of 110°, respectively 90°;
- at lateral wind action the lowest aerodynamic resistance coefficient values are in model 2, where the roof slopes are less inclined compared to vertical position and comparative to the inclinations of the other models roof slopes;
- at models 4 and 5, with four-slope roofs, the aerodynamic resistance coefficients to the frontal wind action are lower by 15 ... 20% than the models with two-slope roofs; instead, at wind lateral action, aerodynamic resistance coefficients of these forms of greenhouses were higher than for the two-slope roofs;
- to the frontal wind action, model 5, having the roof made of four symmetrical slopes, presents lower aerodynamic resistance coefficients by 10% compared to those of the model 4, where the slopes are symmetrical two by two; instead, to the lateral the action of the wind, aerodynamic resistance coefficients are lower in model 4 with 5 ... 10% less than in the case of model 5;

In case of experimental researches in wind tunnel (Fig. 14), a difference between thrust forces against different models is noticed starting with wind speeds over 15 m/s.

The best results are observed to model 4 having four unequal slopes roof and the angle of the main slopes of 115°, where the frontal thrust force is 12% lower than in the case of model 1 which has two equal slopes roof and the slopes angle of 110°.

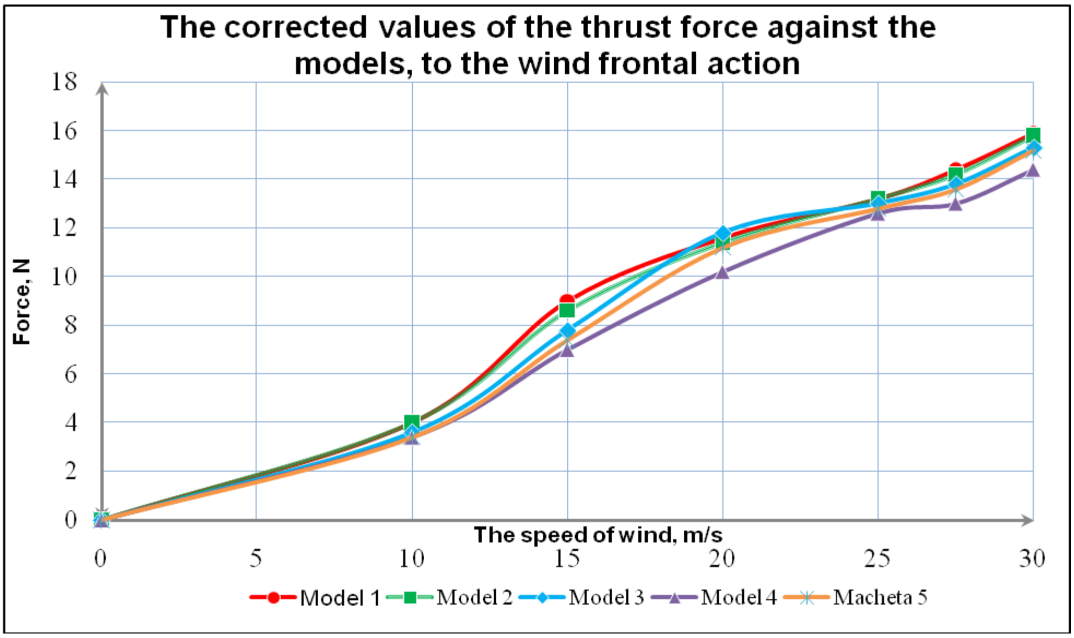

Fig. 14 - Variation of the thrust force against the models to the wind frontal action, according to experimental researches within wind tunnel

In figure 15 are presented the variations of the thrust force against models to lateral wind action, resulted according to experimental researches in wind tunnel. In this case, the best results are offered by model 5 with four equal slopes roof forming a top. Actually, at this model the thrust force is equal for the two wind action directions, meaning that to lateral wind action, the respective force is higher for the other models, especially for those with two-slope roof.

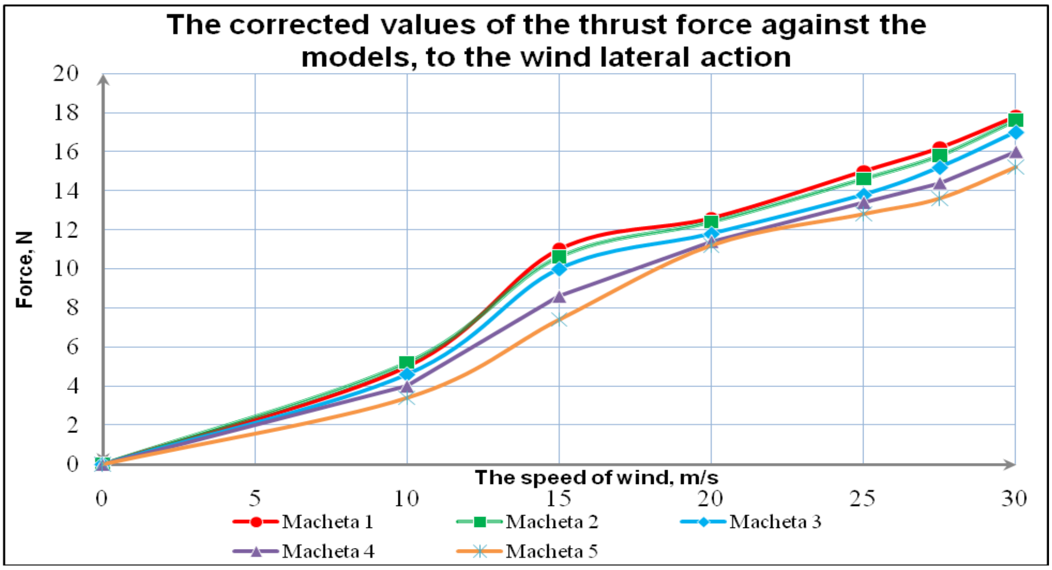

Fig. 15 - Variation of the thrust force against models to lateral wind action, resulted in wind tunnel experimental researches

CONCLUSIONS

- Experimental researches in aerodynamic tunnel on greenhouses models similar to those that are going to be placed on some building roofs in big cities must totally observe the specified requirements in Code CR1-1-4/2012.
- The results obtained in the researches carried out in this paper underline the necessity of using, at the specific calculations for the resistance structures of the greenhouses placed on building roofs, some aerodynamic resistance coefficients by approximately 20% higher than those referring to normal building roofs.

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USING THE INDEXES IN ESTIMATING RAINFALL EROSIVITY – CASE STUDY BUCHAREST
/
UTILIZAREA INDICILOR ÎN ESTIMAREA EROZIVITĂŢII PLUVIOMETRICE – STUDIU DE CAZ BUCUREŞTI

Conf. Ph.D.Eng. Rusănescu C.O.*1), Prof. Ph.D. Eng. Paraschiv G.1), Prof. Ph.D. Eng. Biriş S. Şt.1), Prof. Ph.D. Eng. Voicu G.1), Ph.D Rusănescu M.2), Conf. Ph.D.Eng. Begea M.1)
1) Polytechnic University of Bucharest, Faculty of Biotechnical Systems Engineering / Romania; 2)Valplast Industry Bucharest
E-mail :otiliarusanescu@yahoo.com

Keywords: *rainfall erosivity, Fournier indexes, angot indexes*

ABSTRACT
This paper evaluates rainfall aggressiveness on Bucharest substrate using the following indexes: Fournier (IF), Modified Fournier (IFMs) Index Angot. They can be used to assess the susceptibility to erosion of land, for the calculation of the loss of land and soil erodibility , land sensitivity assessment slip due to heavy rain. These indices were calculated based on rainfall in Bucharest within the interval analyzed of 2009-2015. Rain from heavy rains has the force to deploy and carry soil particles; soil erosion is very high during these rains. Surplus quantities of rainfall cause intense processes of soil erosion, landslides, floods and floods.

REZUMAT
În prezenta lucrare este evaluată agresivitatea pluvială asupra substratului în Bucureşti utilizând indici: Fournier (IF), Fournier Modificat (IFM) şi Indicele Angot. Pot fi utilizaţi pentru evaluarea susceptibilităţii terenurilor la eroziune, pentru calculul de erodibilitate a pierderilor de teren şi sol, în evaluarea sensibilităţii terenurilor la alunecare datorate precipitaţiilor intense. Aceşti indici au fost calculaţi în funcţie de precipitaţiile căzute în Bucureşti intervalul analizat a fost 2009-2015. Ploaia din precipitaţiile torenţiale are forţa de a disloca şi transporta particulele de sol, eroziunea solului devine foarte mare în timpul acestor ploi. Cantităţile excedentare de precipitaţii determină procese intense de eroziune a solurilor, alunecări, viituri şi inundaţii.

INTRODUCTION
Soil erosion is the detachment and transport of soil particles under the action of water and air. The result is the destruction of soil erosion (by washing the surface layer of the richest in humus profile belittle its fertility) or modification of soil cover.
Assessing the aggressiveness of rain on the substrate was determined using the following indices: Fournier index (IF), Modified Fournier Index (IFM) Index Angot.
These indices can be used to assess susceptibility to erosion of land for calculating the erodibility loss of land and soil, land sliding due to the sensitivity assessment of intense rainfall (Scrinzi et al., 2006). The literature shows that the index modified Fournier and Fournier index are relevant in studies focused on aggressiveness precipitation [5,12].

Choosing the critical value of 100 mm, under which aggressiveness climate is considered low, it is supported by Rice, Pillsbury (1982), who developed an index of severity of rainfall causing landslides and erosion that takes into account rainfall and the duration of the phenomena hours.

Interpretation classes erosivity determined by Fournier index [9,12]; [8, 1]; (Costea, 2012) is presented in Table 1.

Heavy rains are heavy with high intensity and short duration, falling on small areas, are more common during the warm season (June, July). Rain from heavy rains has the force to deploy and carry soil particles; soil erosion is very high during these rains. Heavy rains with water drops with diameters of 3-7 mm and beans hail impact in pluviodenudation (erosion exerted by rain drops) and, according to some authors, and washing the surface runoff [8]. Surplus quantities of rainfall causes intense processes of soil erosion, landslides, floods and floods [3].

Rains falling in several days and increases surface run an action of erosion on slopes slopes, much bigger as water infiltration capacity decreases. The number of consecutive rainy days is an indicator of the intensity of erosion processes and mass movement, because the amount and persistent rains contribute to state fragility systems [7]. Heavy rain has the strongest effect on the landscape and soil erosivity. Efficiency is measured aggressiveness and rain erosion better when the rain intensity is considered a period of 15 minutes. Heavy which have a minimum of 0.6 mm / min for a 15-minute period are considered to be aggressive heavy [4].

MATERIAL AND METHOD

Erosivity rainfall estimation using Fournier index (IF).

Fournier index (IF) is calculated according to the amount of rainfall in the wettest month of the year and the annual amount of precipitation thus expressing the degree torrential rainfall:

$$IF = \frac{P_m^2}{P} \tag{1}$$

Where: P_m = rainfall in the wettest month of the year

P = the annual amount of precipitation

Table 1

Grid interpretation of classes erosivity by erosivity index Fournier [1, 5, 9]

Rainwater erosivity classes based on IF		
Class	**IF (mm)**	Erosivity rain
1.	0-20	Very low
2.	20 - 40	Low
3.	40-60	Moderate
4.	60-80	Severe
5	80-100	Very severe
6.	> 100	Extremely severe

Modified Fournier Index (IFM)

Modified Fournier Index (IFM) is determined by the following formula:

$$IFM = \sum_{1}^{12} \frac{p_i^2}{P} \tag{2}$$

Where

p_i = the average amount of rainfall for the month of i (mm)

P = average annual rainfall

And modified Fournier index [13]

Table 2

Rainwater erosivity classes depending modified Fournier index (IFM), [2, 5]

Rainwater erosivity classes based on IFM		
Class	**IFM (mm)**	**Aggressivity rain**
1.	0-60	Very low
2.	60 - 90	Low
3.	90 – 120	Moderate
4.	120 – 160	High
5.	> 160	Very high

Angot rainfall index (K)

The index rainfall Angot is the demarcation between the months of dry and rainy according to the values obtained can assign qualifiers month rainy - values above par (K> 1) - and month dry, values subunit (K <1).

It is used to highlight the susceptibility to landslide and erosion linear land area analyzed from the data monthly and daily rainfall in order to identify the months, seasons and years with susceptibility very high and very low rainfall to produce landslides [6].

Angot rainfall index is a ratio between the average daily volume of precipitation in a month and the annual average amount [6, 14, 15, 16, 17]:

$$K = \frac{p}{P} \tag{3}$$

Where:

$$p = \frac{q}{n} \tag{4}$$

$$P = \frac{Q}{365} \tag{5}$$

So
$$K = \frac{q \cdot 365}{Q \cdot n} \tag{6}$$

Where: q – The amount of monthly precipitation,
n – number of days in the month under review,
Q – multi-annual amount of precipitation [6, 14, 17].

Depending on the values obtained (below par or above par) for this index were determined susceptibility classes for triggering slope processes for linear erosion or flooding.

During the same year recorded above par value of the index, mainly in the semester hot months, when all the conditions for triggering slope processes and linear erosion.

If the Angot index values are between 1.0 - 1.5, it can show a predisposition to the onset of low and very low such processes. At values between 1.5 - 2.0 this predisposition is average. Angot index values exceed 2.0 when there are conditions for triggering slope processes, and at values above 2.5 are favorable conditions for triggering slope processes and linear erosion.

Erosion occurs with greater intensity in the warm half of the year. On the southern slopes, sunny and dry, surface erosion due to heavy rains in summer is manifested more intensely than the northern ones, moister and more protected by dense herbaceous vegetation.

Heavy rains are heavy with high intensity and short duration, falling on small areas and are more common in warm seasons. Rain from heavy rains has the force to deploy and carry soil particles; soil erosion becomes so great during these rains.

During the semester cold Angot index values are below par, these months are considered dry (Table 3).Depending on the measured values highlights the rainy periods (rainy month) for values above par (K> 1) and dry intervals (dry month), for values below par (K<1) [6,14, 15, 17].

Table 3

Classes' susceptibility rainfall responsible for triggering / activation of landslides based on attributes rainfall Index Angot (Dragotă C., et al 2008)

Attributes rainfall	Very dry	Dry	Normal	Rainy	Very rainy
Classes susceptibility	Very low	Low	Moderate	Big	Very big
Angot rainfall index values (K)	<0.99	1.00-1.49	1.50-1.99	2.00-2.49	>2.50

RESULTS

Rainwater aggressiveness classes based on Fournier index were calculated according to the amount of rainfall recorded by the weather station at the Biotechnical Faculty of Engineering U.P.B. (2009-2015).(Table 4).

Annual amounts of Fournier index (IF) calculated for Bucharest in the period 2009-2015, reaching values below 60 mm in the years: 2009, 2010, 2011, 2013, 2014, low rainfall aggressiveness, for 2015 very low. 2012 (64.9 mm), characteristic of a severe storm aggression, due to the plain relief, by the low forest vegetation cover, can accentuate problems of swamping, soil washing and surface erosion. Soils in the next UPB are very low class and low erosion analyzed rainfall in most years except 2012 when rainwater erosion was severe using the scale [9].

Table 4

Rainwater aggressiveness classes based on the calculated IF for Bucharest between 2009-2015

Analyzed years	IF (mm)
2009	31.0
2010	20.1
2011	37.2
2012	64.8
2013	11.0
2014	24.6
2015	14.2

Table 5

Rainwater erosivity classes by IFM for Bucharest intervals 2009-2015

Analyzed years	IFM
2009	78.7
2010	75.0
2011	77.4
2012	96.6
2013	77.7
2014	105.9
2015	73.8

In Bucharest the average values of this index is between 53.6 mm and 105.9 mm. According to rainfall aggressiveness classes based on IFM Bucharest aggression resulting low for the years: 2009, 2010, 2011, 2013, and 2015. For the years 2012 and 2014 follows a moderate aggression.

Triggering geomorphological processes of erosion may determinant be a prolonged period of falling precipitation or high intensity thereof, leading to the accumulation of a large volume of water that flows down the slopes as run-off, favoring the production processes and torrential runoff.

Thus, the analysis values IF and IFM calculated for the period 2009 - 2015 we can conclude that the soils in Bucharest are at risk of aggression rainfall low, very low and moderate being placed in classes 1 and 2 aggression rain, and a risk of moderate rain aggressiveness depending on the characteristics of space morphodynamic analyzed the duration and intensity of rainfall within the period analyzed. It is noted that precipitation has importance in the processes of soil erosion.

Table 6

Distribution of monthly rainfall index Angot in Bucharest (2009-2015)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2009	0.7	0.7	0.7	0.3	1.1	1.8	2.6	1.2	1.2	1.1	0.4	0.1
2010	0.4	1.6	0.8	0.9	2.0	1.7	1.1	0.4	0.6	1.1	0.3	1.1
2011	0.4	0.3	0.1	0.9	3.2	1.9	1.7	1.3	0.0	0.9	0.1	1.1
2012	1.3	0.4	0.3	1.1	3.9	0.8	0.6	0.7	0.9	0.5	0.2	1.4
2013	1.0	0.9	1.1	0.5	1.4	2.2	0.5	1.0	1.5	1.3	0.7	0.0
2014	1.0	0.0	0.6	1.4	1.6	2.0	0.8	0.7	0.6	0.8	0.5	1.9
2015	0.5	0.7	1.6	0.9	0.8	1.0	1.0	1.4	1.4	1.0	1.7	0.0

Table 7

Percentage distribution of rainfall index Angot in Bucharest (2009-2015)

Distribution Percentage Index Angot	<0.99	1-1.49	1.50-1.99	2-2.49	>2.5
2009	50.00%	33.33%	8.33%	0.00%	8.33%
2010	50.00%	25.00%	25.00%	0.00%	0.00%
2011	58.33%	16.67%	16.67%	0.00%	8.33%
2012	66.67%	25.00%	0.00%	0.00%	8.33%
2013	58.33%	25.00%	8.33%	8.33%	0.00%
2014	66.67%	8.33%	25.00%	0.00%	0.00%
2015	58.33%	25.00%	16.67%	0.00%	0.00%
Total	58.33%	22.62%	14.29%	1.19%	3.57%

Angot index calculated for 2009-2015 (Table 6) based on the values recorded by the weather station rainfall (2009-2015), has values above par (rainy months) in 2009, in the months: February, May, June, July, August September, October, 2010 in the months: February, May, June, July, October, December in 2011 in the months: May, June, July, August, December; in 2012 in the months: January, April, May, August, December; 2013 in the months: May, June, September, October; 2014 in the months: January, April, May, June, December; 2015 in the months: March, August, September, October, November -October and January, February, March, April, November, December (dry months) subunit values. These values show that rainy period coincided with a period of maximum biological activity of the plant, the entire area of analysis. Depending on Angot index values obtained for less than 1 dry months are: 2009: January, March, April, November, December; 2010 months: January, March, April, August, September, November; in 2011, months: January, February, March, April, September, K = 0, October, November; in 2012, months: February, March, June, July, September, October, November; 2013, months: January, February, March, April, July, August, November, December, K = 0; 2014, months: February, March, July, August, September, October, November; 2015, January, February, April, May, June, July, December, K = 0.

According to the index values Angot, in 2009 the dry period January to April, August K = 2.5, 2014 and 2013, K = 2.1 favorable conditions for triggering slope processes and linear erosion.

According to the index values Angot, in 2010 the dry period January to April, May K = 2, favorable conditions for triggering slope processes and linear erosion. In May 2011, K = 3.2, May 2012, K = 3.9, September 2013 K = 2.7 which indicates favorable conditions for triggering slope processes and linear erosion.

Analyzing the percentage averages of the monthly Index Angot for the period 2009 - 2015, the weather station at the Faculty of Biotechnical Systems Engineering from the UPB that 57.14% of the values are below par, so a climate very dry there are no conditions for triggering processes erosion and 42.86% of values are above par indicating that the prevailing rainy intervals are dry. Whichever of 42.86%, 19.05% attribute precipitation is dry, normal rainfall attribute 16.67%, 2.38% and 4.76% a rainy climate very rainy climate, creating favorable conditions for rainwater erosion.

For the years 2013 and 2014 high values over 2 to 2.5 or even 3 at some stations, indicating favorable conditions for triggering slope processes and linear erosion (Table 7).

CONCLUSIONS

1) Application Fournier indices for assessing the aggressiveness of rainfall is a simple, fast;

2) The two indexes are influenced by the characteristics of rainfall, so the monthly and annual values recorded at stations representative for Bucharest, which offer local or regional character;

3) Both indexes indicate the same classes of aggression Fournier rainwater;

4) The modified Fournier index is more relevant for the study of aggression because rainfall consider the amount of precipitation in different months of the year and the change during a given year;

5) Obtained indices fall largely under moderate aggression class, but there was years ago, when aggression was moderate rainfall (2012, 2014).

Analyzing the indices for assessing the aggressiveness of rain on the substrate appears that periodically it creates favorable conditions for occurrence and manifestation of erosion rainwater their effect is stronger when occurring after a period of prolonged drought, especially during March-April July and August or in some cases, from October to November.

Analyzing the percentage averages of the monthly Index Angot for the period 2009 - 2015, the weather station at the Faculty of Biotechnical Systems Engineering from the Polytechnic University of Bucharest that 57.14% of the values are below par, so a climate very dry there are no conditions for triggering processes erosion and 42.86% of values are above par indicating that the prevailing rainy intervals are dry. Whichever of 42.86%, 19.05% attribute precipitation is dry, normal rainfall attribute 16.67%, 2.38% and 4.76% a rainy climate very rainy climate, creating favorable conditions for rainwater erosion.

For the years 2013 and 2014 high values over 2 to 2.5 or even 3 at some stations, indicating favorable conditions for triggering slope processes and linear erosion

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DEVELOPMENT AND IMPOROVMENT OF AGRICULTURAL TECHNIQUES OF MISCANTHUS GROWING IN FOREST –STEPPE ZONES OF UKRAINE
/
РОЗРОБКА ТА УДОСКОНАЛЕННЯ АГРОТЕХНІЧНИХ ПРИЙОМІВ ВИРОЩУВАННЯМІСКАНТУСУ В УМОВАХ ЛІСОСТЕПУ УКРАЇНИ

Dr., PhD. Eng. Gumentyk M. Ya.[1)], Prof. Phd Kharytonov M.M.*[2)]
Institute of bioenergetic cultures and sugar beet of National Science Academy of Ukraine
Dnipropetrovsk State Agrarian and Economic University
Email: envteam@ukr.net

Key words*: miscanthus, elements of growing technique, width between rows, between row plowing techniques, biomass.*

ABSTRACT

Optimization of existing and development of new agricultural techniques for planting and culturing of miscanthus rhizomes were performed considering peculiarities of soil-climatic conditions of forest-steppe zone of Ukraine. The study of miscanthus growing comprising application of advanced techniques of plowing between rows was performed. Optimal techniques of planting and optimal width between rows were defined during study.

Proposed technology of miscanthus growing, comprising rhizomes planting employing square – foot technique is different from other techniques of rhizomes planting as proposed one employs autumn planting campaign on specially prepared field, in particular, combs, that have shape of the pyramid with cut edge have to be formed on field, along and across the field to improve the quality of tillage between rows, enhance moister preservation and create more favorable conditions for plants' shooting and more effective weed fighting. To achieve higher efficiency for weed fighting, double mechanical cleaning from weeds was performed during the vegetation period before closing of above-ground parts of miscanthus. This technique allowed to achieve 60 – 70 % of removal of shoots of annual weeds.

Distance from the row to the closest blade, which is supported by regulating plate was find to be optimal in a range between 7 and 9 cm. Spade razors same as scooping working parts on each rod of the ramp on two side holders were installed to achieve better performance and rotation batteries were installed on central and back holders.

Тези

Виконано вдосконалення та розробка агротехнічних прийомів посадки та догляду за ризомами міскантусу для вдосконалення технології вирощування біомаси в конкретних ґрунтово-кліматичних умовах Лісостепу України.

Наведено результати досліджень з вивчення та розробки агротехнічних прийомів вирощування міскантусу при вдосконаленні операції міжрядного обробітку ґрунту. Встановлено і обґрунтовано способи посадки, оптимальну ширину міжрядь та різні варіанти догляду за посадкою в умовах лісостепу України.

Технологія вирощування Міскантусу, що передбасчає посадку ризом в грунт, квадратно-гніздовим способом відрізняється тим, що, посадка ризом в грунт проводиться осінню в спеціально сформовані гребені у вигляді зрізаної піраміди, які формуються повздовж і поперек площі поля з метою якісного проведення досходового міжрядного обробітку ґрунту, збереження вологи та створення сприятливих умов проростання росли та боротьби з бур'янами.

З метою ефективної боротьби з бур'янами проводиться двохразовий механізований догляд за рослинами, протягом періоду вегетації до змикання надземної частини міскантусу. Даним прийомом знищуються сходи однорічних бур'янів на 60 - 70%.

Відстань від рядка до найближчої точки леза, що спирається на регулювальний майданчик, може бути у межах 7-9 см. За присипаючими робочими органами встановлюють на кожному гряділі у двох бічних тримачах лапи-бритви, а в задньому центральному тримачі – ротаційну батарею.

INTRODUCTION

During last decade searching of renewable energy sources drew a lot of attention, especially in developed countries (*Pidlisnyuk et al, 2012; Rakhmetov et al, 2015; Shumny et al, 2010; Yu et al, 2015*).

Bioenergetics as a science of production and application of biofuels was in the focus for researchers, thus high productive energy crops were found to be another promising resource for Ukraine along with, primary and secondary agricultural residues from food crops *(Geletukha et al,2014).*

Perennial crop *Miscanthus* is found to be one of the most promising as for many years it was successfully used as feedstock for cellulose and solid biofuels production (*Hodgson et al., 2010, Huang and He., 2010*).

Completeness of seed *germination* and vegetative *growth and development of rhizomes* for *Miscanthus, and yield, accordingly,* strongly depend on temperature and soil moisturizing conditions *(Arnoult and Brancourt-Hulmel, 2015*).

The period of germination for plants elongates if soil temperature remains low during the period, besides of that, long-term lack of moisture in soil leads to plants' death (*Heaton et al,2004*). According to monitoring studies, that were performed earlier, soil moisturizing not always appear to be at sufficient rate for intensive development of plants.

Moisture content in the top layer of the soil during the period of planting is constantly changing and strongly depends on weather conditions (*Zub and Bracourt-Hulmel.* 2010). Therefore, it is hard to achieve high rate of seeds germination for miscanthus, which is necessary to achieve high biomass yield. Soil moister content and seeding time are main factors defining shooting rate and further stem development rate. Late development of the stem is common trait of all perennial plants, which can be suppressed by weeds during the first development period, thus another important factor, which plays important role for productivity is weed protection.

Analysis of existing practice showed that optimal agro-engineering conditions for rising of *Miscanthus* rhizomes cannot be fully supported with existing culturing techniques applied in Ukraine. As a result, it is difficult carry out efficient weed control in the sufficient timeframe with available mechanical means.

The aim of the research was to find ways to optimize existing and develop of new agricultural techniques for planting and culturing of *Miscanthus* rhizomes considering peculiarities of soil-climatic conditions of forest-steppe zone of Ukraine.

MATERIAL AND METHOD

Field study was conducted according to the generally accepted agronomic methods during 2011 – 2015 years in Borshivsk region of Ternopolskaya oblast. The total square of experimental plots was 0.4 ha. Experiment was set in four repeats according to the generally accepted field study procedures.

Two-factor experiment was established for two techniques of rhizomes planting (ordinary and square-foot). Factor A was the term of planting: 1) autumn (2nd – 3rd decade of October); 2) spring (2nd – 3rd decade of April).

Factor B. 1) plowing between rows 2) hilling rows with the accompanying covering the weeds with soil.

Total seeding plots had square of 400 m^2, control – 100 m^2, with four repeats. All experimental plots were randomized by placing them in two storeys.

The soil type was determined as light grey ashed which mobile phosphorous content (determined according to method developed by Kirsanov) in 30 cm layer 9.5 mg per 100 grams of soil, and exchange potassium content (by Kirsanov) 6 mg per 100 grams of soil. Nitrogen content (by Cornfield) was 28 mg per 100 grams of soil, acidity of soil (pH) – 6.0.Climatic conditions are mainly responsible for harvest yield, in forest – steppe zone moister is main limiting factor.

This region has mild-continental climate with not significant amplitude of temperature fluctuation, and could be characterized with short, mild winter, warm and humid summer and sufficient rate of precipitations. Climatic features of the region are defined by year passage of main meteorological elements of weather (temperature, precipitations) and their distribution across the region.

After the sum of active temperatures, bulk amount of precipitations and vegetation period, the territory of experimental plots dislocation could be attributed to "Warm Podillya" region, which has mild, humid enough continental climate.

Average sum of positive temperatures in the area is 2500…2600ºC. The period with average daily temperature above 10 ºC lasts 160 – 165 days. During this period territory gets average precipitation rate at 370 – 420 mm and 570 – 680 mm through the whole year with hydrothermal coefficient – 1.4 – 1.6.

Weather conditions during the experimental period through 2011 – 2015 years are depicted in figure 1.

First half of April of 2011 appeared to be cold with not significant precipitation rate. The temperature had raised and remained on same rate with lasting drought until the 3rd decade of May.

During June and July, the precipitation rate was 45 mm higher of many years average for same period, which provided favorable moister regime for soil and good development and growth for such energetic crops as *Miscanthus* and *Switchgrass*. Nevertheless, August and September were dry, which lead to low harvest yields.

Weather conditions of 2012 could be characterized with the warmest beginning of the vegetation season from all years during which this study was held.

Average daily air temperature in April was 10.3 º C, which is in 2.9 º C higher from average meaning for this time for many years.

It was obvious, that summer of 2012 was warm enough for normal growth and development of the crop. Meantime the precipitation rate was beyond sufficient, which slowed down the plants' development.

That is why first period of active growth was taking place during June and July and second – end of August and beginning of September.

According to the observation data obtained in 2012, the temperature regime in the period of active plants' growth (May – September) was quite steady, although higher than average meaning for many years with not significant deviation up to 3 º C.

The lowest rate of precipitation was registered in May – 21.5 mm, which had negative impact on plants' shooting. Although large amount of precipitations territory got in June – 105.5 mm and August – 77.5 mm, which influenced growth positively.

Comparing with average weather features for many years with 2012, it could be concluded that year was quite hot and humid which had the impact on harvest accordingly.

2013 year had similar weather features as previous, although there were some differences. In 2012 in 2nd and 3rd decades of April territory got 83,0 mm of precipitations, and in 2013 almost same amount (78.8 mm) was registered during first half of April. From the second half of 2nd decade of April till the middle of the 2nd decade of May precipitation rate was only 11,4 mm, which affected shooting of plants.

The registered precipitation rate was on 90,3 mm higher than average for many years in May (from 3rd decade) and till June. As the result, high moistening rates for soil during that period were provided, which supported intensive growth of plants.

From 3rd decade of May and till June the registered precipitation rate was on 90.3 mm higher than average for many years, which provided high moistening rates for soil during that period and intensive growth of plants was supported.

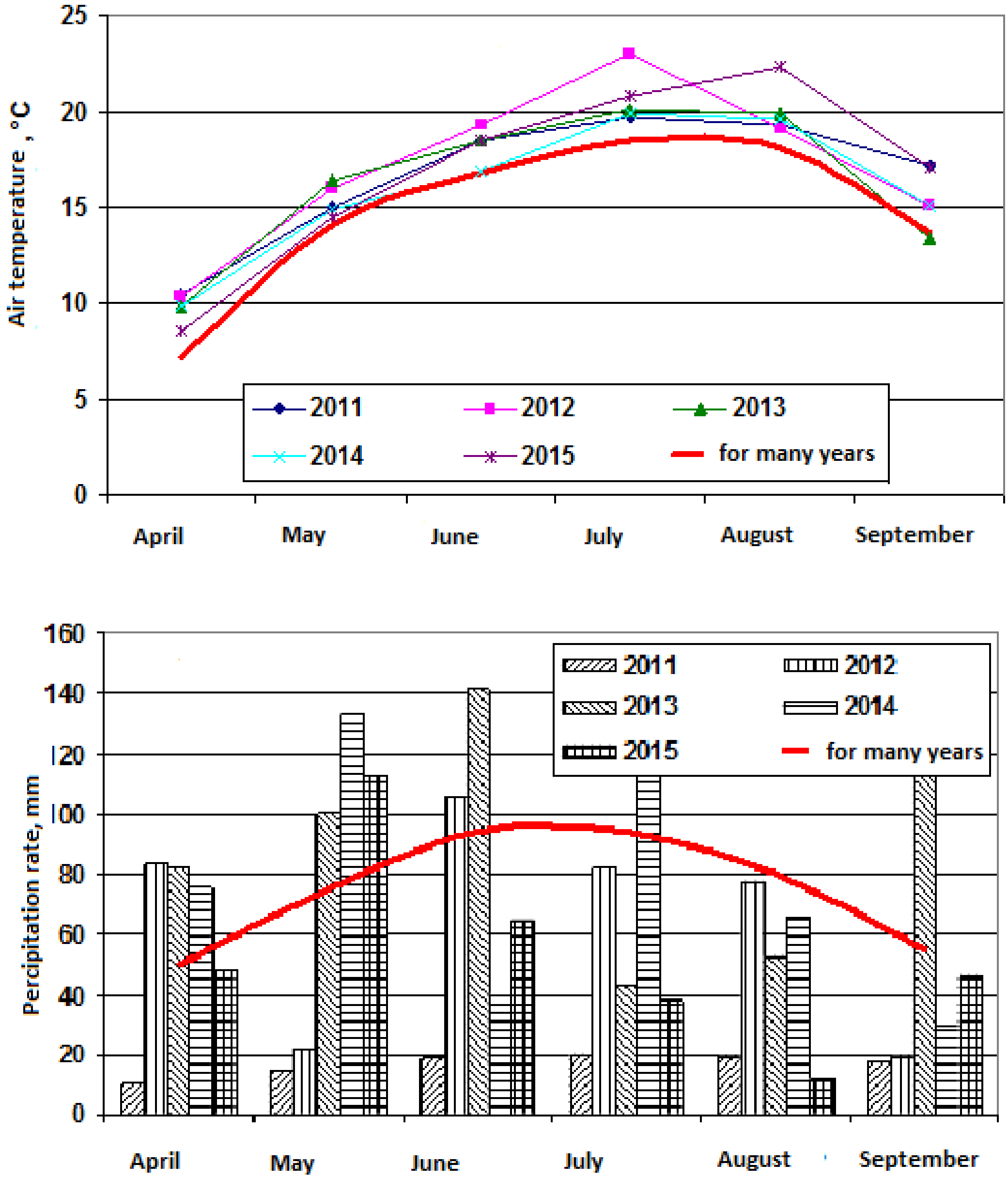

Fig. 1 - Temperature and precipitation rate during five years

During 2012 – 2013 years in May average monthly temperature was 16.0 and 16.4 °C, when in 2014 it was only 14,9 °C. Precipitations bulk amount in May of 2014 was twice higher than average for many years, according to observations, which positively influenced shooting of plants. Following year (2015) could be described as hot, in August and September temperature of air was higher of average on 4.3 and 3.5 °C accordingly.

Precipitations distributing during year could be characterized with certain inequality: in June, July and August precipitations amount was 29.2 mm, 56.2 mm and 68.7 mm less accordingly from average for many years and in May territory got 37.9 mm more than average for many previous years.

Weather conditions during other months were not significantly different from average for many years.

During 2011 – 2015 weather was dry with higher of average temperatures. At the same time, there was inequality of precipitations distribution through the vegetation seasons.

Optimal culturing conditions for plants could be supported with different agrotechnical means before and after planting along with picking of appropriate sorts and finding optimal time for agrotechnical events according to region features and weather conditions for a certain year.

Soil aeration regime can be regulated by loosening of soil between rows and surface drying of over moisturized areas. Conditions of illumination for plants can be improved by adjusting of planting density and distance between rows. Temperature regime is the hardest to regulate although it affects significantly shoots preservation and their bushing and further development.

RESULTS

Square foot growing technology for *Miscanthus* comprises planting of rhizomes during spring into combs formed during autumn. *Miscanthus* rhizomes are capricious to planting conditions and require certain moister content and depth of scoops.

Higher survival rate and synchronizing of shooting of *Miscanthus* rhizomes was achieved by creation of optimal conditions and using of effective and rational machinery means for soil preparation and weed fighting.

In autumn, after harvesting of previous crop, deep plowing was performed. Soil ridge was done in the form of a truncated pyramid. For planting the *Miscanthus* rhizomes square-cluster method was chosen (fig. 2).

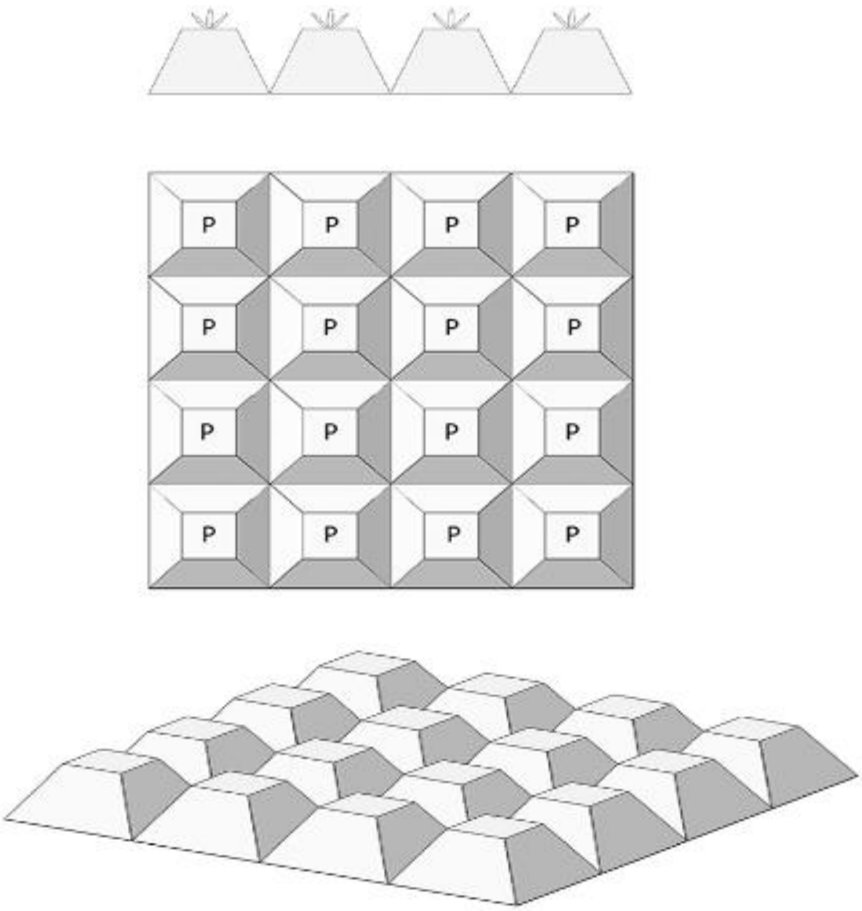

Fig. 2 - Square – foot techniques of planting of *Miscanthus* rhizomes

Technology of soil tillage during the *Miscanthus* rhizome planting is similar to those for other crops. Tillage usually serves for two main purposes: a) reduction of passes for aggregates) improving conditions for rhizomes germination and productive development of plants miscanthus.

Miscanthus plants during first 2 – 3 weeks are developing slowly. Weeds, especially dicotyledonous, suppress shoots in case when temperature conditions do not exactly meet species requirements.

The highest shoots growth rate was observed for *Miscanthus* rhizomes planted in autumn and early spring period in second decade of April. The optimal scooping depth for rhizomes for these planting times was 8 – 10 cm. This operation during planting improves agrotechnical conditions of growing and weeds fighting during the first vegetation year.

First plowing between rows was performed after previously created profile of rows before shoots of *Miscanthus* rhizomes appeared, which allowed decreasing cost of further weeding and soil loosening in rows.

To achieve higher effectiveness in weed fighting, double mechanical weeding was performed during the vegetation period before closing of above-ground parts of miscanthus.

This technique allowed destroying 60 – 70 % of shoots of annual weeds. Proposed technology of miscanthus growing, comprising rhizomes planting by square – foot technique differs with that rhizomes planting is taking place during autumn into specially formed combs that have shape of the pyramid with cut edge, which were formed along and across of the field to improve the quality of tillage between rows, moister preservation and creating of more favorable conditions for plants' shooting and more effective weed fighting.

For weed scooping with soil close to the rows of miscanthus, aggregates were specially equipped, tractor MTZ-82 (100) and cultivators KRNB-5.6.-02 were equipped with modified protective disks (fig. 3).

Fig. 3 - Aggregate for weed scooping and forming of rows profile between *Miscanthus* rows

Cultivators' preparation was the same as for the first soil loosening which also comprises preparation of moving parts in a certain way.

First protective discs were modified. To the area where discs stand, opposite to those leaning with lateral part on the holders of the hooks, the part of the wire 80 mm long and with 4 mm thickness were welded, which provided the angle between disks hanging on hooks and the row about 12 – 14 ˚.

On the elongated platen in the front part of the ramp, two protective disks were installed with angle 12 – 14 ˚ towards the direction of the rows with concave side oriented towards miscanthus rows.

Distance from the row to the closest blade, which is hold by regulating plate could be between 7 and 9 cm. Spade razors as scooping working parts on each rod of the ramp on two side holders were installed and rotation batteries were installed on central and back holders.

The front part razor spades were installed on each ramp holding rod for the weed scooping during summer vegetation (not later than in June) and in central and back parts – protective disks were installed as well.

For working parts the depth of cultivation was regulated same way as for soil loosening in the areas between rows and in the areas of rows. Cultivating depth for working organs should be close to the required height of platen and depth of razor spades pass and rotation batteries – up to 5 cm.

Bioenergy yield from obtained solid fuel is important characteristics of *Miscanthus* culturing efficiency. Estimated values are given in the table 1.

Table 1

Energy yield of *Miscanthus* depending on the soil preparation technique before planting (average data through 2011 – 2015 years).

Planting technique	Row biomass yield, tons per hectare	Dry biomass, %	Dry biomass yield, tons per hectare	Solid fuel yield, tons per hectare	Energy yield, GJ per hectare
Ordinary	28.0	79.5	22.3	24.7	412.4
Into combs	29.8	79.2	24.5	26.6	449.5

Highest energy yield 449.5 GJ per hectare for *Miscanthus* was obtained with foot-square planting technique when rhizomes where put into combs with distance between rows around 70 cm and minimal culturing cost.

CONCLUSIONS

1. *Miscanthus* yield could be increased by planting of rhizomes into combs with square-foot spacing with early planting and with plating depth 8 – 10 cm.

2. The impact of terms and depth of planting on the biomass yield could be observed during the first vegetation year, but tendency could be supported by difference of plants standing density (defined with shooting rate and winter survival rate for plants).

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INFLUENCE OF PLANT MINCING LEVEL ON ACTIVE PRINCIPLES CONTENT OF THE INDIGENOUS SPECIES *Portulaca Oleracea*
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INFLUENŢA NIVELULUI DE TOCARE ASUPRA CONŢINUTULUI DE PRINCIPII ACTIVE AL SPECIILOR INDIGENEE DE Portulaca Oleracea

PhD. Pharm. Popescu (Popiniuc) C.[1, 5], Assoc. Prof. PhD. Pharm. Eng. Popescu C.*[2, 3], Eng. Manea Şt.[2], Eng. Găgeanu G.[4], PhD. Stud. Eng. Găgeanu I.[4], PhD. Eng. Voicea I.[4], PhD. Eng. Vlăduţ V. [4], PhD.Pharm. Abbas H.[1], Ch.Eng. Dune A.[2], Prof.PhD.Pharm. Lupuleasa D.[1]

[1]University of Medicine and Pharmacy "Carol Davila" - Faculty of Pharmacy, Bucharest, Romania; [2]S.C. HOFIGAL Export Import S.A., Bucharest, Romania; [3]Faculty of Pharmacy, “Vasile Goldiş” Western University, Arad, Romania; [4] INMA, Bucharest, Romania; [5]Innergy (SC INNER Chi Nature srl), Constanta, Romania - working point, Voluntari, Romania

Tel:+4 0722611658; E-mail: popescu_carmen88@yahoo.com

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ABSTRACT

Within this paper, a research on influence of plant’s mincing degree on obtaining extracts of purslane, was performed. For this study, were used the fresh plant, then the dry plant minced in a plant cutting machine of TIMATIC type. Following the plant chopping, several fractions have resulted: the smallest fraction under 1mm and an equal proportion mixture of 2 fractions ranged between 2 and 4 mm (fraction a) and 4÷6.3 mm (fraction b). Method of preparation established for obtaining the purslane extract from fraction under 0.25 μm (by SC Hofigal Export Import SA) is the simple maceration in hydro-alcoholic solution in the equipment named „ Multifunctional assembly of extraction/ concentration NS-0.5. Extract from fractions a. and b. was obtained on an extractor of TIMATIC type, using distilled water as solvent.

The results obtained from the study performed on purslane hydro-extracts as small and medium fractions have shown that the capitalization of purslane can become very profitable in Romania, both in terms of food and medicinal plant, with beneficial effects on economy.

REZUMAT

În cadrul acestei lucrări s-a efectuat un studiu privind influenţa gradului de mărunţire a plantei asupra obţinerii de extracte din iarbă grasă. Pentru studiu s-a utilizat planta proaspata, apoi uscată, care a fost mărunţită prin tocare într-o maşină de tăiat plante, tip TIMATIC. În urma procesului de tocare au rezultat mai multe fracţii. S-au luat în studiu cea mai mică fracţie, sub 1mm şi un amestec în proporţii egale din 2 fracţii cuprise între 2 şi 4 mm (fracţia a) şi 4÷6,3 mm (fracţia b). Metoda de preparare stabilită pentru obţinerea extractului de iarba grasa din fracţia sub 0.25 μm (de SC Hofigal Export Import SA) este macerarea simplă in solutie hidroalcoolica in ecghipamentul denumit Ansamblu multifunctional de extractie/ concentrarea NS-0,5. Extractul din fracţiile a şi b s-a obţinut pe un extractor tip TIMATIC, utilizând ca solvent apa distilată.

Rezultatele obţinute din studiul efectuat pe hidroextractele din graşiţă de fracţie mică şi fracţii medii, relevă faptul că activitatea de valorificare a plantei numită „Iarbă grasă”, poate deveni o activitate profitabilă în ţara noastră, atât din punct de vedere alimentar, cât şi ca plantă medicinală, cu anumite efecte benefice în plan economic.

INTRODUCTION

Common purslane, *Portulaca oleracea*, is a member of the Portulacaceae family with more than 120 different species found in that family. It is a weedy summer annual species that is abundant throughout the world, invading vegetable gardens, bare areas, low-maintenance lawns, ornamental plantings, and agricultural areas [6].

It is a plant belonging to Romanian spontaneous flora and also other countries flora, being a low height plant, stretched on soil, with pulpy stems and leaves with small and yellow flowers, that grows through crops and in ruderal places. In our country it is more spread in Oltenia and Muntenia, where it is used when preparing salads, due to its sour taste, but also in sour soups. In Dobrogea, it is introduced in pie composition along with patience dock or spinach. It has emollient, depurative and diuretic qualities [1, 10].

In Romania, this plant is considered a weed, but abroad it is valorised and in USA and even in very developed countries (France, Germany, Greece and Cyprus) it is well recognised. It is considered almost a food plant, used as salad and in other culinary products. Beside its food intake, it is most appreciated in terms of medicine, for its exceptional composition. It is among the few plants which contain Omega-3 fatty acid, a valuable element for human health, especially for liver, being recommended for different diseases and even infections. Few people know that *Portulaca oleracea,* considered by most people as a weed, is edible both in fresh stage and prepared, being mentioned by Dioscoride in list of medicinal plants used by Dacians under the name of „Iax” [8].

Fig.1 – *Portulaca oleracea*

Purslane may be capitalized in food and tea industry. This plant is harvested, conditioned and dried as other medicinal plants, after which it is minced for obtaining a clean product easily packed and stored.

In Middle East, delicious salads from chopped purslane leaves and yoghurt and different green vegetables (cucumbers, pepper, etc.), are prepared as steak garnishing. Purslane is one of the ingredients of famous Lebanese salad named fattoush. Mature leaves are being soaked and used as vegetables. When cooking, their mucilaginous content is increased, making it a good thickener for soup and stew. In Turkey, for example, purslane is being used for preparing lamb and beans stews, while around the Mediterranean Sea is used for preparing soups. In Mexico, this plant is cooked with pork meat, tomatoes and hot pepper (especially those from chipotles variety). Purslane is very good when is prepared with spinach, olive oil and lemon juice. It may accompany the meals prepared from beet, beans, cucumbers, eggs, newly-grown potatoes, yoghurt. Among the other spices, garden chervil, watercress (nasturtium), cress, rucola, sour dock, parsley and mint go very well with lamb tongue.

Common purslane is a prostrate, succulent annual plant that often forms a dense mat. The reddish stems originate from a central rooting point, radiating out like spokes of a wheel. The stems vary in length, commonly up to 12 inches. Leaves are sessile, oval, smooth, succulent, and shinny, and vary from ½ to 2 inches in length. The leaves, although generally arranged opposite, may also occur alternately along the stem, particularly near the base. Small (3/8 inch), five-petal, yellow flowers are borne singly in leaf axils and open only in sunshine. Seeds are borne in a small pod with a top that comes off like the lid on a cookie jar. Seeds are reddish brown to black, oval, and tiny (about 1/64 to 1/32 inch in diameter). Common purslane is a prolific seed plant. A single plant may produce 240,000 seeds, which may germinate even after 5 to 40 years. In late summer, flat mats of mature purslane can be turned over to reveal thousands of seeds on the soil surface [6].

According to studies from Texas University from San Antonio, the purslane leaves (that can be cooked) contain more fatty acids Omega-3 than any other edible plant, being perfect for improving brain and heart functioning. Researchers discovered that purslane contains 10 up to 20 cancer-inhibitor antioxidants than any other vegetable or fruit tested.

The stem is of 15-30 cm height, being ascending, pulpy, without hair, sour-cherry colour at its lower part. Lower leaves are inversely egg-shaped elongated, bud hairy leaves. Flowers are yellow, sessile; with 2 unequal sepal calyx; crown made of 4-6 falling petals; Andros made of numerous stamina (8-15); gynoecious with ovary next to base, style endowed with 4-6 stigma. Flowers (V-X).Fruit is an ovoid capsule with numerous shinny reniform dark-brown seeds.

Portulaca oleracea. It is annual plant from *Portulacaceae family*, with shinny pulpy and succulent leaves, little yellow-reddish flowers with 5 petals and decumbent cylindrical-shaped stem up to 40 cm height. Root is deep and resistant in compact and arid soil. Leaves, root as well as seeds and flowers are edible.

Harvest is made in summer, when plant is bloomed and fully developed, using the aerial part. At its maturity the plant is supposed to contain the biggest quantity of bioactive components. These components can be extracted from plants either in cold water or in hot water, or using a solvent, most frequently the ethanol.

Mincing may be performed by chopping when useful parts are cut (stems, leaves, flowers), at size appropriate to subsequent processing (packing for tea, maceration, extraction, etc.), or by grinding.

MATERIALS AND METHODS

Within the tests made at INMA, a medicinal plant cutting machine of TIMATIC type (fig. 2), was used. It belongs to a technological primary processing line of medicinal and aromatic plants necessary to economic agents that are involved in processing dry vegetal or freshly harvested matter.

Fig.2 – Machine for cutting plants- TIMATIC

The cutting machine is manually supplied on the conveying band so that stems are oriented towards the machine's direction. Plants cut at the pre-established size according to their subsequent use, fall on conveyor's band and are transferred to the vibrating separator's funnel. [7].

Material chopped, before sorting operation is subject to a passage through a sieving system Retsch, of AS 200 basic type, for making a selection based on calculation of fractions with highest share in minced matter. Fraction 1 under 1mm size and fraction 2, made of two sub-fractions, as equal parts, namely a.) of 2 and 4mm and b.) at 4 and 6.3 mm size, were considered.

Fig. 3 – Chopped purslane

Fig. 4 – Retsch sieving of AS 200 basic type

In order to obtain the dry vegetal product from purslane (*Portulaca oleraceea*), after harvesting, the vegetal product is subject to the following operations (in SC Hofigal Export Import SA): *sorting, washing, drying, chopping*. Extract from fraction 1 (SC HOFIGAL SA) has been obtained through maceration.

The vegetal-origin dried raw material, after being minced according to 8mm sieve, is weighted with a balance.

The vegetal raw material and extraction solvent are introduced into the extraction vessel. Ratio between vegetal product and solvent is of 1:5. The re-circulating pump is driven for ensuring the moistening of raw vegetal matter with extraction solvent. The solvent recirculation takes about one hour. Percolation is an efficient method of extracting the active constituents from leaves, flowers, fruits, bulbs, seeds, bark, roots, aromatic herbs, culinary herbs medicinal and other plants.[9]

Fig. 5 – Timatic percolator by which means the purslane extract was obtained

As the percolation extract is diluted, it had to be concentrated for being subject afterwards to detailed chemical and physical tests.. For this operation was used a rotating evaporator of HEI VAP BASIC 1 type (fig. 6). Working parameters were: water bath, 60ºC temperature, in void.

Fig. 6 – Rotary evaporator HEI- VAP BASIC 1 / G1B used for obtaining purslane extract concentrate

For identifying FLAVONOIDS, were used:

Equipment: water bath, analytical balance.

Reactive substances: *sodium acetate R, solution 100 g/L; aluminium chloride R, solution 25 g/L; methanol R; ethanol R, solution 50% (V/V); solution test for solid samples to be analyzed:* at a certain quantity of sample to be analyzed provided in Technical specification are added 100 mL *ethanol R, solution 50 % (V/V)* in a wide-neck flask and heated when boiling in surging back water bath, for 30 minutes. The hot solution is filtered (if the case is) and completed up to 100 mL by washing the residues with the same solvent; test *solution for liquid analyzing samples* (liquid extracts or tinctures): according to technical specification, the product itself is used as testing solution.

Working technique: 10 mL testing *solution is diluted with methanol R* at 15 mL in a quoted flask. It is agitated for 2-3 minutes and then let to rest for 10 minutes. It is filtered and the first parts of filtrate are removed. In a 25 ml quoted flask are introduced 5.0 mL testing *solution*, 5.0 mL *sodium acetate R, solution of 100 g/L* and 3.0 mL *aluminium chloride R, solution of 25g/L*. It brought to the mark level with *methanol R*.A yellow colour specific to flavonoids appears.

For identifying **AMINO-ACIDS were used**:

Equipment: water bath;

Reactive substances: ethanol R, solution 50% (v/v); ninhydrin solution R_1: ninhydrin R,10 g/L in ethanol R; test solution: if no other indication in Technical Specification exists, for10.0 g sample are added 100 mL ethanol R, solution 50% (v/v), in a large-neck flask and heated to boil in water bath for 30 minutes under reflux. Hot solution is filtered and cooled.

Working technique: at 10.0 mL test solution are added several drops of nynhidrin solution R_1. It appears a lilac-blue colour specific to amino-acids.

For identification of **POLYPHENOLS, were used**:

Equipment: analytical balance

Reactive substances: phosphotungstic *sodium solution R (Folin reactive substance):* 10g ***phosphotungstic*** *sodium* R, 10 mL *phosphorus acid R* and 75 mL water *R* are heated to boiling temperature, under reflux, for two hours. After cooling, are added water *R* at100 mL; *sodium carbonate R solution 200 g/L*; *ethanol R solution 50 % v/v; test solution*: at a certain sample to be analyzed provided in Technical Specification of product, 100 mL *ethanol R solution 50 % v/v are added in* a large-neck flask and heated up to boiling temperature, on water bath, under reflux for 30 minutes. The hot solution is filtered, if the case is.

Working technique:

For 5 mL test *solution* 5 mL *phosphotungstic sodium solution R* and 10 mL *sodium carbonate R solution 200 g/L, are added*. It appears a blue-greenish colour appropriate to polyphenols colour.

For identifying the **ASCORBIC ACID, were used**:

Equipment: unnecessary.

Reactive substances: sodium acid R, diluted: 20 g sodium acid R are diluted for 100 mL water R; silver nitrate, solution R_2: silver nitrate R, solution 17 g/L; test solution: the manner in which it is obtained is described in product Technical Specification.

Working technique: at 1.0 mL test solution are added 0.2 mL sodium acid R, diluted and 0.2 mL silver nitrate, solution R_2. A grey precipitate has resulted.

For determining the **RELATIVE DENSITY were used**:

Equipment: analytical balance; pycnometer;

Reactive substances: *water R;*

Working technique: the empty pycnometer is weighed, is filled with *water R* at 20^0C and in weighed again. Difference between pycnometer mass with water *R* and empty pycnometer represents the mass of water volume *R* at 20^{0}C (m_1). Pycnometer is emptied, dried and is filled with *sample to be analyzed* brought at 20^{0}C temperature and is weighed. Difference between the pycnometer mass with liquid and empty pycnometer represents the mass of *sample to be analyzed, at* 20^{0}C (m). Precision of determination is of fourth decimal place.

Calculation formula:

$$d_{20}^{\ 20} = \frac{m}{m_1} \tag{1}$$

where:

d_{20}^{20} = relative density;
m = mass of *sample volume*, in g;
m_1 = mass of water volume, in g.

For determining the **RESIDUES BY EVAPORATION** were used**:**
Equipment: water bath, analytical balance.
Reactive substances: phosphorus pentoxide R or anhydrous silica gel R.
Working technique:

In a vessel of about 50 mm diameter and 30 mm height are rapidly introduced 2.00 g or 2.0 mL from the extract to be analyzed. It is evaporated to dryness on water bath and is dried in the oven at 100.0 – 105°C for three hours. It is cooled in a phosphorus sodium R or anhydrous silica gel dessicator and is weighed. The obtained result is calculated as percentages or grams/ Litre.

Calculus:

a) $\text{Reziduu uscat}, \% = \frac{m_1 - m_0}{m_p} \cdot 100$

where:

m_1 = mass of sample vessel after drying, in g;
m_0 = empty vessel mass, in g;
m_p = mass of sample to be analyzed, in g;
100 = correlation factor.

For determining the **TOTAL POLYPHENOL CONTENT EXPRESSED IN CHLOROGENIC ACID, were used**:
Equipment:

- analytical balance;
- spectro-photometer UV-VIS.

Reactive substances:

- natrium wolframate R;
- Phosphorus acid R;
- water R;
- natrium phosphotungstic solution R (Reactive Folin: 10 g natrium wolframate solution R,10 mL phosphorus acid R and 75 mL water are heated up to boiling temperature, under reflux, for 2 hours; after having cooled, it is diluted with water R at 100 mL;
- natrium carbonate solution R 200 g/L;
- caffeic acid R;
- standard solutions:

- caffeic acid solution R 20 µg/mL;
- caffeic acid solution R 30 µg/mL;
- caffeic acid solution R 40 µg/mL;
- caffeic acid solution R 50 µg/mL;
- caffeic acid solution R 60 µg/mL;
- caffeic acid solution R 70 µg/mL;
- caffeic acid solution R 80 µg/mL;
- caffeic acid solution R 90 µg/mL;
- ethanol solution R 50% v/v;
- test solution: at 1.0g *sample to be analyzed* are added 100mL *ethanol solution 50% v/v R*, in glass stopper flask and heated to boil on water bath under reflux, for 30 minutes. Hot solution is filtered through wadding in a quoted flask of 100mL and after cooling the solution, it is completed up to 100mL by washing the residue with *ethanol solution of 50% v/v R.*

Working technique:

At 5.0 mL test *solution* are added 5 mL natrium *phosphotungstic solution R*, is agitated and then filtered. The first filtrated parts are removed. 2.5 mL filtrate is diluted with *solution 200 g/L natrium carbonate R* at 25 mL, in a quoted flask. The solution absorbance is determined at 660 nm, using as compensation liquid a solution prepared from 2.5 mL filtrate and *water R* at 25 mL, in a quoted flask .Total poly-phenol concentration of the *sample to be analyzed* is calculated by means of a calibration curve, taking in work 8 boiling tubes: 1.0; 1.5; 2.0; 2.5; 3.0; 3.5; 4.0; 4.5 mL *ethanol solution 0.1 g/L caffeic acid R*, at which are added 4.0; 3.5; 3.0; 2.5; 2.0; 1.5; 1.0 and 0.5 mL *water R* and then 5.0 mL *natrium phosphotungstic solution* R for each standard sample. From each standard sample obtained, 2.5 ml are taken out, brought to the mark level in a quoted flask of 25 mL with *solution 200 g/L natrium carbonate R* freshly prepared.

The solution absorbance is determined at 660 nm, using as compensation liquid a solution prepared from 2.5 mL out of each sample brought to the mark level with *water R* in a quoted flask of 25 mL.

Calculus:

a) $$\text{Total polyphenols expressed in caffeic acid, \%} = \frac{C}{m_p \cdot 100}, \quad (2)$$

where:

C = oncentration read on the calibration curve, in µg /mL;
m_p = mass of sample to be analyzed , in g;
100 = correlation factor.

$$\text{Total polyphenols expressed in chlorogenic acid, \%} = \frac{C \cdot 2{,}016}{m_p \cdot 100}, \quad (3)$$

where:

C = concentration read on the calibration curve, in µg /mL;
m_p = mass of sample to be analyzed , in g;
2,016 = factor of transformation of caffeic acid content in chlorogenic acid;
100 = correlation factor.

For determining the **AMINO-ACID CONTENT EXPRESSED IN GLUTAMIC ACID were used**:

Equipment: analytical balance

Reactive substances: ninhydrin solution 10 g/L; solution of sodium citrate R 1M ; water R; solution of glutamic acid R 0.5 g/L (0.05 g glutamic acid is dissolved and brought to level with water R in a quoted flask of 100 mL);

- stock solution: the working method is provided in product's Technical Specification.
- test solution: 0.5 mL stock solution is treated with 0.2 mL ninhydrin solution 10 g/L and a drop of sodium citrate solution R 1M in a Erlenmeyer glass of 25 mL that maintains on bath water under boiling up to evaporation, approx. 60 minutes. Residue formed is dissolved in 5 mL water R and after vessel repeated cleaning is brought into a quoted flask of 25 mL. It is completed up to the level mark with water R;
- reference solution: 0.5 mL glutamic acid solution R 0.5 g/L is treated in the same conditions as test solution.

Working technique: the absorbent of test solution and referrence solution is read at λ = 570 nm, according to water R.

$$\text{Content of amino-acids expressed in glutamic acid/, \%} = \frac{A_p}{A_e} \cdot \frac{m_e}{m_p} \cdot 100 \quad (4)$$

where: Ap = sample absorbent; Ae = standard absorbent; m_p = sample mass, in g; m_e = standard mass, in g;

For determining the **MUCILAGINOUS CONTENT, were used**:

Equipment: heating bath, oven, and analytical balance;

Reactive substances: ethanol R;

Working technique:

1 g *sample to be analyzed is weighed for dry* plants, respectively 5g for fresh plants and 10g sample for liquid extracts and tinctures unless otherwise is provided in product Technical Specification.

The sample weighed is introduced in a graded glass Berzelius, over which are added 50 mL *water R* and is boiled for one hour, always adding water R in the evaporated liquid, when is necessary. Hot extract is pressed through gauze cloth, and over the obtained filtrate is added *ethyl alcohol* 96% in a ratio of 1 : 1 (v/v), for making mucilage precipitate. It is let 24 hours in the refrigerator. Mucilage is filtered on a quantitative filter paper, previously brought at a steady mass and is dried at 50 C in the oven up the constant mass. Mucilage filter paper is let to get cool in the dessicator for one hour, after which is weighed and the percentage of mucilage extracted is calculated by the formula:

$$\text{Mucilage content, \%} = \frac{M_f - M_h}{M_p} \cdot 100 \quad (5)$$

where:

M_f = final mass of filter paper with mucilage after filtering (g);
M_h = initial mass of filter paper (g);

M_p = mass of sample considered (g)

For determining the **MINERAL CONTENT were used**:
Equipment: analytical balance; spectrometer of atomic absorption;
For determining silicon, platinum crucibles and plastic laboratory utensils, are used.
Working conditions:
- wave length at which is made the determination (table 1):

Table 1

Metal	Cadmium (Cd)	Copper (Cu)	Iron(Fe)	Calcium (Ca)	Lead (Pb)	Zinc (Zn)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Manganese (Mn)	Selenium (Se)	Nickel(Ni)	Silicon(Si)	Chromium (Cr)
Wave length in mm)	228.8	324.8	248.3	422.7	217.0	213.9	202.6	589.6	766.5	279.5	196.0	232.0	251.6	357.9

- acetylene-air flame;
- acetylene-nitrogen protoxide flame

Reactive substances: hydrochloric acid R, without heavy metals, nitric acid R, without heavy metals; hydrogen fluoride acid R, without heavy metals ; standard solutions of respective metals of 1000 ppm;
- reference solutions: for obtaining the calibration curve, reference solutions of different concentrations, prepared from standard solution of 1000 ppm, in nitric acid solution 1%, are used (table 2):

Table 2

Denomination	**Metal reference solutions** (µg/mL, ppm)						
Cadmium (Cd)	0.2	0.4	0.6	1.0	-	-	-
Copper (Cu)	1.0	2.0	3.0	4.0	5.0	-	-
Iron(Fe)	1.0	2.0.	3.0	4.0	5.0	-	-
Calcium (Ca)	1.0	2.0.	3.0	4.0	-	-	-
Lead (Pb)	0.2	0.5	1.0.	1.5	-	-	-
Zinc (Zn)	0.1	0.3	0.5	1.0	1.5	-	-
Sodium (Na)	0.2	0.4	0.6	0.8	1.0	1.2	-
Potassium (K)	0.4	0.6	0.8	1.0	1.2	-	-
Magnesium (Mg)	1.0	5.0	10.0	15.0	20.0	-	-
Manganese (Mn)	0.1	0.2	0.4	0.6	1.0	1.5	2.0
Selenium (Se)	0.5	1.0	2.0	3.0	4.0	5.0	-
Nickel (Ni)	1.0	2.0	4.0	6.0	8.0	-	-
Silicon (Si)	10.0	50.0	100.0	150.0	200.0	-	-
Chromium (Cr)	0.5	1.0	2.0	3.0	5.0	-	-

Value of correlation coefficient R, from standard curve should not be smaller than 0.995;
- test solution for plants and their parts: according to product Technical Specification a certain quantity of sample is weighed in China crucible or platinum crucible for determining silicon and is calcinated at 600-800^{0}C for four hours. After the calcination, 5 ml of a mixture made of hydrochloric acid R:water R (1:1) (v/v), are added, after which the dry evaporation takes place. The residue from the crucible is taken over in a quoted flask of 50 mL by consecutive washing three times with 2.5 mL out of a mixture made of hydrochloric acid R:water R (1:5) (v/v). Then, 5 mL solution made of the mixture of nitric acid R and water R, (1:2) (v/v) are added into the crucible and are brought to dryness. After drying, the residue is taken over by repeated washing three times in a row each with 2.5 mL solution made of hydrochloric acid R:water R, (1:5) (v/v), collecting the fractions in the same flask used for the first washing series. The washing is continued with water R up to the level of flask liquid; For determining the silicon, the platinum crucible containing the sample to be analyzed is cooled in dessicator, then the quantitative residue is taken over with 2-3 ml hydrogen fluoride R, by repeated washing, gathering the fractions into a quoted flask (50-100 mL), then it is washed and brought to level with water R.
- test solution for other types of products, (excipients, tinctures, fatty oils, essential oils, etc.): method of obtaining test solution is presented in product Technical Specification;
- blank solution: solution made of nitric acid R 1% – without heavy metals.

Working technique

- The absorbants of reference solutions and test solution are determined. Value of reference solution determined is automatically decreased from the value obtained at test solution.
- The values obtained for the respective metal concentration are registered, in µg/mL (ppm).

Calculation:

a) $$M\ (\mu g/mL)\ ,(ppm) = \frac{C \cdot V}{m_p} \quad (6)$$

where:

C = concentration of metal displayed by apparatus, in µg/mL, (ppm);
V = volume of quoted flask used for preparing the test solution, in mL;
m_p = mass of sample to be analyzed, in g;
M = metal analyzed, in µg/mL, (ppm).

b) $$M\ (\%) = \frac{C \cdot V}{m_p \cdot 10^4} \quad (7)$$

where:

C = concentration of metal displayed by apparatus, in µg/mL, (ppm);
V = volume of quoted flask used for preparing the test solution, in mL;
m_p = mass of sample to be analyzed, in g;
M = metal analyzed as percentage;
10^4 = correlation factor.

RESULTS

The vegetal dry product obtained by SC HOFIGAL SA was broken by two methods: first,(HOFIGAL), respectively by chopping (INMA), the main physical and chemical charcateristics being determined.

Secondly,the finely ground material (HOFIGAL), under 0.25 µm was subject to a simple maceration process, and roughly chopped material (INMA) at 0.1÷6.3 mm size was distiled by percolation and then, made concentrate, obtaining the following results:

2. Analysis of vegetal product

2.1. Analysis of vegetal product freshly harvested

Table 3

Den. no.	Characteristic	Results of fresh plant Hofigal/ Alexandria	Results of fresh plant Hofigal/ Bucharest
1	Microscopic features	Stem is of 15-30 cm height, ascending, pulpy, without hair, sour-cherry colour at its lower part. Lower leaves are inversely egg-shaped elongated and hairy	High stem of 15-30 cm, ascending, pulpy, glabra, sour-cherry colour at its lower part. Lower leaves are inversely egg-shaped elongated and hairy
2	Identification : - Flavonoids(chemical reaction) - Amino-acids(chemical reaction) - Polyphenols(chemical reaction) - Sugars (chemical reaction) - Carotenoids (spectrophotometry UV-VIS)	 Without chemical reaction It is appropriate It is appropriate Without chemical reaction Without chemical reaction	 Without chemical reaction It is appropriate It is appropriate Without chemical reaction Without chemical reaction
3	Loss by drying,%, max	75.0	90.8
4	Total ashes,%, max	2.3	1.82
5	Content of: - total polyphenols expressed in chlorogenic acid,%	0.36	0.25
	- glutamic amino-acids,%	0.35	0.18
	- ascorbic acid,%	0.004	0.021
	- essential oil, mL/kg	No traces of essential oil at distillation	No traces of essential oil at distillation
	- terpene substances, %	Can not be determined because of lack of essential oil	Can not be determined because of lack of essential oil
	- mucilaginous substances%	5.3	6.2
	- minerals: Ca Mg Na K Mn Fe Zn Cu Pb Cd Cr	 50 90 30 650 ND 6 2,8 <0,1 ND ND ND	 120 150 12 520 0,3 12,2 3,6 ND ND ND ND

2.2. Analysis of dry vegetal product minced with vegetal material grinding mill MMC 2, with 8mm sieve, in normal conditions

Table 4

Den. No.	Characteristics	Results obtained with dry plant Hofigal/ Alexandria	Results obtained with dry plant Hofigal/ Bucuresti
1	Macroscopic features	Stem is of 15-30 cm height, ascending, pulpy, without hair, sour-cherry colour at its lower part. Lower leaves are inversely egg-shaped elongated and hairy	Stem is of 15-30 cm height, ascending, pulpy, glabrous without hair, sour-cherry colour at its lower part. Lower leaves are inversely egg-shaped elongated and hairy
2	Identification : - Flavonoids(chemical reaction) - Amyno-acids(chemical reaction) - Polyphenols(chemical reaction) - Sugars (chemical reaction) - Carotenoids(spectrophotometry UV-VIS)	 Without chemical reaction It is appropriate It is appropriate Without chemical reaction Without chemical reaction	Without chemical reaction It is appropriate It is appropriate Without chemical reaction Without chemical reaction
3	Loss by drying,%, max	6.1	9.4
4	Total ashes,%, max	2.5	2.3
5	Content of: - total polyphenols expressed in chlorogenic acid,%	1.25	1.31
	- glutamic amino-acids,%	3.16	1.96
	- ascorbic acid,%	Unquantified races	Unquantified traces
	- essential oil, mL/kg	No traces of essential oil when distillating	No traces of essential oil when distillating
	- terpene substances, %	Can not be determined because of lack of essential oil	Can not be determined because of lack of essential oil
	- mucilaginous substances, %	2.24	2.2
	- amino-acids expressed in glutamic acid, %	6.2	4.0
	- minerals: Ca Mg Na K Mn Fe Zn Cu Pb Cd Cr	 174 730 8500 100 2,3 9 10 ND ND ND ND	 233 943 445 5002 1,8 3,2 5 ND ND ND ND

3. Analysis of extracts

3.1. Analysis of hydraulic extracts obtained at SC Hofigal Export Import SA

Table 5

Den. no.	Characteristics	Results Extract of (dry) purslane in EtOH 30%	Results Extract of (dry)purslane in EtOH 70%
1	Description: - aspect - colour - smell - taste	 - clear liquid - brown - characteristic - characteristic	 clear liquid - brown - characteristic - characteristic
2	Identification: - Flavonoids(chemical reaction) - Amino-acids (chemical reaction) - Polyphenols (chemical reaction) - Ascorbic acid (chemical reaction)	 Without chemical reaction It is appropriate It is appropriate Without chemical reaction	 Without chemical reaction It is appropriate It is appropriate Without chemical reaction
3	Relative density, d_{20}^{20}	0.972	0.905
4	Content of: - total polyphenols expressed in chlorogenic acid,%	0.079	0.088
	- amino-acids expressed in glutamic acid, %	0.37	0.17
5	- minerals: Ca Mg Na K Mn	 ND 2 50 110 ND	 0.7 1 35 6 ND

	Fe Zn Cu Pb Cd Cr	2.5 8.4 ND ND ND 1.7	2.5 8.4 ND ND ND 1.7

3.2. Analysis of extracts obtained at INMA (distillate and concentrate) from dried vegetal product minced at 0.1÷6.3 mm size.

Table 6

Den. no.	Characteristics	Extract of concentrate of *Portulaca Oleracea*	Extract of *Portulaca Oleracea* distilat
1	Description: - aspect - colour - smell - taste	 - clear liquid - brown - characteristic - characteristic	 clear liquid - colourless - characteristic - characteristic
2	Identification: - Flavonoids(chemical reaction) - Amyno-acids (chemical reaction) - Polyphenols (chemical reaction) - Ascorbic acid (chemical reaction)	 Without chemical reaction It is appropriate It is appropriate Without chemical reaction	 Without chemical reaction Without chemical reaction Without chemical reaction Without chemical reaction
3	Relative density, d_{20}^{20}	1.002	1.068
4	Residue obtained by evaporation, %	1.9	0.6
5	Content of : - total polyphenols expressed in chlorogenic acid,%	0.058	Does not create chemical reaction
	- amino-acids expressed in glutamic acid, %	0.32	Does not create chemical reaction
6	Mucilage, %	0.23	0.1
7	Content of minerals: Ca Mg Na K Mn Fe Zn Cu Pb Cd Cr	 0.8 15 19 60 0.15 0.8 0.7 0.3 ND ND ND	 0.1 0.5 0.6 30 ND ND 0.06 ND ND ND ND

CONCLUSIONS

Analyzing the obtained results after the four studied samples (vegetal product freshly harvested, dry vegetal product in controlled conditions, diluted and concentrated extract at INMA and respectively hydro-alcoholic extract 30% and 70% Hofigal, the following can be concluded:

A. Content of active principles in plant freshly harvested versus controlled dry plant:

- Commonly, the mass loss parameter by drying is much greater in the plant freshly harvested comparing to the dry one (approximately 10 times higher).
- Total ash is greater but not significantly at the dry plant comparing to the plant freshly harvested.
- Content of total polyphenols expressed in chlorogenic acid is much bigger at dry plant comparing to the fresh one (e.g. 0.25% versus 1.31%).
- Content of amino-acids expressed in glutamic acid is much higher at dry plant comparing to the fresh one (e.g. 0.35 % versus 3.16 %).
- Mucilage content is a little bigger at dry plant comparing to fresh plant.
- Content of C vitamin is clearly bigger at fresh plant (0.004- 0.021%) versus dry plant, where only C vitamin unquantified traces are present.
- It has been found that fatty oil can be dosed in case of dry plant (2.20- 2.24%), while at fresh plant there are only oil traces.
- It is noticeable the very high content (which is normal) of mineral salts and oligoelements at dry plant versus fresh plant [calcium 174 versus 50; magnesium 730 versus 90; sodium 8500 versus 30; manganese 2.3 versus undectable (ND); zinc 10 versus 2.8].
- It is noticeable the copper presence in fresh plant ND (undectable) in the dry one and manganese in dry plant comparing to fresh plant where it is absent.

- It has been noticed that heavy metals, such as lead, cadmium are absent, fact that beside the vegetal product quality aspects adds also the product security as raw material and implicitely the end product safety as medicines, food supplements and cosmetics or body care products, that will be produced .

B. Content of active principles in hydro-alcoholic extract 30% versus hydro-alcoholic extract 70%:

- Content of total plyphenols expressed in chlorogenic acid is bigger at *hydro-alcoholic extract 70%* than at *hydro-alcoholic extract 30%* (e.g. 0.088 % versus 0.079 %).
- Content of amino-acids expressed in glutamic acid is much higher of over 100%, in hydro-alcoholic extract 30% than at hydro-alcoholic extract 70% (e.g.0.37 % versus 0.17 %).
- It has been found that mineral salts or oligoelements are absent in hydro-alcoholic extracts, namely: in hydro-alcoholic extract 30% there are ND (undetectable)calcium, manganese, copper, and in hydro-alcoholic extract 70% there are ND manganese, copper.
- It has found the very small content of mineral salts and oligoelements for both hydro-alcoholic [undetectable calcium ND versus 0 0.7; magnesium 2 versus 1; sodium 50 versuss 35; potassium 110 versus 6; iron 2.5; zinc 8.4, chrome 1.7].
- It is important the fact that heavy metals such as lead and cadmium are absent.

C. Content of active principles in distilled watery extract, diluted versus concentrated watery extract:

- Concentrated watery extract creates chemical reaction and confirms presence of amino-acids and polyphenols, while at distilled watery extract their presence is not identified.
- Content of total polyphenols expressed in chlorogenic acid is of 0.058% for concentrated extract and ND (undetermined) at diluted one.
- Content of amino-acids expressed in glutamic acid is of 0.32 % and ND (undetermined) at diluted one;
- Mucilage content is significantly higher, over 100% at concentrated watery extract comparing to diluted one.
- Ascorbic acid and fatty oil are absent in both watery extracts.
- It has found the very small content of mineral salts and oligoelements at watery extract concentrated and their absence or very low content at diluted watery extract [calcium 0.8 versus 0.1; magnesium 15 versus 0.5; sodium 19 versus 0,6; potassium 60 versus 30; manganese 0.15 versus undetectable (ND); iron 0.8 versus ND; zinc 0.7 versus 0.06; copper 0.3 versus ND].
- Copper does exist in concentrated watery extract and ND in diluted one.
- It is important to notice the lack of heavy metals, lead and cadmium.

D. Content of active principles in watery extract versus hydro-alcoholic extract:

- Content in total polyphenols expressed in chlorogenic acid is significantly higher than the watery one (e.g.0.079 or 0.088 % versus 0.058 or absent %).
- Content of aminoacids expressed in glutamic acid is much higher at hydro-alcoholic extract versus watery extract (e.g. 0.17- 0.37 % versus 0.32 or absent %).
- Mucilage content is present in watery extract both concentrated and diluted and absent in hydro-alcoholic extract.
- Ascorbic acid does not create chemical reactions with any type of extract.
- It has found out that the mineral salt and oligoelements are in very small content for both hydro-alcoholic and watery extract [undetectable calcium ND or 0.7 versus 0.1- 0.8; magnesium 1-2 versus 0.5- 15; sodium 35- 50 versus 0.6- 19; potassium 6- 110 versus 30- 60; manganese ND versus undectable (ND) - 0.15; iron 2.5 versus 0.8- ND; zinc 8.4 versus 0.06- 0.7; copper ND versus ND- 0.3].
- It is important that heavy metals (lead and cadmium)are absent that beside the quality aspect offered by vegetable product are also emphasized the safety aspect as raw material and implicitly the end product safety as medicines, food supplements and cosmetics or body care products, that will be produced .

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DEHYDRO-FREEZING AS A NOVEL PROCESS FOR EXTENSION OF TOMATO SLICES SHELF LIFE
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فناوری ترکیبی خشک کردن و انجماد به عنوان یک روش جدید برای افزایش ماندگاری ورقه های گوجه فرنگی

Reihaneh Ahmadzadeh Ghavidel [1*], Mohammad Rasoul Baraee Nejad[1)], Mehdi Ghiafeh Davoodi[2)]
[1)]Department of Food Science and Technology, Quchan Branch, Islamic Azad University, Quchan, Iran
[2)]Technical and Engineering Research Section, Agricultural and Natural Resources Research Center of Khorasan Razavi, Iran
E-mail: reahmadzadeh@yahoo.com

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ABSTRACT

Tomatoes are commonly used throughout the world. Tomato is rich in lycopene that is one of the most powerful antioxidants. Compared with other fruits or vegetables, the storage life of tomato is very short. In the current study, de-hydro-freezing method was used as a novel technology for increasing tomato's shelf-life. For this purpose, a mild drying method was used for reducing moisture content, and then, fruits were frozen for certain periods of time.Texture, index image, moisture content and sensory properties were investigated. Data were analyzed in a completely randomized design with three replications. The result showed that application of 0.5% citric acid along with 1% ascorbic acid in osmotic salt solution at 7% concentration, and sodium metabisulfite at 1% were the best samples in terms of sensory properties, appearance, quality and texture.

چکیده

گوجه فرنگی به طور گسترده ای در تمام دنیا استفاده میگردد. گوجه فرنگی غنی از لیکوپن میباشد که یک آنتی اکسیدان بسیار قوی است. در مقایسه با میوه جات و سبزیجات دیگر، عمر انبارمانی گوجه فرنگی خیلی کوتاه است. در این مطالعه، روش خشک کردن و انجماد به عنوان روشی جدید جهت افزایش عمر ماندگاری گوجه فرنگی استفاده میگردد. برای این منظور، در ابتدا یک خشک کردن ملایم اعمال میگردد و سپس میوه ها برای مدت مشخصی منجمد میگردند. بافت، اندیسهای تصویر، میزان رطوبت و خصوصیات حسی مورد ارزیابی قرار گرفتند. اطلاعات به دست آمده مورد تجزیه و تحلیل آماری قرار گرفتند. نتایج نشان میدهند که به کار بردن 0/5% اسید سیتریک همراه با 1% اسید آسکوربیک در محلول نمکی غلیظ با غلظت 7% و متا بی سولفیت سدیم 1% بهترین نتایج را از نظر خصوصیات حسی، ظاهر، کیفیت و بافت نشان دادند.

INTRODUCTION

Tomato (*Lycopersiconlycopersicum*L. H. Karst. or *Lycopersiconesculentum*Mill.) cultivation is wide-spread throughout the world. The tomato crop is noted to be the second most important vegetable crop next to potato. Globally, China is by far the largest producer of tomatoes, followed by the USA, India, Egypt and Turkey. Many developing countries still face enormous challenges of post-harvest losses of tomatoes, due to inadequate processing and storage facilities. Tomatoes produced in the peak seasons are either consumed fresh, sold at relatively cheap prices, or are allowed to go to waste [1].

Studies show that tomato contains a large amount of lycopene, which is the major carotenoid, accounting for 90% of the total carotenoids. Lycopene's antioxidant activity is reported to be higher than that of β-carotene, γ-carotene, and α-tocopherol, which provides effective scavenging effects on cancer-causing free radicals. Epidemiological studies have shown that lycopene in tomato is particularly effective in fighting prostate cancer, cervical cancer, cancer of the stomach and rectum as well as pharynx and oesophageal cancers [1, 2].

In the latest years, tomatoes and the obtained products became interesting subjects for researchers, due to their high biological value, antioxidant activity and functional characteristics. At a certain degree, all the products obtained from tomatoes present antioxidant characteristics, determined by the bioactive compounds, like lycopene, ß-carotene, vitamin C, polyphenols and flavonoids, were of special interest. Dried tomatoes present a special interest, because some bioactive antioxidants are found in their composition at concentrated state. Lycopene has the highest value, with antioxidant and curative specific features on some diseases, and consequently, the lycopene-rich products may be used for obtaining foods and bioactive food supplements (BFS). The efficiency of using dried tomatoes as foods with health claims or BFS is conditioned by the degree of maintaining the bioactive components [3].

Nowadays, there are technical opportunities (modern technologies and equipment) for using drying in order to develop the production of foods with health claims and BFS, because modern technologies for drying farming raw material allow us to take into account the requirements of these products, such as the preservation of bioactive nutrients, at rates with pharmacological effect on the human body [3].

The terms of drying refers generally to the removal of moisture from a substance. It is the most common and the most energy-consuming food preservation process. Vacuum freeze-drying is the best method of water removal with final products of highest quality, compared to other methods of food drying [4].

Osmotic dehydration is an important process that enables the partial removal of water by direct contact of a product with a hypertonic medium. This gives rise to two major simultaneously countercurrent mass transfer fluxes, namely water flow from the product to the surrounding solution and solute infusion int2. shapes, such as halves, slices and quarters [6].

The aim of the current work was to study the influence of drying process on tomatoes quality and physico-chemical properties.

MATERIALS AND METHODS

Preparation of raw materials

The tomato fruits were purchased from a greenhouse situated near Mashhad city. The healthy fruits were sorted and washed. Chemicals including salt (purchased from local market), ascorbic acid (Merck, Germany), citric acid (Merck, Germany), and metabisulfite (ShimiGostar Co.) were prepared. Other materials were prepared from the Agricultural Research and Natural Resource Center of Khorasan.

Preparation of osmotic solutions

In this study, five osmotic solutions were examined as treatments. The osmotic solutions were prepared as follows: 7% sodium chloride, 0 and 0.1% ascorbic acid, 0, 0.5 and 1% citric acid, combinations of the acids and 1% metabisulphite (to maintain the color quality), and control treatment without using any acid. The temperature of osmotic solutions was adjusted to 5-10 °C. In addition, three methods of drying were used as follows: osmotic solutions, drying by hot air flow, and freezing. During each stage, the qualitative parameters, such as texture, color, aroma and flavor, were examined during storage and after freezing.

Based on fruit weight, osmotic solutions were prepared by dissolving the solutes in 1 L of water at 10 °C. The solutions were stirred until the solutes were completely dissolved too. Then, the fruits were submerged into the osmotic solutions. After 20 min, the fruits were placed on drying trays and dried by a drying cabinet at 50-55 °C for 3 h. The moisture was recorded at regular intervals.

Physico-chemical tests

Moisture measurement

To measure moisture content, the plates were weighed, and then, put in an oven adjusted on 103±2 °C for 30 min.

After cooling, the samples were weighed until samples showed constant weights. Afterwards, 5 g of sample were transferred onto a container dish and placed in an oven for 2-3 h. After cooling, the plates were placed in a desiccator and weighted. The moisture content was calculated using equation 1:

Equation 1:

Moisture content (%) = (normative weight- fixed weight) / normative weight × 100

Sodium chloride measurement

In order to measure sodium chloride, 5 ml of a solution were mixed with 100 ml of tomato extract in a flask. Then, the mixture was made into the total volume with distilled water. Next, two drops of 0.05 M potassium chromate were added, by a bubble pipette inside; at this time, yellow color was observed. Finally, the solution was titrated with 0.01-M original standard silver nitrate, (adding titration reagent caused red sediment, and was continued until the color turned to milky). The procedure was repeated three times. The sodium chloride was calculated using the following Equation 2:

(ClNa g / 100 L) sodium chloride = A × 58.5 × N × 100/ W × 1000

Acidity measurement

Firstly, the tomato extracts were ground into powder. Then, 10 g of the powder were added into 100 ml distilled water; the mixture was stirred using a magnetic stirrer for 30 min before filtering by a Buchner funnel and vacuum pump. Finally, 10 ml of the extract was poured into a 100-ml flask and titrated with phenolphthalein and 0.01 N sodium hydroxide until the color turned purple. The acidity based on citric acid was determined as follows:

Equation 3:

Consumed acidity in terms of citric acid = N × V× 0.064 × 100 × B/M

where N is normality of sodium hydroxide, V is volume of consuming sodium hydroxide, B is inversion of dilution, and M is weight of prototype. It should be noted that one ml of sodium hydroxide (0.1 N) is equivalent to 0.0064 g of citric acid.

Texture assay

In order to assess the tomato texture, a texture-meter was used. In this way, the rate of required force to penetrate a needle probe (30 mm per min) into the tomato (trigger value: 0.50 N and 30 mm: target value) was calculated. The test was carried out in three periods of 15 days, and the firmness of tomato was measured as main parameter in this test [7].

Image processing

Color space of *L*,a** and *b** have three components of *L** which is equivalent to the brightness: between zero (black) and 100 (full reflection of light). Component values of *a** are unlimited, amount of positive values equals to red and negative values to green. Also, the component values of *b** are infinite. The yellow ones are the positive and negative values are blue, respectively. The color system acts similarly to the human's eye and is not affected by the shooting device. Almost, the *L*a** and *b** color space is applied in food industry researches and the images format must be in JPG.

Color measurement

In order to use image processing techniques, 2×2 cm tomato skin and longitudinal sections of the fruits were prepared and photographed by a scanner with a resolution of 300×300 pixels. The levels of firmness and color of the fruits were evaluated by Image-J software.

Statistical design and analysis of data

The obtained results were evaluated using SPSS version 17 in a completely randomized design. Each of the samples prepared in triplicate and the corresponding tests were conducted using Duncan's multiple range test at 0.95% significance difference level (P<0.05), and eventually, the results were plotted using Microsoft Excel.

Table 1

List of pretreatments

Treatments	Citric acid	Ascorbic acid	Sodium chloride	Metabisulfite
1(Control)	0	0	0	0
2	1%	0	7%	1%
3	0	1%	7%	1%
4	1%	1%	7%	1%
5	0.5%	1%	7%	1%

RESULTS AND DISCUSSION

Acidity

According to the results shown in Table 2, the fitted model seems to be significant for the acidity. As can be seen in Figure 1, the amount of acidity of samples is higher than the control treatment. Since the acid is used in the samples, the increase of acidity seems to be logical. Among the different percentages of used acids, the effect of citric acid on elevation of this factor was more than that of ascorbic acid. The maximum of the acidity was observed in samples containing 1% citric acid (group 2) and in the samples containing both 1% citric acid and 1% ascorbic acid (treatment 4). This is because of higher acidity power of ascorbic acid than citric acid. Golkhandan's study [8] showed that the use of osmotic solution with citric acid was more effective for increasing the acidity in kiwi fruit samples.

Sodium chloride percentage

This test was designed to measure the salt of tomato samples; analysis of variance showed that the pattern designs of tests are significant. (Table 3). The amount of salt in the control sample was zero due to lack of use of osmotic solution. The results showed that the effect of citric acid on the absorption of salt was higher than other kind of acids; the treatment number 2, 1% citric acid, showed the maximum absorption of salt, and after that treatment, number 4 had the greater amount of absorption, containing 1% citric and 1% ascorbic acid. As can be seen, ascorbic acid had little effect on the absorption of salt.

If the amount of salt in samples was greater than normal range, the acceptability would be reduced among consumers; but if the salt was close to the taste of control sample, the flavor of the product would be more favorable. Thus, it can be expressed that the mixture of 1% ascorbic acid and 0.5% citric acid have close taste to the control sample and taste better.

Table 2

ANOVA results of acidity

Treatment	Degree of freedom	acidity
Treatment	6	*74.49
Error	14	1.05

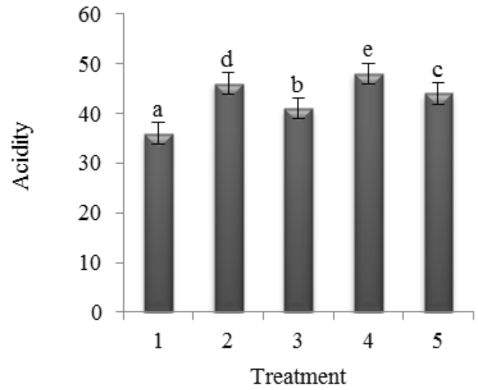

Fig. 1 - Effects of different treatments on acidity of dehydro-frozen tomatoes

Table 3

ANOVA results of salt

Treatment	Freedom degree	Salt
Treatment	6	*0.496
Error	14	0.03

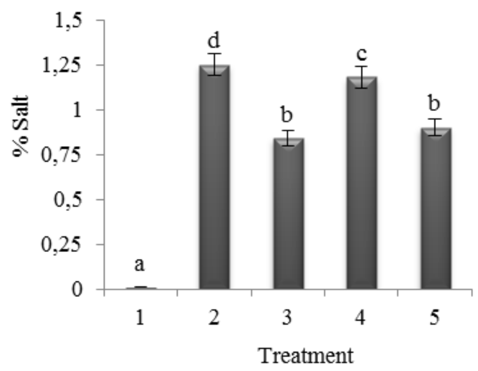

Fig. 2 - Effect of different treatments on salt absorption of dehydro-frozen tomatoes

Moisture

The analysis of variance indicated that there were significant differences between the independent variables during the first and second 15-day periods. Food moisture reduces its shelf-life and increases the risk of mold contamination. Reducing the moisture in tomato samples enables us to increase its shelf-life. Application of 7% salt osmotic solution caused a significant difference between drying and post-freezing methods. Furthermore, application of different osmotic solutions decreased moisture content, compared with control treatment. The results of the first 15-day period showed that samples contained 1% ascorbic acid, and samples treated with citric acid resulted in less moisture content, and the highest amount of moisture was related to control group. In sample number 3, which contained only 1% of ascorbic acid, moisture content value was close to the control sample. Therefore, it can be assumed that ascorbic acid is more effective for reducing the moisture. The simultaneous use of acids could not decrease moisture content.

Table 4

ANOVA results of humidity

Sources of variation	Freedom degree	Humidity
First 15-day period	4	*23.25
Second 15-day period	4	*21.65
Error	5	2.06

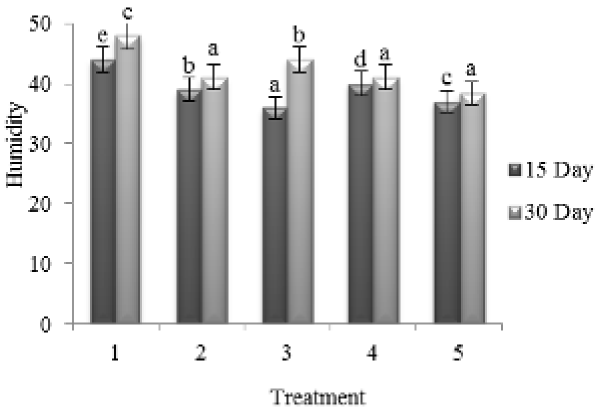

Fig. 3 - Moisture content of treated samples during storage

During the second 15-day storage period, 1% citric acid caused the lowest moisture content; while treatments number 4 and number 5 showed higher moisture content. Moreover, the maximum amount of moisture was recorded in control samples. Comparison of moisture contents during two 15-day intervals revealed that increase in shelf-life of frozen tomatoes caused higher rates of moisture content. The moisture content of control treatment as well as ascorbic acid-treated sample was higher than that of the citric-acid treated samples.

It should also be noted that moisture content in sample number 4, containing 1% citric acid and 1% ascorbic acid, showed the minimum changes during storage time. According to the results, it can be stated that citric acid was more effective in reducing the moisture content, compared with ascorbic acid. In addition, combination of acids showed a synergistic effect on moisture loss and resulted in increase of tomato shelf-life.

Histological examination of the product

To determine the appropriate texture of tested samples, the texture samples of healthy tomatoes must be specified. The firmness of fresh tomatoes was considered. Analysis of variance showed that there are significant differences between treatments n terms of texture during 15 and 30-day storage periods.

The evaluation of samples during the first 15-day period showed that all samples, except for control sample, have similar texture to fresh tomatoes. Soften texture of fresh tomatoes could be due to excess water and less concentration of dissolved solids. Control samples were undergone more texture damage because of lack of salt and acid, and this may lead to absorb more water, and resulted in formation of ice crystals during the frozen storage period.

Table 5

ANOVA results of texture

Sources of variation	Degree of freedom	Firmness
Sources of variation	4	0.976*
First 15-day period	4	3.76*
Second 15-day period	5	0.058

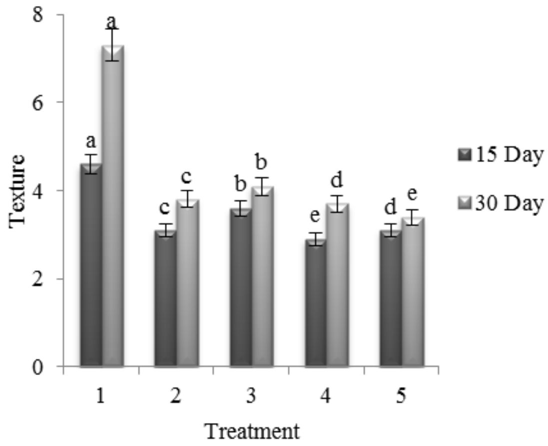

Fig. 4 - Effect of different treatments on texture (firmness) of dehydro-frozen tomatoes

Among tomato samples, sample number 4 and number 5 showed similar texture to fresh tomatoes. The assessment of findings showed that during 15-day period, the texture of sample number 5 (containing 0.5% citric acid and 1% ascorbic acid), has slightly changed, indicating the synergistic effect of acids on the texture of dehydro-frozen tomatoes during long-storage period.

Due to increased acidity power of citric acid, the quality of texture is decreased, and this led to tomato tissue destruction. The results of the second 15-day period showed that the tissues of samples became more rigid during shelf-life; the difference of firmness was higher in control samples than with other treatments. Telis *et al.* [9] have studied the impact of drying and freezing mixed technologies on structure and texture of fruits. They stated that fresh fruits have less flexibility because of further water in their structure, and during the freezing process would be more damaged due to formation of ice crystals.

Applying the mixed process of drying and the post-freezing could be effective to improve the quality and texture of fruits. Maestrelli and Bertalo [10] have conducted a research on a new method on hydro-frozen of tomatoes. Their results showed that this method helps to maintain the quality and nutrients in the final product. Other researches have shown that citric acid caused more soft texture of pineapple chunks, and this was because of its high acid content [11].

Color evaluation

According to Table 6, color indexes were affected by the treatments.

Table 6

Results of variance analysis of color indices

Sources of variation	Degree of freedom	l	a	B
First 15-day	4	82.09*	13.75*	5.026*
Second 15-day	4	79.45*	6.88*	4.73*
Error	5	0.17	0.07	0.26

***L* index**

The *L* index represents the brightness of the sample. According to the results, application of ascorbic and citric acids increased *L* index in tomatoes, compared to control samples. The effect of citric acid was more pronounced than that of ascorbic acid. However, there was no significant difference between the 0.5% and 1% concentrations of citric acid in terms of brightness. The results of the second 15-day period showed the same results.

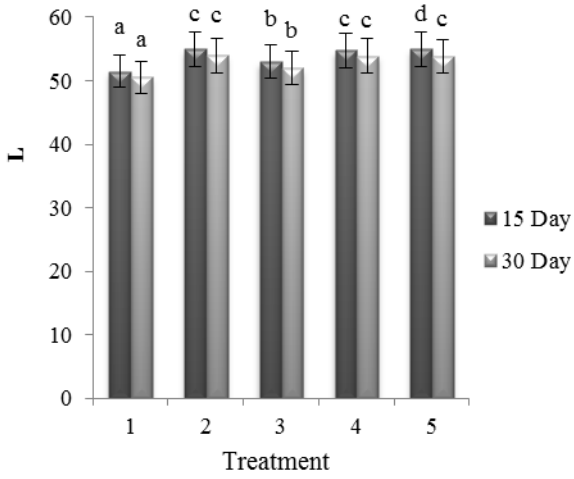

Fig. 5 - The effect of different treatments on (L) index of dehydro-frozen tomatoes

Obtained results from 15-day and 30-day storage periods indicated that change of brightness was very low in the samples containing 0.5% citric and 1% ascorbic. However, there were no significant differences between samples number 2, number 3 and number 4 in terms of brightness during 15-day and 30-day periods. Sahin *et al.* [12] have shown that application of citric acid and ascorbic acids as pre-treatment increase the brightness of the tomato samples in freeze-drying technique.

***b* index**

The *b* index stands for yellow to blue color of the sample. The current findings indicate that the application of ascorbic acid and citric acid significantly increase the amount of this component, compared with control samples. The result of this component is consistent with light indicator. As can be seen, during the first 15-day period, the maximum amount of *b* index was related to sample number 5, containing 0.5% citric acid and 1% ascorbic acid. This point demonstrates the synergistic effect of the acids on improvement of *b* index.

During the second 15-day period, the same trend was observed. The sample number 5 showed the highest rate of *b* index, while no significant difference was observed between samples number 5 and number 4. The degree of *b* index has become less during a longer storage period. Ratti [4] also stated that increased shelf-life in frozen strawberries caused a significant reduction in anthocyanin content and the color indexing parameters.

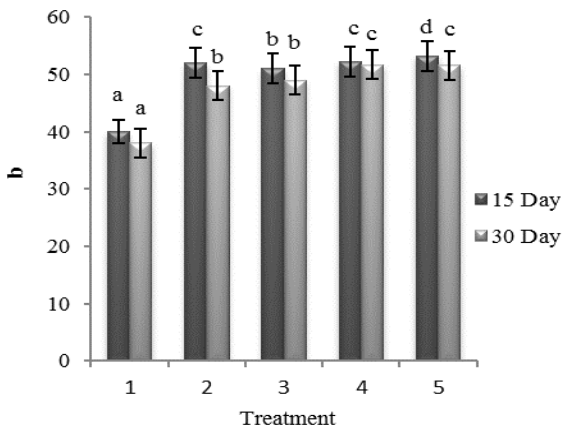

Fig. 6 - Effect of different treatments on (b) index of dehydro-frozen tomatoes.

***a* index**

This index represents the rate of red to blue of the sample. Whenever this index is higher in tomatoes, it is desirable more. As shown in diagrams 3, 4 and 5, the maximum *a* index during the first 15-day period, was related to sample number 4 (containing 1% citric acid and 1% ascorbic acid), which was followed by the sample number 2 (1% citric acid). These results suggest that application of 1% citric acid is more effective than ascorbic acid.

The findings of the second 15-day period showed the same trend, although no significant difference was observed between the samples number 2, 3 4 and 5; it should be noted that sample number 5, containing 0.5% citric acid and 1% ascorbic acid, caused no significant changes during the 15-day and 30-day storage periods. Therefore, it can be concluded that a mixture of the acids can be effective in improving of *a* index during long-storage periods.

Color as a main factor, and is one of the most important parameters in determining the quality of products. Whenever the product shows better color, its acceptance would be higher by consumers. According to results of the three color indexes, it seems that the sample containing 0.5% citric and 1% ascorbic acid could be effective in improving these parameters.

Sahin *et al*. [12] have also reported that application of freeze-drying method and pre-treatment with citric acid and ascorbic acid improve the lighting indices, *a* and *b*. Similarly, Kosar*et al.* [13] have shown that application of osmotic solutions as pre-treatment, freezing and drying methods could improve cucumber color indexes.

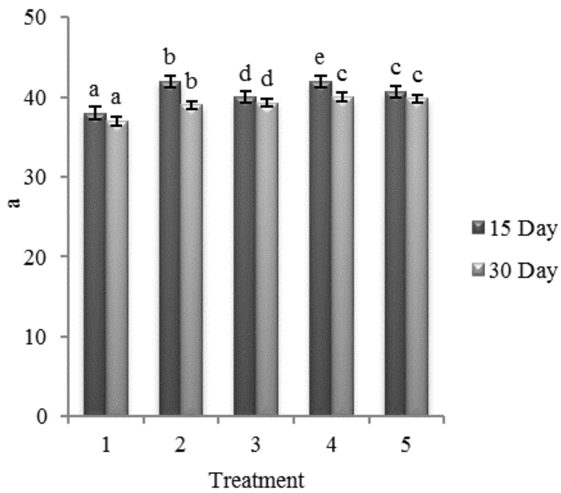

Fig. 7 - Effect of different treatments on a index of dehydro-frozen tomatoes

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RESEARCH ON THE POTENTIAL OF WOOD ENERGY BIOMASS
/
CERCETĂRI PRIVIND POTENŢIALUL ENERGETIC AL BIOMASEI LEMNOASE

Spirchez C.*[1)], Lunguleasa A.[1)], Prună M.[2)], Gaceu L.[1)]
1-Transilvania University of Braşov – Romania; 2-Institute for Research in Construction Technology and Equipment Bucharest – Romania
E-mail: cosmin.spirchez@unitbv.ro

Key words: *biomass, carbone dioxide, wood, calorific value*

ABSTRACT

Biomass is a renewable energy souce that increases every year. It is widespread in the world and has low costs compared to fossil fuels. The biomass resources, that produce combustible material may include wood and wood waste, agricultural grains, municipal waste, animal manure, food processing waste, algae and aquatic biomass.

REZUMAT

Biomasa este o sursă de energie regenerabilă, prin faptul că, creşte an de an. Ea este larg răspândită în lume şi prezintă costuri mici în comparaţie cu combustibilii fosili. Resursele biomasei, din care se produce materialul combustibil, poate include lemnul şi deşeurile lemnoase, cerealele agricole, deşeurile municipale, dejecţiile de animale, deşeuri din procesarea alimentaţiei, biomasa acvatică şi alge.

INTRODUCTION

The importance of woody biomass

Research conducted in the field of energy from biomass shows that by processing conversion can produce electricity and heat. In 2009 biomass has supplied about 10% of total primary energy produced in the world (*Eisentraut and Brown, 2012*).

Biomass participates in the carbon cycle in nature, using carbon dioxide. Carbon dioxide attends both the processes of photosynthesis during growth, but is also the component that determines the complete combustion (Aghamohammadi, 2011).

Among the elementary processes that occur during photosynthesis, about 1% of the energy received from the sun is converted into chemical energy by plants during growth. Solar energy absorbed by the biomass makes up the chemical structure of biomass components (*Morosvolgyi and Vityi 2004*).

Biomass is friendly on the environment and energy neutral on carbon dioxide emissions.

Carbon dioxide is absorbed by plants during growth to form a closed circuit, since the amount of carbon dioxide which was absorbed by the plant during growth will be equal to the same amount that was removed during the process of complete combustion (*Lunguleasa, 2007*).

Biomass can be used in combustion process and most of it doesn't require very large investments such as hydropower, solar, wind and geothermal.

Biomass currently contributes by around 12% to the production of primary energy in the world and in developing countries it occupies 40-50% out of the energy supply.

Biomass is an alternative source, contributing by 7% of the energy produced in the world (*Gominho, 2012*).

Forms of biomass

Romania, according to estimates of National Institute of Statistic has a potential of 60% in production of energy from existing biomass sources.

Romania has an area of 6.3 million hectares, representing 27% of the existing teritory (Beldeanu, 2004).

Biomass differs from other forms of renewable sources in that it represents a rich raw material that can be transformed through various conversion processes in gas, liquid and solid.

Biomass is devided into four main categories described in normative SR EN 14961-1:

- forest production: wood, wood cutting waste, sawdust, shrubs, wood chips, bark resulting from the operation of forestry;
- waste from agricultural production of agricultural products, grain waste, urban inorganic waste;

- grain energy: processing crops in brief, starch crops (maize, wheat, barley), sugar crops (sugarcane and sugar beat), oilseeds (sunflower, soybeans, safflower).

In literature they are mentioned woody crops called energy production as poplar (Populus alba), ash (Frasinus excelsior), willow (Salix viminalis), birch (Betula pendula), beech (Fagus sylvatica), black locust (Robinia psudacacia).

These species are considered to have high energy potential, which can get energy products (*Karp, 2011*).

The sawdust remained in woodworking plays an important role in many European countries. Normally, bark and sawdust are organic materials that shouldn't pollute the environment. In many cases, sawdust is used to improve soil texture with nitrogen from fertilizers and lime.

According to statistics, about 1600 tons of sawdust collected and processed annually comes from renewable resources, meaning 1600 tons of forest less or save 9.2 hectares of forest, an average of 218 m^3 of wood per ha (*Romanian forest 2009*).

The briquettes and pellets are made of wood waste products such as wood chips, sawdust and agricultural waste.

Quality briquettes depends on their compressive strength and density, a greater calorific value (*Lunguleasa and Budău, 2010*).

The briquettes have about the same calorific value as high-density tree species such as: oak, beech (*Lunguleasa, Budău and Coşereanu 2010*).

The pellets are obtained by mechanical processing of the wood resulting in smaller products.

Pellets are solid fuels with a low moisture content (max.12%), obtained from sawdust, wood chips, wood shavings. Wood pellets are clean fuels with low carbon dioxide emissions. Energetic pellets capacity is 19700kJ/kg at a moisture content of 0% (*Berkesy, 2011*).

MATERIAL AND METHOD

Determination of calorific energy of wood materials is determining fuel used in order to asses the amount of energy contained in the biomass.

Besides calorific value from lignocellulosic biomass assessment is necessary to determine calorific characteristic and other features that:

- energy density;
- during combustion;
- burning speed;
- ash content.

According to research carried out at EU level there is a number of refulations on classification, determining calorific combustible value of wood and product descriptions (DIN 51900-1, SR EN 14961-1).

Determination of calorific wood is almost similar to that of coal.

In general, the method for determining the calorific value is done separately from solid, liquid and gaseous fuels (ASTM D3286-96, Dihoiu 1995).

The number of trials required by regulatory and other researches is 5.8 or 10 samples investigated experimentally. The instalation used to determine the calorific value of wood biomass combustion was explosive XRY-1C type, produced by Schanghai Geological Instrument of China (fig.1).

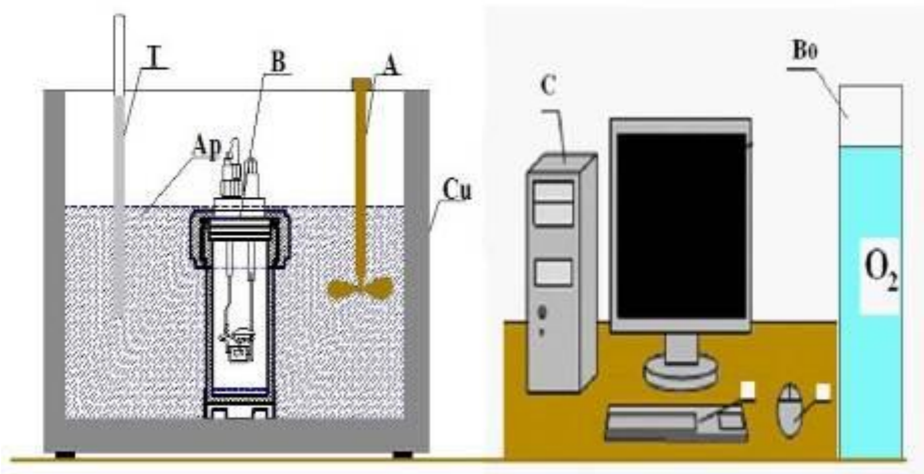

Fig.1 - The installation for determining the calorific value of woody biomass bomb calorimeter

The process for determining the calorific value of the wood refers primarily to the preparation of raw materials and installation, and the determination itself and eventually, to final output.

Preparing the wood for testing consists in taking a small part of about 0.6-0.8 grams of whole material, sample weight having an accuracy of 0.0002 grams.

This sample is placed in a porcelain crucible and placed in a laboratory oven in order to dry at a temperature of 103ºC.

Preparation for the test installation refers to verification of water in calorimeter, agitator A, water press, computer software C, the thermometer outside the calorimeter T and the level of gas pressure in the oxygen cylinder Bo.

Test sample binds cotton thread, and puts in the crucible of the bomb.

Nickeline spiral thread binds evidence and cotton thread, which is positioned right after the protective cover.

The crucible cap is connected to the bomb calorimeter by the electrodes which are continuous with the wires coupling the bomb calorimeter.

Gross calorific value is determined by the relationship:

$$Pc_i = Pc_s - 6\ (U + 9h)\ (kJ/kg), \qquad (1)$$

where:

Pc_s – net calorific value (kJ/kg);

U-moisture content sample (kg/kg);

h-hydrogen content in the wood sample (3.6%).

Net calorific value is determined by the relationship:

$$Pc_s = k\ (t_f - t_i)/m_l - q_s - q_b\ (kJ/kg), \qquad (2)$$

where:

k- coefficient calorimetry;

t_f- final temperature (º C);

t_i- initial temperature (º C);

m_l-mass sample (kg);

q_s- heat consumption for nickeline burning wire (kJ);

q_b- heat produced by burning cotton thread (kJ).

RESULTS

The test for determining calorific value has three distinct periods (fig.2):

- Initial period aims to assess variations in temperature of the water in the bowel calorimetry due to heat exchange with the outside before firing.

During this period, of usually 5 minutes, it must read with precision.

every minute the thermocuple temperature.

Last temperature in the initial period is the first periodic leading temperature.

- Period begins by lighting the main sample and results in increasing water temperature in calorimetric vessel. To determine the final temperature it displays the temperature every minute. The values recorded in this period varys during combustion of combustible material in bomb calorimeter.

- Final period aims at determining the average water temperature variation in calorimetric vessel due to heat exchange with the outside, after firing.

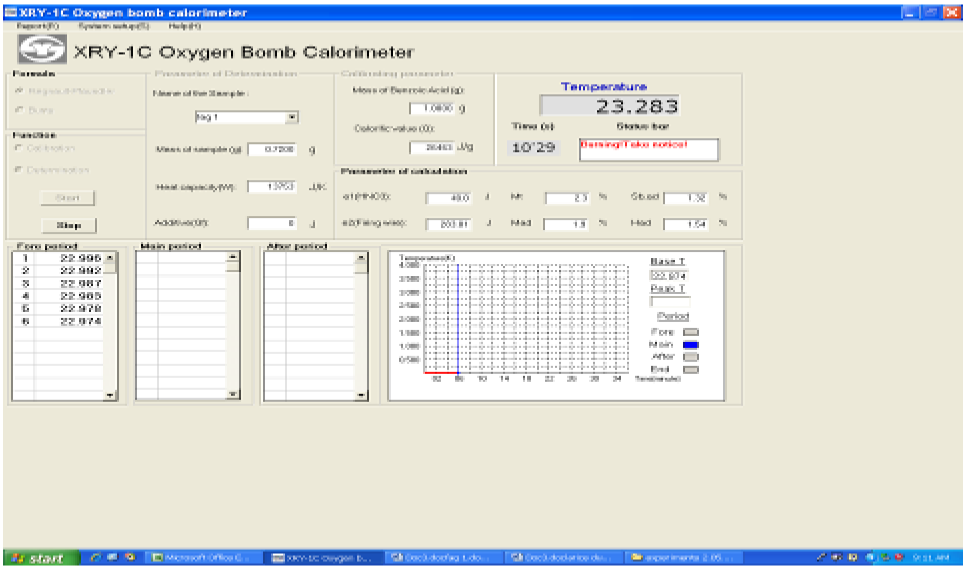

Fig.2 - Description of the process for determining the calorific value

After the measurements are performed the values: for Aesculus hipocastanum, mass sample 0.6200 g, burning time 27 minutes, density sample 0.861 g/cm^3, net calorific value 19567 kJ/kg, gross calorific value 19094 kJ/kg, Carpinus betulus, mass sample 0.6500 g, burning time 26 minutes, density sample 0.866 g/cm^3, net calorific value 18741 kJ/kg, gross calorific value 18268 kJ/kg, Fagus sylvatica, mass sample 0.6900, burning time 25 minutes, density sample 0.851 g/cm^3, net calorific value 19647 kJ/kg, gross calorific value 19051 kJ/kg, Salix alba, mass sample 0.6400 g, burning time 36 minutes, density sample 0.853 g/cm^3, net calorific value 20830 kJ/kg, gross calorific value 20224, Populus alba, mass sample 0.7660 g, burning time 29 minutes, density sample 0.6790 g, net calorific value 20285 kJ/kg, gross calorific value 19685 kJ/kg.

CONCLUSIONS

- Using wood species such as willow and poplar species that are widespread in Romania, it is considered advantageous in energy production.
- By using wood can protect the environment and contribute substantially at the reducing of carbon dioxide and the effects of global warming.
- As burning period in terms of species it may be noted that poplar burns quickly, consequently heat produced isn't maintained and requires a large amount of material to be burned. Beech compared with poplar, shows a slower burning, favoring maintaining heat.

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THE INFLUENCE OF HARVESTING PROCEDURE ON THE PROPOLIS QUALITY AND SAFETY
/
INFLUENŢA PROCEDURII DE RECOLTARE ASUPRA CALITĂŢII ŞI SECURITĂŢII PROPOLISULUI

PhD. Pharm. Abbas H.[1], Assoc. Prof. PhD. Pharm. Eng. Popescu C.*[2,3], Ph.D. Stud. Eng. Mircea C.[4], PhD. Eng. Vlăduţ V.[4], PhD. Pharm. Popiniuc C.[1,5], Prof. PhD.Pharm. Lupuleasa D.[1]

[1]University of Medicine and Pharmacy "Carol Davila" - Faculty of Pharmacy, Bucharest / Romania
[2]S.C. HOFIGAL Export Import S.A., Bucharest / Romania; [3]Faculty of Pharmacy, "Vasile Goldiş" Western University, Arad / Romania;
[4]INMA Bucharest / Romania; [5]Innergy (SC INNER Chi Nature srl), Constanta, Romania-working point, Voluntari / Romania
Tel:+40722611658; E-mail: popescu_carmen88@yahoo.com

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ABSTRACT

The propolis taken into study was harvested from beehives placed in a climatic and geographic area with a high degree of cleanness in the environment, without industrial emissions and especially characterized by the presence of a diversified spontaneous flora situated far away from polluting sources. Propolis, a natural product that is waxy, sticky, light-brown to dark-brown in colour, having a resinous aspect, is collected from bees (Apis melifera). The propolis analyzed in physical-chemical terms contains active ingredients, representative both qualitatively and quantitatively, giving it great added value. In this paper, studies were conducted on the physical and chemical characterization of propolis obtained through a procedure that kept under control its traceability, from the quality and quantity of flora, to the quality materials for producing the hives, the collecting nets, on their location thereof, their preparation for harvesting, the cleanliness and hygiene of containers and harvesting tools, enclosures for different operations, but especially the manner and conditions for its primary packaging and storage. The qualitative and quantitative composition of the studied propolis has confirmed the data from the specialty literature on its use as natural source of active ingredients – flavonoids, with antiviral, antibacterial, antifungal and phyto-inhibiting properties, but also polyvalent bioactive for humans and animals as antioxidant, detoxifying, anti-inflammatory, cicatrizing, chelator for heavy metals. In addition, the studied propolis is characterized by the presence of macro and microelements, but especially by the absence of heavy metals, giving it the superiority of usage safety along with aspects regarding its safety.

INTRODUCTION

The origin of propolis resides in the resins collected by bees from the buds and bark of various trees and shrubs. In the beehive, resins are laboriously processed along with bees own secretions, thus resulting the final product, propolis. The biodiversity and implicitly the bio-variety in the composition of propolis make it act very good on pathogen microorganisms without installing the resistance well known in the case of synthesis antibiotics.

The word propolis comes from Greek language, meaning "the part in front of the fortress". It was named so by the Greek scholars which, observing how bees build their hive, they reached the conclusion that this substance plays the role of protection against external aggressors, propolis (Figure 1) turning the beehive into a real fortress [1].

Fig.1 – Propolis [4]

The quantity of propolis that can be obtained from a hive varies depending on a series of factors out of which we mention: the bee species (this is the most important factor), time period (bees produce the most propolis during spring and autumn), and geographic area (hives in areas with forests produce more propolis). [2]

Bees harvest propolis from various trees, at least 20 species (resinous, poplar, alder, cherry, beech, etc.) and transport it into the hive in order to fill its cracks and to cover the dear bodies of different pests in the hive. Propolis has various colours (depending on the tree from which it is harvested) and unique qualities, valued by humans from ancient times. The quantity of propolis that can be obtained from a family of bees varies between 100 and 400 grams per year [2].

Propolis, a natural waxy product, sticky, coloured from light-brown to dark=brown, with a resinous aspect, is collected and produced by bees (*Apis mellifera)*, both for sealing the interior surfaces of the hive, and also for creating optimal conditions for the survival and normal development of bees families.

The name "propolis" derives from two Greek words *"pro"* (meaning *"before"* or *"in front"*) and *"polis"* (meaning *"fortress"* or *"community"*), given by Aristotel for the "reputation of propolis", as a product involved in defending "the community or hive" (Burdock GA., 1998), for maintaining the health of bee families by protecting the walls of hives from the negative action of bacterial, fungal and viral contaminants [Molan P].

Propolis comes from natural balsamic resins (called vegetal exudates), secreted actively by plants (especially by the buds of trees like poplar, birch, willow, etc.) and incorporated into the propolis, without being altered by the secretions of salivary glands during their collection or while adding the wax secreted by the special glands situated on the abdomen of bees during preparation.

In particular, poplar buds (honey species) are attractive for bees, because they produce an exudate containing a few hundred phenol compounds, a characteristic mixture of bioactive substances, the majority, already identified (Greenaway et al., 1990).

The chemical composition of propolis is very complex because it contains more than 200-300 natural compounds. Its biological or pharmaceutical properties depend on the presence of a large number of poly-phenols, mainly flavonoids (flavonoid aglycone), aromatic acids, phenol acids and esters (caffeic and ferulic) triterpenes, diterpenes and lignans (Burdock GA., 1998).

These bioactive compounds, as well as the beneficial properties of propolis vary depending on the plant source (the plants sought by the gathering bees), the geographic area and the gathering period.

Although the chemical composition of propolis is variable (depending on the geographic area, on the variety of trees and other species used by bees for harvesting), there is still a certain group of substances (flavonoids, phenols and terpenes) permanently present in its structure, substances that condition the physic-chemical characteristics and especially the pharmacodynamic ones. Out of these, chrysin, caffeic acid, quercetin, rutin, pynocembrin, pynostrobine, galangin, kaempherol, luteolin, ferulic acid, 5-oxi-dimetoxiflavone etc. and other flavonoid type substances give propolis complex biological properties such as the antibacterial, antioxidant, anti inflammatory, analgesic action, immune-modulating and anti-tumour properties etc.

In fact, propolis was the object of extensive studies on the physic-chemical characteristics, corroborated with the pharmacological ones.

In vitro and *in vivo* experiments highlighted the antiviral, antibacterial, fungicidal, anaesthetic, mitogenic, trophic, anti-inflammatory, anti-carcinogenic, and immunoregulatory action of several propolis extract or of some of its components (Banskota et al., 2001,).

The interest of researches conducted for the biological properties of flavonoids, compounds frequently present in the chemical composition of plants, is also motivated by the fact that numerous products from natural extraction from plants of from honey products that are already in the therapeutical arsenal contain as active principles complex mixtures on flavonoid type polyphenols.

The main bioactive properties of propolis based mixtures are attributed especially to flavonoids, compounds widely spread in the plant kingdom, with complex biological effects, which are exerted through the interaction with a large spectrum of cellular enzymes and metabolic chains.

- **Physical-chemical properties**

A good quality propolis should contain at least 50-50% resinous maters and balms; wax up to 30%, ethereal oils over 14% and pollen around 5%. An inferior quality propolis can contain up to 70% wax and pollen. It has a much more solid consistency and it is used by bees especially for insulating the beehive.

At the same time, it should be kept in mind that the properties of propolis vary rapidly after extracting it from the beehive. The most rapid variation takes place in the first two-three hours, afterwards developing slowly, however depending significantly on storage conditions, and the beneficial action of propolis disappearing generally after 1-3 years. Also, it noticeable the fact that propolis contains two different types of wax. Mainly, the type A wax is found, which is similar to the actual wax, but in a proportion that varies by 6%. There is also found a type B wax, clearly different, similar to vegetal waxes (they can be separated due to their different solubility in hot concentrated and respectively diluted alcohol) [9].

The specific weight of propolis is usually set between 1.033 and 1.145 kg/m^3, thus showing a very big variation. Propolis is extremely difficult soluble in water, but it is partially soluble in alcohol, ether, acetone, chloroform, propyleenglycol, benzene, dimethyl sulfoxide and ethylenediamine. Depending on the temperature, an important variation is registered both for the speed of dissolution, but also of the separation of different elements in the composition, such as wax, which dissolves in hot alcohol, but it is hard dissolved in cold alcohol. Insoluble remain especially impurities and foreign bodies. Different solubility of the components in propolis, depending on the solvent used, is also used for achieving a quality control for the propolis in its pharmaceutical applications, but also for obtaining different propolis extracts [9].

At 15^{o}C it is hard and friable, and at higher temperatures it becomes soft and sticky [5]. The melting point is situated at 60-70^o C [6].

- **Chemical composition**

Propolis is composed of vegetal resins, balm of different compositions, wax, ethereal oils, iron, microelements – copper, zinc, manganese, cobalt, to which are added pollen, flavonois, secretions from the salivary glands of bees [10], (Bankova V., 2000; Barbarić M., Mišković K., Mirza B., Baus Lončar M., Smolčić-Bubalo A., Željko D. and Medić-Šarić M., 2011).

Chemical composition represents a mixture of substances, mainly: flavonoid derivates, ferulic acid (active against Gram positive and Gram negative germs), waxes, amino acids, balms, ferments, microelements (silica, magnesium, copper, molybdenum, arsenic, tin, aluminium, vanadium, wolfram, iron, gold, iridium, calcium, cadmium, cobalt, strontium), antibiotic substances, resins, aromatic acids, acids [10], (Popescu C.V., 2013).

- **Uses in human medicine**

Modern studies regarding the properties of this natural mixture have astonished scientists: *no less than 21 bacteria, 9 species of parasite fungi, 30 types of viruses (including their varieties) are destroyed by propolis*, which is the strongest anti-infectious medicine known [1], (Popescu C.V., 2013; Banskota A.H., Tezuka Y. and Kadota S., 2001; Burdock G.A., 1998; [19].

Called the most "medicinal" bee product, with over 70 proven pharmacological properties, it has hundred of indications and it has been used therapeutically since ancient times. Due to its antiviral, antibiotic, antitoxic and anti-inflammatory properties, propolis has many uses, covering a very large pallet of affections and diseases. It can be used both externally and internally, being conditioned under numerous forms allowing the two manners of administration (Popescu C.V., 2013; Amoros M., Simoes C.M.O., Girre L., Sauvager F., Cormier M., 1992; Bankova V.S., Popov S.S. and Marekov N.L., 1983; Grange J.M., Davey R.W., 1990; Korel W., Scheller S., Shani J., Pietsz G. and Czuba Z., 1993; Kosalec I., Pepeljnjak S., Bakmaz M. and Vladimir-Knezevic S., 2005; Kujumgiev A., Tsverkova I., Serkedjieva Y. et al., 1999; Mirzoeva O.K., Grishanin R.N., Calder P.C., 1997).

Internally, it can be used as bio stimulator, increasing physical resistance removing fatigue and stress. Propolis cures mouth sores, stomatitis, and it is recommended in the treatment of bleeding gums. Respiratory virus diseases are efficiently fought by propolis, due to its strong antiviral actions. Propolis can also be successfully used for diseases of the digestive apparatus, either viral or infectious, as enteritis, acute or chronic colitis. Also for internal use, propolis helps in case of hypertension or atherosclerosis, helps in all hepatitis and meningitis types and is beneficial for the urinal apparatus, preventing and treating reno-urinal infections [11], (Fresco P., Borges F., Marques M.P.M., Diniz C., 2010; Galvao J., Abreu J.A., Cruz T., Machado G.A.S., Niraldo P., Daugsch A., Moraes C.S., Fort P. and Park Y.K., 2007).

Internally it is also administered in the form of food supplements, which, through their content in flavonoids, have antioxidant, hepatoprotective properties (Robak Y., Grywlewski R.J., 1988; Russo A., R. Longo and A. Vanella, 2002).

At external level it is used in the diseases of the otorhinolaryngology apparatus: tonsillitis, pharyngeal-tonsillitis, laryngitis. A piece of cotton placed on the tip of a baguette is dipped well in propolis tincture. It is applied with the help of this instrument directly on the affected area, the results being immediate [11].

It is excellent in treating open wounds and burns of all types, as well as for infectious eczema or moles and warts, combining equal proportions of propolis tincture with comfrey and celandine tincture. Rebuilds tissue affected by wounds, cuts and especially burns or frostbites and is extremely efficient in cicatrizing with very few visible marks the wounds following surgeries [11].

MATERIAL AND METHOD

a. The gathering of propolis requires a lot of time and sometimes it is a rather difficult action if the beekeeper doesn't know some more efficient methods. The majority of beginner beekeepers collect propolis by scraping it directly off the frames, the little planks on the bottom, the walls of the beehive (this method being a difficult one) [2].

In order to increase the quantity of collected propolis, some resort to leaving a space between the planks (2-3 mm) to favour the production of propolis, placing strips of plastics with 5 mm meshes on the backs of frames and collecting it by scraping after removing the strips, etc. [2].

One of the easiest and effective method of collecting propolis is the one using the plastic net (of the mosquito type, but with larger meshes) covering the entire nest and leaving a space between the back of the frames and the plastic net (the space can be achieved in different manners – a wooden frame, a metal grid, etc.). Over the net is placed a cotton material that is periodically lifted in order to create new spaces for propolis.

After the propolis is produced, the net is lifted and is placed in the freezer in order to be able to extract the propolis. When cold, propolis becomes breakable and through friction, it falls easily from the net. After harvesting, propolis is conditioned by eliminating foreign bodies (bee's residues, wood chips, etc.) [2].

The net for collecting propolis at a 25x0.5 m roll (fig. 2) is specially designed for harvesting propolis from 58 beehives (10R).

Fig. 2 – Net for collecting propolis [3]

The net is built by thermo-welding filaments of elastic polypropylene in 2 planes (fig. 3), thus maintaining a distance that allows it to be filled with propolis by the bees.

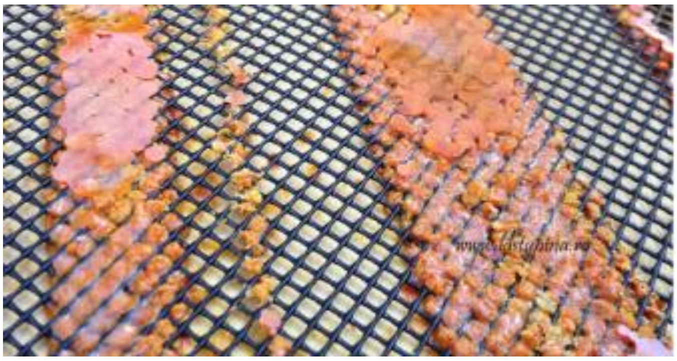

Fig. 3 – **Net for collecting propolis** [7]

The net is cut at 500 x 440 mm size (10R beehive) or 500 x 500 mm (1R beehive) and is placed above the frames beginning with the month of August [3].

The net can be placed directly on the frames or above them, and between the net and the frames, a few sticks or perches can placed, as spacers, to facilitate bee circulation. By the end of September, the empty meshes of the net will be mostly filled with propolis by the bees, a moment when they can be removed from the beehives. To increase the degree of filling, the nets can be rotated at one time, at a 90° angle from the initial position [3].

In order to harvest the propolis from the nets (fig. 4), they are rolled up and placed in the freezer. After 24 h at -20° C, the rolls are taken out and shaken / hit softly. The frozen propolis will be breakable and will easily detach from the respective nets [3].

Fig. 4 – Harvesting propolis from the nets [3]

Oros type collector – formed of a laminated galvanized grillage, plastic net and collecting canvas, which is placed above the nest, instead of the bridge. The net and the collecting cloth remain throughout the year in the bee family. The lamellar grillage is introduced in April, once with the extension of the hive, and is removed in October, when the bee families are prepared for winter. During the honey season, every time the plastic net is loaded on the majority of its surface with propolis, the collecting cloth where the majority of the propolis adheres is detached, replacing it in its initial position. The propolis is harvested from the collected cloth once a year after the cloth was kept for a few days at low temperature (freezer) [6].

The plastic Propolis collector for 10 frames (size 425 mm x 510 mm) is placed under the bridge, and when the bees have filled it, it is rolled and placed in cold storage [8].

Fig. 5 – Plastic propolis collector (for 10 frame beehives) [8]

b. Storage: propolis is kept at temperatures of maximum 20^{o} C, in places with no moist and foreign smells, in the shape of spherical balls, covered in aluminium or plastic bags (fig. 6). It can also be kept in coloured bottles, closed with caps and then sealed with paraffin. It is not recommended to be heated or melted (and neither to be kept at high temperatures) because in that way propolis would lose its very important volatile oils. The best method of storage is in the form of propolis tincture, this way the properties of propolis not being harmed (this being the form in which it is most often consumed) [2].

Fig. 6 –Storing propolis in plastic bags [6]

c. Verifying the physic-chemical quality of the product PROPOLIS is performed in accordance with the provisions of the European Pharmacopoeia, edition in force and of the Romanian Pharmacopoeia, edition X, chapter IX. D.1 [29].

The *aspect* (viscous, sticky consistency, when kneaded leaves traces) and *colour* (brown-tan, darker or lighter, gray-green, with homogenous colour or marbled on sections) are determined organoleptically.

The *smell* (pleasant, characteristic to resins and balms) is determined in accordance with the provisions of the European Pharmacopoeia, edition in force, chapter 2.3.4.

Working technique: on a watch glass with a 6-8 cm diameter are placed fragments of propolis. After 15 minutes is determined the smell or is verified the absence of smell.

Solubility: soluble in ethanol and ether, not soluble in water.

Identification (AL flavonoids, chemical reaction, Positive)

It is performed in accordance with the provisions of the European Pharmacopoeia, edition in force and of the Romanian Pharmacopoeia, edition X, chapter IX. D.1.

Identification A

- Identification through macroscopic analysis

It is performed in accordance with the provisions of the Romanian Pharmacopoeia, edition X, chapter IX. D.1., through macroscopic examination.

Working technique: the propolis is presented in solid state, with aspect of resins of different shape, globular or shavings, depending on the manner of extraction from the beehive.

The colour varies from green, brown and black depending on the botanic source. At room temperature it is soft and can be modelled by hand, and at cold temperatures it becomes breakable.

Identification B

Flavonoids: is performed in accordance with the method developed in the *S.C. Hofigal Export Import S.A.* laboratory, through chemical reaction.

Reagents:

- *Sodium acetate R, 10% solution;*
- *Aluminium chlorate R, 2.5% solution;*
- *Methanol R;*
- *Ethanol R, 50% (v/v);*
- *Test solution*: for 1.0 grams of sample for analysis are added 100 ml of *ethanol R, 50% solution (v/v)* in a ground mouth flask and it is heated until boiling point, on water bath, at reflux, for 30 minutes. The hot solution is filtered through cotton, in a graduated flask and after cooling is readjusted to 100 ml, by washing with the same solvent.

Working technique

In a 25 ml graduated flask are introduced: 5.0 ml *test solution*, 5.0 ml *sodium acetate R 10% solution* and 3.0 ml *aluminium chlorate R, 2.5% solution*. It is filled up to the sign with *methanol R*. A yellow coloration appears, specific to flavonoids.

Foreign matters

Are determined in accordance with the European Pharmacopoeia, edition in force, chapter 2.8.2.

Working technique: 100 grams of *product for analysis* are weighed and scrapped in a thin layer.

Foreign impurities are determined through visual examination or with a magnifier (6x). the foreign mineral elements are separated, weighed and the result in percentages is calculated.

Heavy metals, (Pb)

The quantitative determination of mineral substances and oligoelements (Ca, Mg, Mn, Na, K, Fe, Zn, Cu, Pb, Cd) was carried out through atomic absorption spectrometry combined with MS (mass spectrometry), in accordance with the European Pharmacopoeia, 8th edition, using GBC AVANTA equipment.

The atomic absorption spectrometry, GBC AVANTA, is equipped with:

- cathodic lamps as radiation sources for Ca, Mg, Na/K, Fe, Cu, Zn,Mn, Pb, Cd;
- deuterium lamp, used as a background corrector;
- PC;
- printer

Observation: the laboratory glassware is washed well using nitric acid (R) 10 g/l solution, before using it.

Working conditions:
- acetylene – air flame;
- acetylene flow rate: 1.6 l/min.

Reagents: hydrochloric acid R with no heavy metals, nitric acid R with no heavy metals, standard lead (Pb) solution, 1000 parts per million (ppm), standard cadmium (Cd) solution, 1000 parts per million (ppm), standard calcium (Ca) solution, 1000 parts per million (ppm), standard magnesium (Mg) solution, 1000 parts per million (ppm), standard sodium (Na) solution, 1000 parts per million (ppm), standard potassium (K) solution, 1000 parts per million (ppm), standard iron (Fe) solution, 1000 parts per million (ppm), standard manganese (Mn) solution, 1000 parts per million (ppm), standard zinc (Zn) solution, 1000 parts per million (ppm), standard copper (Cu) solution, 1000 parts per million (ppm).

-reference solution Pb with the following concentrations: 0.2 ppm, 0.5 ppm, 1 ppm, in *nitric acid 0.1 M* prepared from the standard lead solution *(1000ppm); The wavelength at which the reading is performed is: 283.3nm*

- *reference solution* Cd with the following concentrations: 0.2 ppm; 0.4 ppm; 0.6 ppm and 1.0 ppm obtained by diluting the *standard Cd solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 228.8nm*
- *reference solution Mg* with the following concentrations: 1.0 ppm, 2.0 ppm, 3.0 ppm and 4.0 ppm obtained by diluting the *standard magnesium solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 279.5nm*
- *reference solution Ca* with the following concentrations: 1.0 ppm, 2.0 ppm, 3.0 ppm and 4.0 ppm obtained by diluting the *standard Ca solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 422.7nm*
- *reference solution* Na with the following concentrations: 0.4 ppm; 0.6 ppm; 0.8 ppm ; 1.0 ppm and 1.2 ppm obtained by diluting the *standard Na solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 589.6nm*
- *reference solution* K with the following concentrations: 0.4 ppm; 0.6 ppm; 0.8 ppm ; 1.0 ppm and 1.2 ppm obtained by diluting the *standard K solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 766.5nm*
- *reference solution* Mn with the following concentrations: 0.05 ppm; 0.1 ppm; 0.2 ppm ; 0.4 ppm ; 0.6 ppm; 1.0 ppm; 1.5 ppm and 2.0 ppm obtained by diluting the *standard Mn solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 279,5nm*
- *reference solution* Zn with the following concentrations: 0.1ppm; 0.5 ppm; 1.0 ppm; 1.5ppm and 2.0ppm obtained by diluting the *standard Zn solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 213,9nm*
- *reference solution* Cu with the following concentrations: 0.5 ppm; 1.0 ppm, 2.0 ppm; 3.0 ppm,5.0 ppm obtained by diluting the *standard Cu solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 324.7nm*
- *reference solution* Fe with the following concentrations: 1.0 ppm; 2.0 ppm; 3.0 ppm; 4.0 ppm and 5.0 ppm obtained by diluting the *standard Fe solution (1000 ppm)* with *nitric acid 0.1 M* ; *The wavelength at which the reading is performed is: 248.3nm*

Observation: the value of correlation coefficient R, from the calibration curve for each of the element analysed mustn't be inferior to 0.9800.

- *test solution*: ~2.0 g of the product for analysis are weighed in porcelain crucibles and are calcined at a 600-700^{o} C temperature for four hours. After calcining and cooling, in the crucible are added 5 ml mixture of hydrochloric acid R: water R (1:1 ratio), next taking place the dry evaporation, on the asbestos sieve. A quantity of 50 ml of the residue in the crucible is taken into a graduated flask, through three consecutive washes each with 2.5 ml hydrochloric acid R: water R mixture (in a 1:5 ratio). Next, in the crucible are added 5 ml mixture of hydrochloric acid R: water R (1:2 ratio) and again is dried. After drying, the residue is taken through three repeated washes, each with 2.5 ml hydrochloric acid R: water R (ratio 1:5) mixture, collecting fraction in the first graduated flask used for the first wash. the wash is continued using purified water and is completed up to 50 ml with the same solvent.
- *blank solution*: *nitric acid R 1%* solution – *with no heavy metals*

Working technique: the absorbents of the reference solutions and of the test solution are determined. The value of the absorbent of the blank solution is automatically decreased from the value obtained for the test solution. The values obtained for the concentration of each element are registered, expressed in ppm.

Calculus:

The lead content is calculated using the formula:

$$XXX, ppm = \frac{C \times V}{m_p} \times F$$

where:

XXX = the element which is determined

C = the metal concentration registered by the device, ppm

V = the volume of the graduated flask used, ml

m_p = the weight of the sample for analysis, grams

F = dilution factor

Loss by drying

Is determined in accordance with the European Pharmacopoeia, edition in force, chapter 2.2.32.

Working technique: 1.0 grams of sample for analysis is dried in an oven at 105° C ± 2° C for 2 hours. The result is expressed in percentages. The loss by drying is calculated using the following formula:

$$\text{Loss by drying } \% = \frac{m_1 x\ 100}{m_0} \quad \text{where}$$

m_0 = the weight of the sample for analysis, in g;

m_1 = the weight of the sample after drying, in g;

Total ash content

Is determined in accordance with the European Pharmacopoeia, edition in force, chapter 2.4.16.

Working technique:

A porcelain or platinum crucible is heated using incandescence for 30 minutes, is cooled in the dessicator and is weighed. 1.0 gram of the sample for analysis is weighed in the crucible. It is dried at 100°C – 105 °C for an hour and is calcinated until it reaches a constant mass, in a calcining oven at 600° C ± 25 ° C, leaving the crucible to cool down after each calcination. If the residue shows coal particles, a few drops of warm water are added to the crucible, is filtered and the filter with the precipitate is calcinated. The combined filtrates are evaporated with precaution until dry and are calcinated to a constant mass. After cooling in the dessicator, the residue is weighed. The result is expressed in mass percentages.

Assay:

a. Content of total polyphenols expressed in caffeic acid and/ or chlorogenic acid.

Product behaviour in terms of total polyphenols expressed in caffeic acid, % and/or chlorogenic acid, is very important to be determined, as their content is directly proportional with the products drying method, and total polyphenols content (giving the non-enzyme antioxidant features) increases along with drying, controlled by stages.

This test was performed in compliance with the method developed in S.C. HOFIGAL EXPORT IMPORT S.A. laboratory, by spectrophotometry UV - VIS [34].

$$\text{Loss by drying } = \frac{m_0 - m_1}{m_0}[\%] \qquad (1)$$

where:

m_0 = the weight of the sample for analysis, in g;

m_1 = the weight of the sample after drying, in g; is in fact D.M. (dry matter), not the loss (m_0-m_1/m_0).

Reagents: sodium wolframate R; phosphoric acid R; water R; sodium phosphorwolframate solution (Folin Reagent): 10 g sodium wolframate R 10 mL phosphoric acid R and 75 mL water R are heated to reflux, for 2 hours, and after cooling it is completed with water R at 100 mL; sodium carbonate solution R 200 g/L; caffeic acid R/chlorogenic acid R.

Standard solutions: chlorogenic acid solution R 20 µg/mL; chlorogenic acid solution R 30 µg/mL; chlorogenic acid solution R 40 µg/mL; chlorogenic acid solution R 50 µg/mL; chlorogenic acid solution R 60 µg/mL; chlorogenic acid solution R 70 µg/mL; chlorogenic acid solution R 90 µg/mL; ethanol solution R 50% v/v; idem for caffeic.

Analysis sample: product as powder, alcoholic extract and as a powder mixture of different ratios.

Test solution: 10 g of analysis sample are weighed with analytical balance, after which they are brought into a balloon of 150 - 200 mL, 100 mL ethanol R 50 % v/v are added and water bath heated to boiling point, to reflux, during 30 min. The hot solution is filtered through cotton, in a levelled balloon and after cooling is completed up to 100 mL, by cleaning the residue with the same solvent (solution A). 5 mL solution A are brought to 50 mL in a levelled balloon with ethanol R 50 % v/v.

Working technique: At 5.0 mL test solution are added 5 mL sodium phosphor-wolframate solution R, are agitated and filtered; the first 2 mL of filtered solution are removed. 2.5 mL of filtrate are diluted by sodium carbonate solution R 200 g/L at 25 mL, in a graded balloon. The solution absorption is determined at 660 nm, using as compensation liquid a solution prepared of 2.5 mL filtrate and 25 mL water, in a graded balloon. Total polyphenols concentration of sample to be analyzed is calculated by means of a calibrating curve, working with: 1.0; 1.5; 2.0; 2.5; 3.0; 3.5; 4.0; 4.5 mL standard solution of chlorogenic acid or caffeic acid R 0.1 g/L, after that are added 4.0; 3.5; 3.0; 2.5; 2.0; 1.5; 1.0 and 0.5 mL water R and then 5.0 Ml sodium phosphor-wolframate solution R for each unit. From each units obtained, 2.5 mL are taken out and are graded and levelled in a balloon of 25 mL with sodium carbonate R 200 g/L freshly separated. The solution absorption is determined at 660 nm, using as compensation liquid a solution prepared from 2.5 mL out of each sample brought to level with water R in a graded balloon of 25 mL.

b. Determination of total flavonoids expressed in rutin

Is performed in accordance with the CC-MFC 064 method of analysis, edition in force, from the physical-chemical methods file, elaborated after the Romanian Pharmacopoeia, edition in force, taking 1.0 g sample for analysis.

Equipment:

- spectrophotometer UV-VIS

Reagents:

- methanol R;
- methanol R, 50% solution (v/v);
- sodium acetate R, 100 g/l solution;
- aluminium chlorate R, 25 g/l solution;
- rutin (s.r.), 0.01% solution, in methanol R;
- *solution A*: 1.0 sample for analysis is placed in a 150-200 ml ground mouth flask, 100 ml m*ethanol R 50% (v/v) solution* are added and is heated to boiling point, on water bath at reflux, for 30 minutes. The hot solution is filtered in a 100 ml graduated flask and after cooling is refilled to the sign, by washing the residue with the same solvent (solution A);
- *test solution*: 5 ml of *solution A* are placed in 100 ml a graduated flask and the flask is filled to the sign with *methanol R*. the flask is strongly agitated and left to rest for 10 minutes. The solution is filtered, removing the first portions from the clear filtrate and 5 ml are measured in a 25 ml graduated flask. 5 ml *sodium acetate R 100 g/l solutions* are added and 3 ml *aluminium chlorate R, 25 g/l solution*, shaking after each addition of reagent; it is filled to the sign with *methanol R*, and the solution obtained is strongly shaken.
- *compensation solution*: 5 ml of test solution diluted at 25 ml with *methanol R*.

Working technique

The absorbance of the test solution is measured compared to the compensation solution, after 20 minutes in the spectrophotometer at 430nm, in the 1 cm vat. In the event that the extinction of the solution is greater than 0.3, the adequate dilution is performed.

The quantity of flavonoids is calculated in relation with the standard rutin curve, establishing thus: in three 25 ml graduated flask are introduced 1, 2 and 3 ml of rutin (s.r) 0.01 solution in methanol R. in each graduated flask are added 5 ml *sodium acetate R 100 g/l solution* and 3 ml *aluminium chlorate R, 25 g/l solution,* shaking after each addition of reagent*.* The flasks are filled to the sign with *methanol R and* are strongly shaken. The solutions obtained are read with the spectrophotometer at 430nm, in the 1 cm vat, in relation to *methanol R*.

The flavonoid content, expressed in rutin is calculated using the formula:

$$\text{Flavonoid content expressed in rutin \%} = \frac{C \times V_1}{m_p \cdot V_2} \times 10^{-4} \times F$$

where:

C = the concentration read on the calibration curve, in µg/ml;
m_p = mass of the *sample for analysis*, in g;
V_1= volume of the graduated flask used, in mL;
V_2 = volume of *solution A* taken into work, in mL;
F = dilution factor.

RESULTS

The propolis studied from a physical-chemical point has remarked itself by a high degree of purity proven by the very low proportion in foreign matters caused by the manner of preparation and insurance of obtaining and harvesting propolis.

The propolis studied corresponded to all the physical-chemical quality parameters analyzed namely: Description (aspect, colour, smell), Solubility, Identification A: flavanoids (chemical reaction), Foreign matter, loss by drying, total ash, Content in: -total polyphenols expressed in caffeic acid / chlorogenic acid; - total flavonoids expressed in rutin.

Cumulative results are presented in table 1.

Table 1

Physico-chemical characterization of propolis

No.	Characteristics	Admissibility limits	Results
1	Description - aspect - colour - smell	 - compact mass, with inhomogeneous structure, marbled aspect hard, sticky consistency, - brown-tan, with green shades - pleasant, characteristic of resins and balms	 corresponds corresponds corresponds
2	Solubility	soluble in ethanol and ether, not soluble in water	corresponds
3	Identification: A: flavonoids (Chemical reaction)	positive	positive
4	Foreign matter: - fragments of plant tissue from plants buds, hairs from the bodies of bees, mechanical impurities incorporated by the beekeeper during harvesting) % max.	0.1	0.02
5	Heavy metals, (Pb), ppm, max.	5.0	<5, ND (Not Detectable)
6	Loss by drying, % max.	10.0	1.5
7	Total ash content %, max.	3.0	1.67
8	Content of: - total polyphenols expressed in caffeic acid / chlorogenic acid % min - total flavonoids expressed in rutin %, min	 5.0 3.0	 6.8/ 10.14 19.92

Noteworthy are very good results obtained by the presence of total polyphenols and flavonoids, in amounts greater than the minimum limits of admissibility imposed by international pharmacopoeia and specialty literature.

The results of quantitative determinations of natural substances, oligoelements and heavy metals are presented as a recapitulation in Table 2.

Table 2

Propolis- Mineral and oligoelement content

No.	Sample name	Microelement content [mg/100g]									
		Ca	Mg	Na	K	Mn	Fe	Zn	Cu	Pb	Cd
1	Propolis	12.0	15.0	10.0	100	2.5	65	14.0	ND*	ND*	ND*

* = Non Detectable

Conclusions from the tests:
- very good content in minerals necessary for human body;
- the presence of zinc is of major importance in obtaining finished products destined for prostate cancer, but also as non enzymatic antioxidant;
- a very good balance between sodium and potassium;
- due to the fact that that lead and cadmium elements were not found, the conclusion is that the product is qualitative, but especially safe; from the *toxicological point* the plant product does not show any risks, which makes it safe to use it in finished products, medicines or food supplements;
- is a real potential to fructify the curative properties and especially the one of natural mineral source, a study more and more addressed at international level.
- an adequate product destined for human administration should have high quality and safety, imposed by regulations in force and therefore we aimed at the toxicological characterization of the product.

CONCLUSIONS

The propolis studied from a physical-chemical point has remarked itself by a high degree of purity proven by the very low proportion in foreign matters caused by the manner of preparation and assuring the obtaining and harvesting of propolis.

The influence of the propolis harvesting system on its physical-chemical characteristics is determined on one hand by the bee's harvesting manner, by the natural environment where the bees harvest, and on the other hand, on the human factor that takes and further process of the product harvested by bees; the factors influencing the characteristics of propolis are: the following ones bee species (the most important factor), the harvesting period (bees produce more propolis during spring and autumn), the geographic area where they collect (beehive from forest areas produce more propolis), the type of trees where they collect (resinous trees, poplar, alder, cherry, birch, etc.), these influencing the colour, conditions of obtaining and harvesting.

Thus, the propolis studied presented for the parameter foreign matter (fragments of plant tissue from plant buds, hairs from the bodies of bees, mechanical impurities incorporated when being harvested by the beekeeper) of 0.02%, compared to the limit of admissibility of 0.1%.

- The chemical composition of the propolis analyzed highlighted the existence in a very big concentration of flavonoids, that of natural source of minerals, components with very antioxidant properties, liver-protective, but especially with positive results (natural extracts from propolis with a high content of flavonoid type polyphenolic compounds) in the curative-prophylactic treatment of acute and chronic infections of the respiratory paths, of inflammatory infections from the gynaecological sphere and mucocutaneous vesicular eruptions with herpetic etiology.
- The very good content in mineral necessary for the human body, the presence of zinc, which has a great importance in obtaining finished products destined for prostatic cancer, but also a non enzymatic antioxidant, a very good balance between sodium and potassium elements have proved that there is a real potential to fructify the curative properties and especially that of natural source of minerals, aspects more and more addressed internationally.
- An adequate product destined for human administration should have high quality and safety, imposed by regulations in force and therefore we aimed at the toxicological characterization of the product. Due to the fact that lead and cadmium elements were not found, the conclusion is that the product is qualitative, but especially safe; from the *toxicological point* of the plant product, fitted in the beehive product category, does not show any risks, which makes it safe to use it in finished products, medicines or food supplements

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INVESTIGATION OF THE EFFICIENCY OF AN ELECTRONIC SYSTEM FOR CONTROL OF THE MEAL PRETREATMENT TEMPERATURE IN VEGETABLE OIL EXTRACTION INSTALLATION
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ИЗСЛЕДВАНЕ ЕФЕКТИВНОСТТА НА ЕЛЕКТРОННА СИСТЕМА ЗА УПРАВЛЕНИЕ ТЕМПЕРАТУРАТА НА МЛИВОТО В ИНСТАЛАЦИЯ ЗА ИЗВЛИЧАНЕ НА РАСТИТЕЛНИ МАСЛА

Lect. Ph.D. Eng. Kadirova S.Y. *[1)], Prof. Ph.D. Eng. Evstatiev I. B.[1)], Assoc. Prof Ph.D. Eng. Manukova A. V.[1)], Lect. Ph.D. Eng. Kolev Zh. D. [2)], Ph.D. Stud. Eng. Gotsov Ts. A.[1)]

[1)] University of Rousse, Faculty of Electrical Engeneering Electronics and Automation / Bulgaria;
[2)] University of Rousse, Agrarian and Industrial Faculty / Bulgaria;
Tel: 00359 877 089 537; E-mail: skadirova@ecs.uni-ruse.bg

Keywords: *electronic system, temperature, meal, vegetable oil, simulation.*

ABSTRACT

For investigation of the efficiency of the developed electronic system for temperature control of the meal, an experimental study has been implemented. In control points of the technological scheme of the toaster meal, temperatures have been measured, and the obtained results have been compared with simulation data from developed software. The software is based on literature and experimental data. The root-mean-square deviation, absolute error, and relative error of the experimentally obtained temperature data related to the simulation data have been estimated.

РЕЗЮМЕ

За изследване ефективността на разработена електронна система за управление на температурата на мливото са проведени експериментални изследвания. В контролни точки от технологичната схема на пекача са измервани температурите на мливото и получените резултати са сравнени със симулационни данни, от разработен софтуер. Софтуерът е базиран на литературни и експериментални данни. Изчислени са средното квадратично отклонение, абсолютната грешка и относителната грешка на получените експериментални данни за температурата спрямо симулационните данни.

INTRODUCTION

The thermal-moisture treatment is one of the most important operations in the preparation of oilseed material for extraction of vegetable oil. The meal enters the toaster (device with continuous operation) and as it passes through the construction, it is treated by moisture and heat simultaneously for an exact duration of time. Control of main parameters is needed for achieving of product with the correct parameters. This result can be observed by applying of electronic control to the process of the thermal moisture treatment of meal in the toaster (*de Figueiredo et al, 2014; Corzo, O et al, 2008; de Figueiredo, et al, 2013).*

The modern methods for electronic control include development of simulation models, describing the treatment processes based on mathematical relations, representing the dynamics of change of main parameters *(Doehlert, D.C. et al, 2009;* de Figueiredo, A.K.et al, 2011*).*

In the current research the meal temperature should be monitored continuously during the process, because if it rises - the quality of the final product significantly decreases. In another hand if the values are under the critical mentioned in the criteria the amount of the extracted oil significantly decreases.

Fig.1 – Input interface of SIM_MEAL

The research is based on results observed by the developed for this purpose physical-algorithmic model giving the relation between the parameters of the meal and the heating fluid. For simulating the process parameters a specialized program **SIM_MEAL** is developed (fig. 1). The simulated graphics present results for the variation of the meal temperature in each step of passing of meal through the toaster's sections (*Kadirova S., A. Manukova. 2009).*

The aim of the publication is to validate the proposed software model based on experimental data.

MATERIALS AND METHODS

The object of study is a toaster for preliminary thermal-moisture processing of meal in vegetable oil extraction technology. The process is characterized by significant inertia and high energy consumption. This defines the necessity of electronic control based on model, simulating the meal pretreatment process. The use of the electronic system provides preparing of high quality heated meal by reduced energy consumption. The product quality mainly depends on the exact maintenance of process parameters in the given range. The structure of the investigated object is shown in Fig. 2 (*Kadirova S., Manukova A., 2009; Spielmeyer A. et al, 2009; Wijesundera C. et al 2008; Shen Z. et al 2012).*

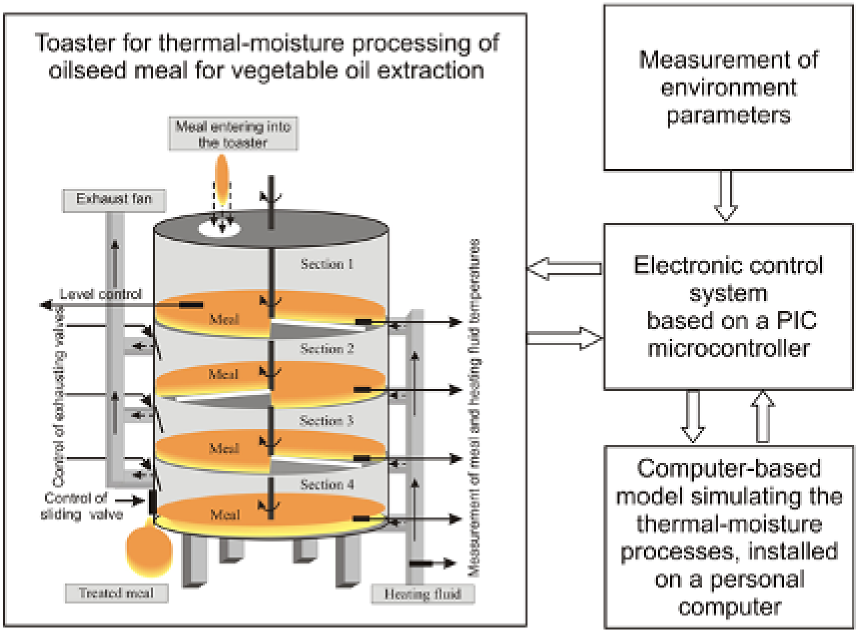


Fig. 2 – Structure of the object of investigation

The important parameters influencing the quality of the treated meal are measured and controlled continuously in time from the microcontroller. They are the temperatures and moistures of the meal in the exit of each section, temperature of incoming and outgoing from the toaster heating fluid, temperature and humidity of the environment, level of meal in the first section of the toaster. Measured data is submitted to the microcontroller and compared with results received from simulation of the process. The alteration of parameters towards the set levels is important for control by the electronic system and for its operating mechanisms respectively.

The temperature of the incoming and outgoing heating fluid, the current meal temperature and moisture in the separate zones, and the speed of meal movement in the toaster are the main control parameters used for control of the meal pretreatment process by the electronic system.

The rate of meal passing through the toaster is maintained by the electronic system as it controls the position of a sliding valve placed at the output of the toaster and thus regulates the flow of discharging of the treated meal. The main parameter influencing the rate and the quality of the extracted oil is the temperature.

RESULTS

For investigating the efficiency of the developed electronic control system some experimental studies are implemented. They are based on the variance of the meal temperature. During the experiment the values of the meal temperatures at the exit of each section have been measured at each 10 minutes because the process has a significant inertness.

The results are presented in tabular and graphic form. In the control points of the technological scheme the current values of the meal temperature of the experimentally obtained results are compared with simulation data from developed software. The software is based on literary and experimental data. The root-mean-square deviation, the absolute error and relative error of experimentally obtained temperature data to simulation data are estimated.

The root-mean-square deviation of the current values of meal temperature at the control points is calculated by the following expression:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{n}}, \text{ [-]} \tag{1}$$

Experimental tests at various temperatures have been conducted and the data is summarized in Tables 1 to 4. In Figures 3 to 7 are presented graphical analogs of change of meal temperature in time. Studies, based on developed software model in MATLAB environment, have been conducted as the results are summarized in Tables 1 to 4 (*Kadirova S., Manukova A., 2009)*.

<u>Comparison of the experimental data with the simulation results at the output of section 1 of the toaster.</u>

Table 1 presents the data for current values of the meal temperature at the output of section 1.

Table 1

Values of the meal temperature at the output of section 1.

Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[ºC]	[ºC]	[-]	[ºC]	[%]	[min]	[ºC]	[ºC]	[-]	[ºC]	[%]
10	47.4	48	0.36	0.6	0.31	110	48.6	49.7	1.21	1.1	0.56
20	46.9	48.6	2.89	1.7	0.89	120	48.4	47.5	0.81	0.9	0.47
30	47.6	45.6	4	2	1.07	130	49.8	46.9	8.41	2.9	1.50
40	49.5	49	0.25	0.5	0.25	140	47.2	48.6	1.96	1.4	0.73
50	47.8	49.3	2.25	1.5	0.77	150	48.3	49.5	1.44	1.2	0.61
60	47.1	49.7	6.76	2.6	1.34	160	48.6	47.8	0.64	0.8	0.41
70	46.2	48.2	4	2	1.06	170	49.5	47.2	5.29	2.3	1.19
80	49.3	47.5	3.24	1.8	0.93	180	47.8	48.9	1.21	1.1	0.57
90	46.4	46.2	0.04	0.2	0.11	190	47.2	46.4	0.64	0.8	0.43
100	49.7	47.3	5.76	2.4	1.24	200	48.9	49.7	0.64	0.8	0.41

The root-mean-square deviation of meal temperature at the output of section 1 of the toaster is $\sigma = 1.61$°C. At the current temperatures the calculated average value of the absolute error is $\varepsilon_{abs} = 1.43$ °C, as the relative is $\varepsilon_{rell} = 0.74\%$.

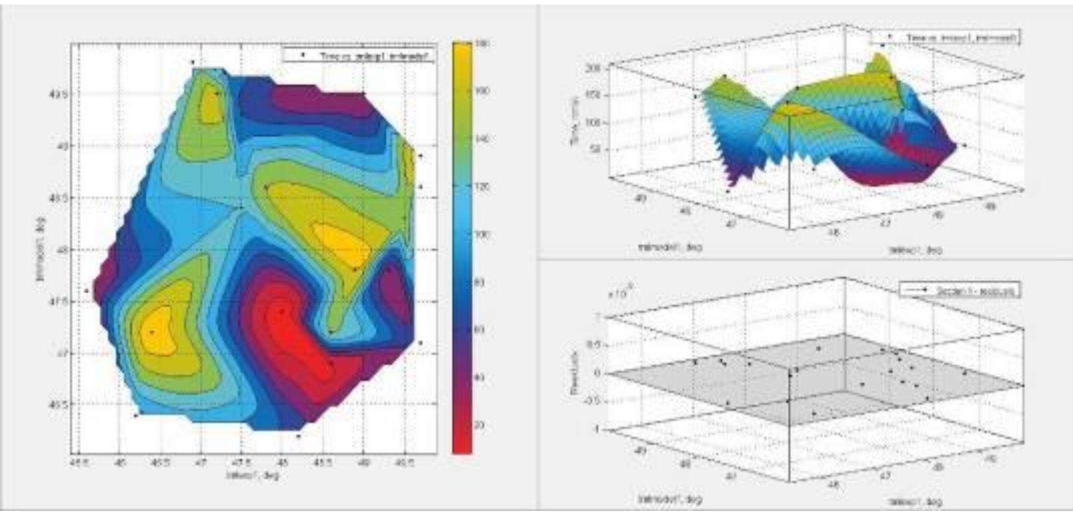


Fig. 3 - Variation of the meal temperature at the output of section 1 in dependence of time

Figure 3 illustrates the change of meal temperature at the output of section 1. The temperature range of the meal is within the field of defined criterial diapason. For section 1 the diapason of change of the meal temperature is $t_{meal\_section\_1\_criteria}$ = (20…50)°C *(Кадирова С., Манукова А., 2009).* The results presented in Fig. 3 are obtained from the simulation model, and the experimental ones are measured in the real toaster.

During the model simulation the variation of temperature values is in the range of $t_{meal\_section\_1\_model}$ = (46.2…49.8)°C , and the experimentally measured in the installation are $t_{meal\_section\_1\_exp}$ = (45.6…49.7)°C. Therefore, the technological requirements for the range of temperature change in section 1 of the toaster are adhered.

› **Comparison of the experimental data with the simulation results at the output of section 2 of the toaster.**

Table 2 presents the values of the meal temperature at the output of section 2.

Table 2

Values of the meal temperature at the output of section 2.

Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[ºC]	[ºC]	[-]	[ºC]	[%]	[min]	[ºC]	[ºC]	[-]	[ºC]	[%]
10	74.2	75	0.64	0.8	1.07	110	73.8	72.5	1.69	1.3	1.78
20	74.8	74	0.64	0.8	1.08	120	73.7	74.2	0.25	0.5	0.68
30	75.5	74.3	1.44	1.2	1.60	130	74.5	73.9	0.36	0.6	0.81
40	73.8	73.9	0.01	0.1	0.14	140	73.8	74.2	0.16	0.4	0.54
50	73.1	73.7	0.36	0.6	0.82	150	73.2	73.8	0.36	0.6	0.82
60	74.6	74.2	0.16	0.4	0.54	160	74.7	74.4	0.09	0.3	0.40
70	73.7	74.8	1.21	1.1	1.48	170	74.3	73.2	1.21	1.1	1.49
80	73	73.9	0.81	0.9	1.23	180	73.8	74.7	0.81	0.9	1.21
90	73.9	74.2	0.09	0.3	0.41	190	74.2	74.9	0.49	0.7	0.94
100	74.6	73.7	0.81	0.9	1.21	200	73.7	73.9	0.04	0.2	0.27

The root-mean-square deviation of meal temperature at the output of section 2 of the toaster is $\sigma = 0.76$. At the current temperatures the calculated average value of the absolute error is $\varepsilon_{abs} = 0.69°C$, as the relative is $\varepsilon_{rel} = 0.93\%$.

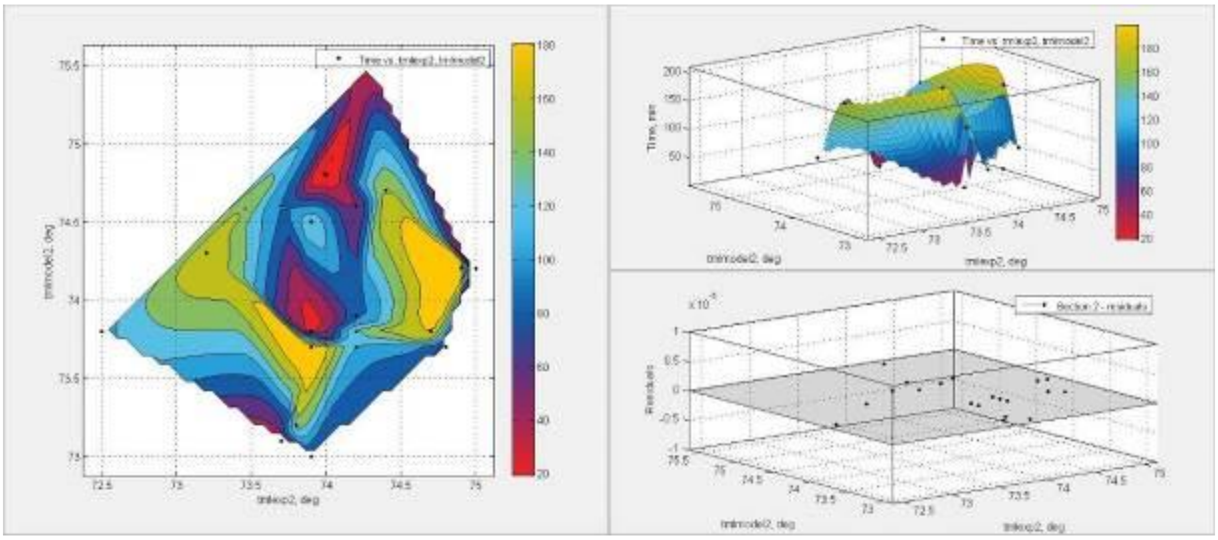


Fig. 4 - Variation of the meal temperature at the output of section 2 in dependence of time

Figure 4 graphically illustrates the change of the meal temperature at the output of section 2. The temperature range of the meal is within the field of defined criterial diapason. For section 2 the diapason of change of the meal temperature is $t_{meal\_section\_1\_criteria}$ = (51…75)°C. *(Кадирова С., Манукова А., 2009).*

During the model simulation the variation of temperature values is in the range of $t_{meal\_section\_1\_model}$ = (73…75.5)°C , and the experimentally measured in the installation are $t_{meal\_section\_1\_exp}$ = (72.5…75)°C. Therefore, the technological requirements for the range of temperature change in section 2 of the toaster are also adhered.

› **Comparison of the experimental data with the simulation results at the output of section 3 of the toaster.**

Table 3

Values of the meal temperature at the output of section 3.

Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[ºC]	[ºC]	[-]	[ºC]	[%]	[min]	[ºC]	[ºC]	[-]	[ºC]	[%]
10	92.5	93.5	1	0.05	0.01	110	92.7	93.8	1.21	1.1	0.29
20	93.8	92.6	1.44	1.2	0.32	120	93.5	92.7	0.64	0.8	0.21
30	92.1	94.4	5.29	2.3	0.62	130	92.7	94.4	2.89	1.7	0.45
40	93.5	93.8	0.09	0.3	0.08	140	94.2	92.8	1.96	1.4	0.37
50	92.1	94.7	6.76	2.6	0.70	150	92.5	93.7	1.44	1.2	0.32
60	94.7	92.3	5.76	2.4	0.64	160	93.7	94.4	0.49	0.7	0.19
70	93.8	93.5	0.09	0.3	0.08	170	94.4	92.8	2.56	1.6	0.43
80	92.9	94.7	3.24	1.8	0.48	180	93.8	94.2	0.16	0.4	0.11
90	94.4	93.5	0.81	0.9	0.24	190	94.2	92.5	2.89	1.7	0.46
100	92.8	94.7	3.61	1.9	0.51	200	94.7	93.7	1	1	0.27

The root-mean-square deviation of meal temperature at the output of section 3 of the toaster is $\sigma = 1.47°C$. At the current temperatures the calculated average value of the absolute error is $\varepsilon_{abs} = 1.27°C$, as the relative is ε_{rel}=0.34%.

Figure 5 illustrates the change of meal temperature at the output of section 3.

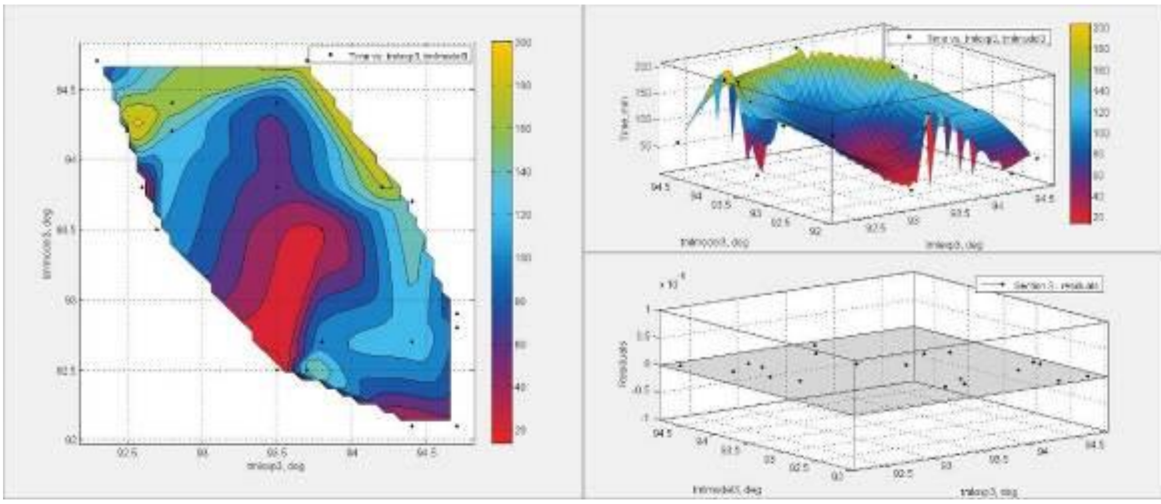


Fig. 5 - Variation of the meal temperature at the output of section 3 in dependence of time

During the model simulation the variation of temperature values is in the range of $t_{meal\_section\_3\_model}$ = (92.1…94.7)°C , and the experimentally measured in the installation are $t_{meal\_section\_3\_exp}$ = (92.3…94.7)°C. For section 3 the diapason of change of the meal temperature is $t_{meal\_section\_3\_criteria}$ = (76…95)° C *(Кадирова С., Манукова А., 2009).* Therefore, the technological requirements for the range of temperature change in section 3 of the toaster are also adhered.

› **Comparison of the experimental data with the simulation results of the heat-treated meal for next technological operation at the exit of the toaster**

Table 4 and figure 6 present the data for the meal temperature of the output of section 4 (the exit of the toaster).

Table 4

Values of the meal temperature at the output of the toaster.

Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error	Time	t_{ml}, model	t_{ml}, exp	Root-mean-square deviation	Absolute error	Relative error
[min]	[ºC]	[ºC]	[-]	[ºC]	[%]	[min]	[ºC]	[ºC]	[-]	[ºC]	[%]
10	109.8	107	7.84	2.8	0.65	110	111.7	110.5	1.44	1.2	0.27
20	106.9	109.1	4.84	2.2	0.51	120	107.7	109.1	1.96	1.4	0.32
30	110.3	107	10.89	3.3	0.76	130	109.8	110.8	1	1	0.23
40	107.4	108	0.36	0.6	0.14	140	106.8	111	17.64	4.2	0.96
50	107.3	106.6	0.49	0.7	0.16	150	111	108.1	8.41	2.9	0.66
60	111.2	107.2	16	4	0.92	160	108.1	110	3.61	1.9	0.44
70	110.4	110	0.16	0.4	0.09	170	107.2	108.3	1.21	1.1	0.26
80	108	108.9	0.81	0.9	0.21	180	107.7	110.4	7.29	2.7	0.62
90	111	110.6	0.16	0.4	0.09	190	107.9	108.2	0.09	0.3	0.07
100	111.7	108.8	8.41	2.9	0.66	200	108.3	111.3	9	3	0.68

The root-mean-square deviation of meal temperature at the output of section 4 of the toaster is $\sigma = 2.25^{o}C$. At the current temperatures the calculated average value of the absolute error is $\varepsilon_{abs} = 1.9°C$, as the relative is $\varepsilon = 0.43\%$.

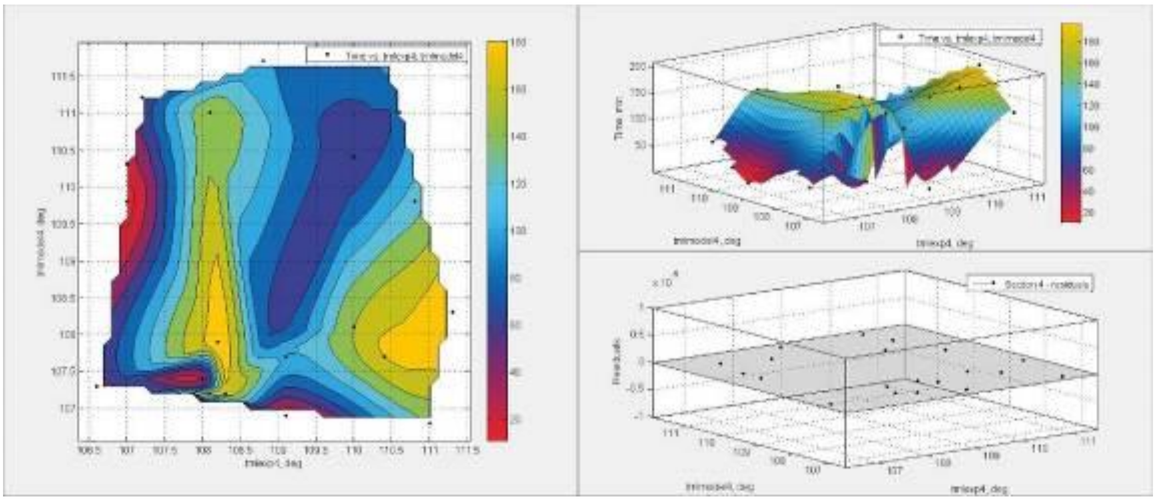
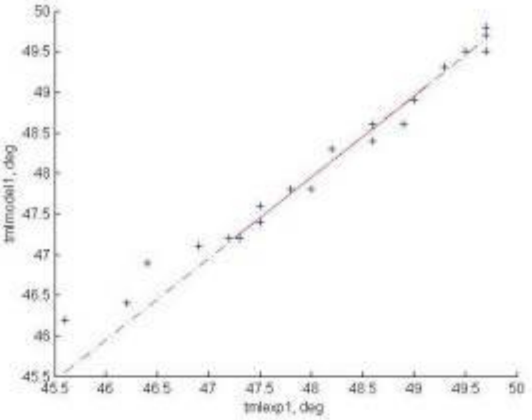


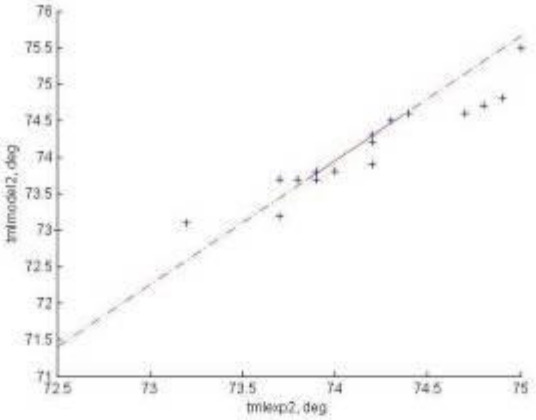
Fig. 6 - Variation of the meal temperature at the output of the toaster in dependence of time

For adherence to specifications of the process of pretreatment of oilseeds for vegetable oil extraction the temperature of the meal must be in the range of 96 ... 115°C *(Кадирова С., Манукова А., 2009).* From the presented results in Fig. 6 it can be seen that the value of the temperature of the heat-treated meal varies within this range. There is no overheating of the material, and the requirement for minimal temperature is also observed.

The graphical interpretation of the evaluation of the adequacy of the software model is presented in Fig. 7. The comparative assessment of function $t_{ml-model} = f(t_{ml-exp})$ shows a linear distribution of results which provides a high accuracy of the effectiveness of the model. The deviation of the values of the model to experimental data can be read from Figures 3 to 6, where dependence is presented in time, and the character of the results‘ surface is flat.



Section 1



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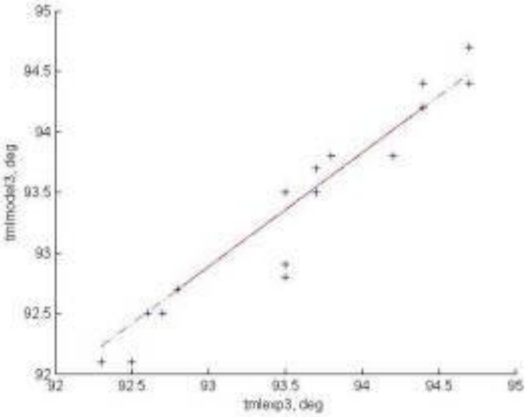
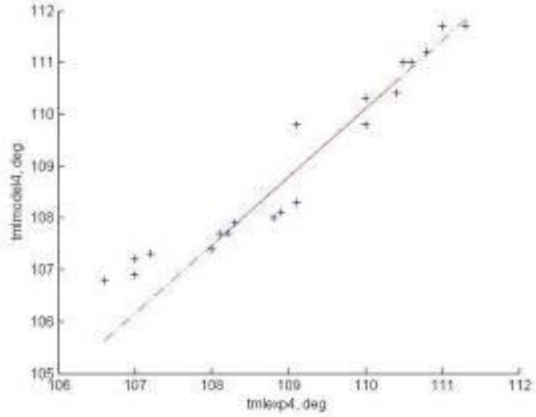


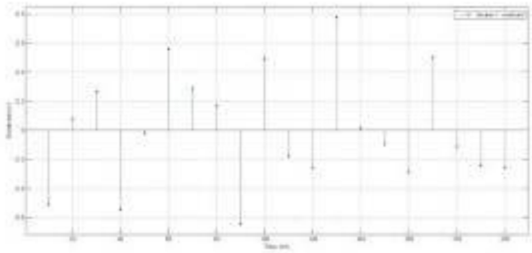
Section 3



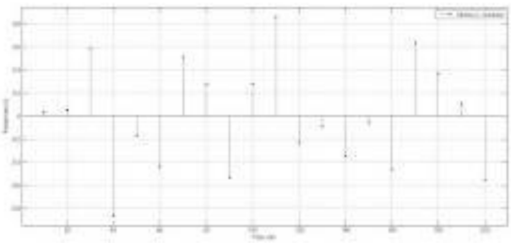
Section 4

Fig. 7 - Variation of the meal temperature at the output of sections – model vs. experiment

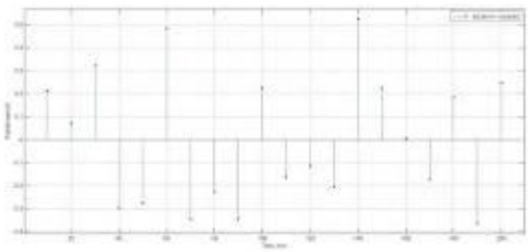
Fig. 8 presents a generalized graph of relative errors of the temperature values at the outputs of each section of the toaster.



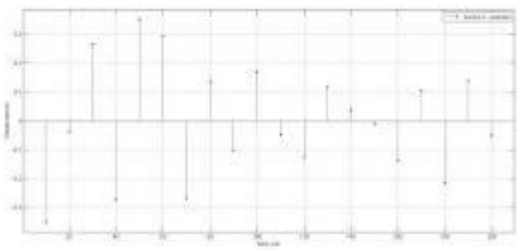
Section 1



Section 2



Section 3



Section 4

Fig. 8 - Variation of relative errors of the temperature values at the outputs of sections

From the presented graph (fig.8) can be seen that the value of the relative error in the first two sections of the toaster is higher than in the third and fourth section. The value of the maximum error for the whole process of thermal-moisture treatment of the meal is approximately 1.5%, which is less than the permissible value of 2%.

CONCLUSIONS

The investigations evaluate the object conditions in meal pretreatment technology. Simulation of the model by different conditions using the developed software allows choosing the best control conditions by the operator. Information obtained allows doing correct analysis of time and resources.

The received simulation and experimental data gives the dynamics of change of the meal temperature in real time.

The efficiency of the models at different levels of controllable parameters in time is evaluated and proven. The investigation is based on comparing of simulation and experimental results' relative errors. The value of the maximum error for the whole process of thermal-moisture treatment of the meal is approximately 1.5%, which is less than the permissible value of 2%.

The results observed from the theoretical and experimental research, the developed mathematical model, methods, graphics and computer program provide the ability to control the process as save time and money.

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REAL TIME STUBBLE COVER RATIO DETERMINATION BY USING AN AUTONOMOUS ROBOT
/
OTONOM ROBOT KULLANILARAK ANLIK ANIZ KAPLAMA ORANININ BELİRLENMESİ

İlker Ünal*[1)], Mehmet Topakcı[2)], Murad Çanakcı[2)], Davut Karayel[2)], Önder Kabaş[1)]
[1)]Technical Science Vocational School, Akdeniz University, 07070, Antalya, Turkey
[2)]Departments of Agricultural Machinery and Technologies Engineering, Faculty of Agriculture, Akdeniz University, 07070, Antalya, Turkey
E-mail: ilkerunal@akdeniz.edu.tr

Keywords: *stubble cover; tillage systems; image processing; autonomous robot*

ABSTRACT

Stubble cover is one of the most important field parameters to protect the soils. Also, it is a decisive criterion for conventional, no-till and reduced tillage systems. In this study, the stubble cover ratio on the field under three different tillage systems was determined and mapped using the online image processing method. The developed system includes the GPS guided autonomous robot, digital camera, and the image processing software. To determine the stubble cover ratio, binary images which were converted from colored stubble images were evaluated by developed software. Also, line transect method was used to make comparison with image processing algorithm. As a result, average stubble cover ratios were calculated as 5.42%, 35.68% and 89.55% respectively for three tillage systems after image processing method. There were no statistical difference between the image processing and line transects method for stubble cover ratios of each tillage systems (P>0.05).

GİRİŞ

Anız kalıntısı, toprakların korunmasında en önemli tarla parametrelerinden biridir. Ayrıca, geleneksel, azaltılmış ve toprak işlemesiz tarım sistemleri için belirleyici bir parametredir. Bu çalışmada, üç farklı toprak işleme yöntemi kullanılarak tarla yüzeyindeki anız kaplama oranı anlık görüntü işleme yöntemi ile belirlenmiş ve haritalandırılmıştır. Geliştirilen sistem, GPS yönlendirmeli otonom robot, dijital fotoğraf makinası ve görüntü işleme yazılımından oluşmaktadır. Anız kaplama oranını belirlemek için geliştirilen görüntü işleme yöntemi ile renkli resimden binary formata çevrilerek değerlendirilmiştir. Ayrıca, kesişen hat yöntemi kullanılarak görüntü işleme algoritmasının etkinliği karşılaştırılmıştır. Sonuç olarak, üç farklı toprak işleme yöntemi için ortalama anız kaplama oranları sırasıyla %5.42, %35.68 ve %89.55 olarak hesaplanmıştır. Her bir toprak işleme yöntemi için kesişen hat yöntemi ile görüntü işleme yöntemiyle belirlenen anız kaplama oranlarının istatistiksel olarak farklı olmadığı belirlenmiştir (P>0.05).

INTRODUCTION

Stubble, traditionally considered as “trash” or agricultural waste, is increasingly being viewed as a valuable resource. Corn stalks, corn cobs, wheat straw, paddy straw and other leftovers from grain production are now being viewed as a resource with economic value (Bahadur, 2015). Stubble is one of the most important tillage factors for improving soil’s physical and chemical properties (Busari, 2015). Stubble helps reduce surface runoff and soil loss (Dickey et al., 1985), conserving soil moisture and improving soil microorganism populations (Peigne et al., 2007), soil organic matter content (Brady & Weil, 2002), and soil hydraulic/physical properties (Agostini, 2012). The effectiveness of stubble is linked to the soil topography and soil slope (Bricchi, 2004), as well as other factors that affect the sustainability of the stubble on the soil surface. Relatively flat fields can be protected against water erosion with 12 to 20 percent stubble cover (Dickey et al., 1985).

Tillage has been an integral component of crop production systems since the beginning of agriculture. The process of tilling or preparing the soil was greatly refined with the invention of the first plow by the Chinese in the sixth century B.C., and since then, various types of tillage equipment and systems have been developed for seedbed preparation and cultivation (Mitchell et al., 2009). Tillage is normally classified as primary or secondary tillage. Primary tillage is deep tillage (> 15 cm) that loosens and fractures soil for weed control and incorporation of stubble, fertilizer, lime, and manure. Secondary tillage (< 15 cm) kills weeds, cuts and covers stubble, incorporates herbicides, and prepares a seedbed. In-crop tillage for weed control or injecting fertilizer or manure it is considered tertiary tillage. Also, tillage systems included under stubble management are no-till, ridge-till, mulch-till, and reduced-till. In this study, the stubble cover ratio on the field under conventional, no-till and reduced tillage systems was determined. Conventional tillage is a multiple tillage pass system that disturbs 100% of the soil surface (full width), including moldboard plowing, that leaves less than 15% stubble on the soil surface after planting. Reduced tillage is a full width tillage system that leaves 15 to 30% stubble cover after one to three tillage passes. No-till is a system with a minimal amount of soil disturbance (> 70% stubble cover) with a row cleaner, coulter, seed opener, or another planter attachment to help establish a good crop stand.

The evaluation of the stubble covering rate and its spatial distribution are important to the scientists who are involved in erosion modelling and surface water flow and to authorities aiming to adopt new legal regulations regarding stubble conservation on arable lands (Arsenault & Bonn, 2005). Several procedures for determining and mapping stubbles exist in the literature, namely visual estimation (McNairn & Protz, 1993), line transect (Morrison et al., 1993), point intercept (Daughtry et al.,1995), meter stick (Hartwig & Laflen, 1978), spiked wheel (Morrison et al., 1995), photographic techniques (Morrison & Chichester, 1991), spectral detection (McMurtrey et al., 2005) and the remote sensing (Bannari et al., 2006). In fact, methods employed to date can be grouped in traditional manual-visual methods and image analysis methods. Ideal method to estimate percent ground cover of stubble mainly includes following procedures: 1. Cheap and easily manipulated equipment should be adopted. 2. The in-situ data should be accurately and objectively treated. 3. The method should save time mostly and be restricted the least when measuring in field. 4. The process should be scarcely disrupted by the operator. The method to take pictures of stubble by digital camera, divides the image to soil and residuals two classes, and calculates percent ground cover of stubble in two-value image arithmetic could be a good choice among other methods. (Zhou & Robson, 2001). Several image processing methods in the literature have been described to estimate stubble cover ratio.

Riberio et al. (2011) proposed the application of genetic algorithms employed during the fine tuning of the segmentation process of a digital image with the aim of automatically quantifying the stubble coverage. The RGB images were used come from a sample of images in which sections of terrain were photographed with a conventional camera positioned in zenith orientation at top of a tripod. The images were taken outdoors under uncontrolled lighting conditions. Researchers reported that up to 92% similarity was achieved between the images obtained by the segmentation process proposed in their paper and the templates made by an elaborate manual tracing process.

Pforte & Hansel (2010) developed the prototype of an online-capable camera sensor for measuring percent stubble cover, appropriate image acquisition equipment and exposure conditions were investigated and different image processing algorithms for segmenting images into stubble and soil were written with the help of commercial software. In study, the camera was mounted onto an all-terrain vehicle (ATV) and the stubble cover of three test fields was analyzed. A large number of observations were obtained using an online camera sensor, and was made evaluation of its correct functioning by means of visual standard methods for estimating stubble cover questionable. Researchers reported that the Pearson correlation between the two measurement approaches was 0.967 for the cover rate observations taken on the three fields.

Jimenez et al. (2013) developed a methodology for estimating the quality of soil coverage by pruning stubble by determining the soil cover percentage, distribution and size of the pruning stubble in olive orchards by image analysis using the threshold segmentation tool in RGB and the block analysis tool. Researchers reported that the percentage of soil coverage after chopping was 39% higher in the high quantity pruning stubble treatment (2.04 kg m^{-2}) but was not significantly influenced by the chopping speed (2.4 to 3.1 km h^{-1}).

The objective of this study was to determine and map the stubble cover ratio of the fields under conventional, no-till and reduced tillage systems using the online image processing method.

MATERIAL AND METHOD

Design of the system

The main aim of the designed system is to determine the real time stubble cover ratio and map it. The system involves three main components:

a. Autonomous robot: a remote-controlled and GPS-guided autonomous robot which can be controlled via the 3G internet and is suitable for image processing applications was used to take pictures of stubble.

b. Data acquisition system: the system is used to collect and process the data from a GPS receiver and the camera for determining stubble cover ratio and mapping operations.

c. Image processing algorithm: the system is used to convert to grayscale images and thereafter convert to binary images from colored stubble images. Finally, the stubble cover ratios were calculated by evaluating the binary images with this system.

Autonomous robot

Autonomous robot is able to steer point to point both autonomously and under manual control (Figure 1). It was developed in our previous study (Ünal & Topakci, 2015). The robot chassis was made of U-steel profile, and the body structure covered with sheet metal with a thickness of 2 mm. The robot was powered by two 24 V – 0.5 kW – 1440 rpm DC motors. Two reducers with 1:30 transmission rate were used to reduce rpm and increase torque. Four 4.00x8 agricultural rubber wheels were chosen to operate in open field conditions. A Roboteq AX3500 (Roboteq Inc., Arizona, USA) motor controller with two channel outputs was used to power and steer the robot by varying the speed and direction of the motors at each side of the chassis. The controller's two channels can be operated independently or combined to set the forward/reverse direction and steering of a robot by coordinating the motion on each side.

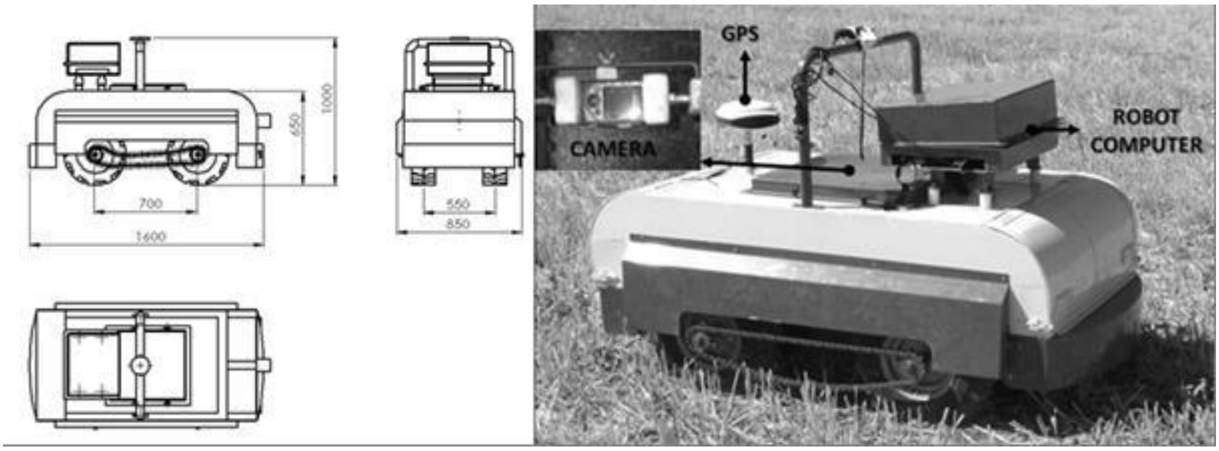

Fig. 1 - Remote controlled and GPS guided autonomous robot

A Promark 500 GPS (Magellan Co., Santa Clara, CA, USA) receiver was used to navigate the robot. Two software based on client/server architecture were developed to control and monitor the mobile robot. The server software was run on the robot computer to collect GPS data to perform steering and to collect stubble images by the digital camera. The client software was run on the remote computer to manually control the robot and monitor the process data. In the server software, the image-processing algorithm was coded for determination of stubble cover. All functions of the digital camera could be controlled by both the server software and the client software. The stubble images obtained by the server software were recorded to the robot computer.

Data acquisition system

GPS receiver was used to transfer data such as geographic coordinate, working speed, etc. on a robot computer. Promark 500 GPS receiver owned by Magellan Co. was used in the study. The receiver has 75 channels and up to 20 Hz data output rate. It is the most flexible GNSS surveying system available, offering multiple operating modes, configurations and communication modules (UHF, GSM/GPRS, EDGE) and protocols. It can connect to CORSE-TR (Continuously Operating Reference Stations - Turkey) via phone data card (SIM Card) for receiving correction signals (Figure 2).

Latitude and longitude data received from a GPS receiver in the NMEA-0183 format are in units of ddmm.mmmm, where dd equals degrees, mm equals minutes, and .mmmm is decimal minutes. For many purposes, position information in this format is more than adequate. However, when plotting position information on maps or carrying out supplemental calculations using the position coordinates, it can be advantageous to work instead with the corresponding grid coordinates on a particular map projection. One of the most widely used map projection and grid systems is the Universal Transverse Mercator (UTM) system (Topakci et al., 2010).

Fig. 2 - Promark 500 GPS receiver

For this reason, data received from GPS receiver was converted to UTM format, and stored to the database by the server software. GPS data must be transferred on the maps to better analyze in the office. Many GPS manufacturers have developed different software packages to create GPS data files for mapping software such as ArcGIS, Surfer, etc. However, these GPS data files are unsuitable for special purpose application software. So, integration of these files into the special purpose software is very difficult. Generally, database files such as .mdb, .dbf, .mdf etc. can be integrated to mapping software. In addition, excel files (.XLS), tab delimited text files (.CVS), comma separated text files (.TXT) can be integrated to mapping software. Developed server software for the study can collect GPS data and create suitable GPS data files for mapping software. In this study, obtained stubble cover data was mapped by using ArcGIS 9.3 software.

Canon PowerShot SX100 IS (Canon Inc., Tokyo, Japan) digital camera was used to take pictures of the stubble. The SX100 IS is designed with 8.0MP sensor, a 10x zoom, optical image stabilization and a comprehensive range of manual photographic controls.The digital camera mounted in sealed box on the autonomous robot. The base area of the sealed box was 45x50 cm. The digital camera is placed at a height of about 60 cm above the soil surface (Figure 3).

Fig. 3 - Digital camera mounted in sealed box on the autonomous robot

Therefore a box was constructed to completely prevent the camera’s field of view from being directly changed by outdoor illumination conditions in order to meet the required minimum image uniformity. All functions of the digital camera can be controlled by the developed server software. The stubble images obtained by the server software were transferred to the client software. During the study, the obtained data was stored into the SQL Server 2005 database.

Image processing algorithm

The image processing software was developed in VB.NET 2005. We used two-value arithmetic images to determine stubble cover ratio (Figure 4).

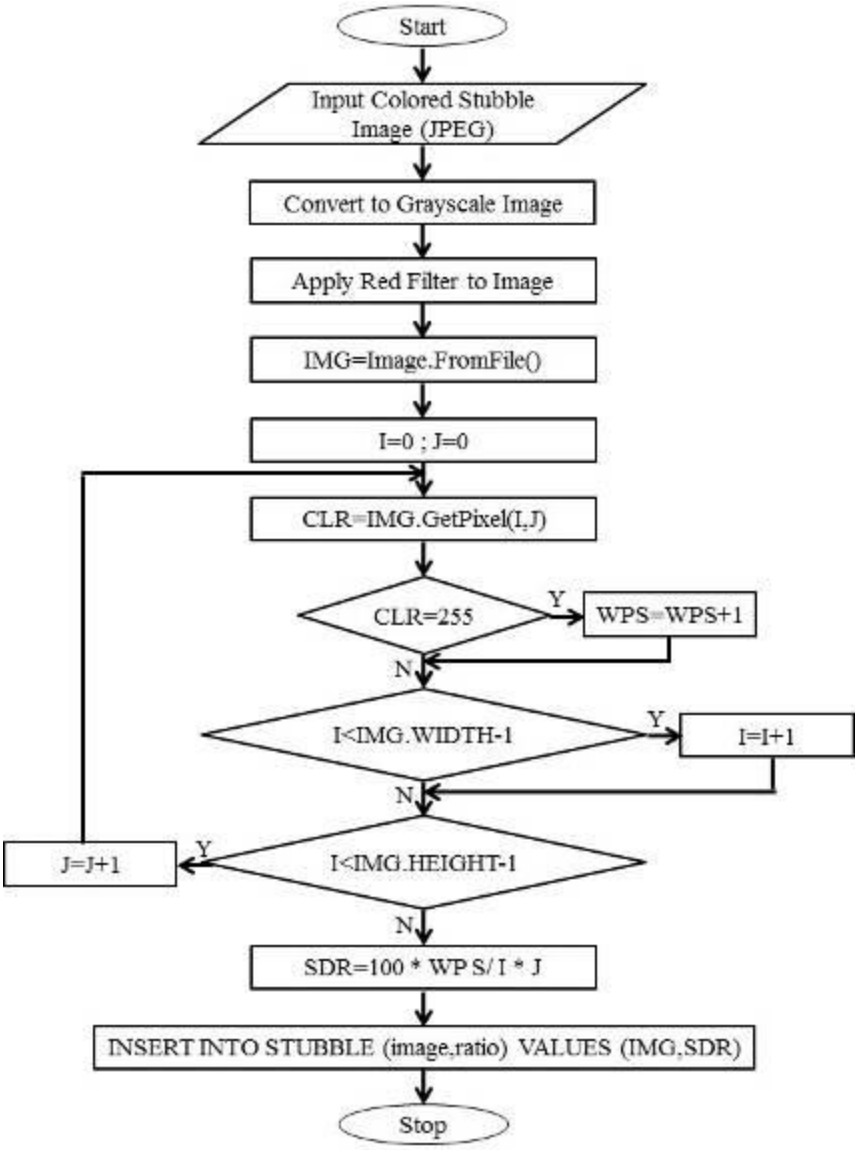

Fig. 4 - Flowchart of image processing algorithm

Firstly, the colored stubble images were collected in JPEG format with an image size of 2,592 by 1,944 pixels. The field images were taken with only camera flash inside robot sealed box. Each image sampled a surface of 0.225 m^2. Secondly, the colored stubble images have been converted to grayscale images to create a monochromatic image as is regularly done in digital image processing. The red filter was used to perform segmentation of the various components (stubble, vegetation, and soil) because this approach allows for the best visualization of the stubble and separation of the plant coverings and soil. Thirdly, grayscale images with red filter calibration converted to binary images by the software and the binary histograms of the stubble images were obtained. Finally, the stubble cover ratios were calculated by evaluating the binary histograms. In the resulting binary image, stubble appeared white and soil appeared black. White pixels inside binary image were counted to determine number of white pixel (WPS) for each image. The stubble cover ratio (SCR) in each image was determined using Equation 1.

$$SCR(\%) = \frac{100 * WPS}{Image\ Resolution\ (2592 * 1944)} \tag{1}$$

In addition to image analysis, stubble cover ratio was also estimated using the line transect method. In line transect method; count the number of times a marked line intersects with a piece of stubble. Use a 50 to 100 cm tape measure (or a rope with marks spaced at 1cm intervals). Stretch the tape (or rope) between two stakes placed diagonally (at a 45 degree angle) of the stubble rows. Looking directly from above the tape (vertically), count the number of times where a "foot" mark intersects with stubble. Make consistent judgments use only the left or right side of the foot mark on the tape (or rope) to avoid over counting stubble. The resulting count converts directly into the percentage of stubble remaining in that sample area. (Example: 47 occurrences of intersection equal 47 percent stubble remaining). In this study, we used steel rule at a 45 degree angle mounted inside 45 x 50 cm rectangle frame (Figure 5).

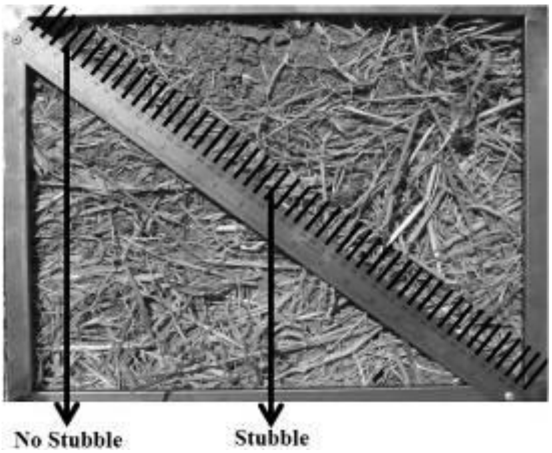

Fig. 5 - Stubble cover ratio determinations with line transect method

Experimental field

Fig. 6 - Experimantal field

The field experiments were carried out in the agricultural experiment field of Batı Akdeniz Agricultural Research Institute, in Aksu, Antalya, located in the West Mediterranean region of Turkey. The research area is located approximately 15 km from Antalya between the coordinates of 36^{o} 56' 34.46" N and 30^{o} 53' 04.10" E. Experimental field has an area of 12 ha with corn silage was planted in June 2012. The crop was harvested with a combine harvester in September 2012. Experimental field was divided to three equal parcels (Figure 6). The treatments included three tillage methods including conventional, no-till and reduced tillage. The stubble images were taken from 24 different spots of the each parcel by the autonomous robot.

Data collection

The digital map of the studied field was transferred into the ArcGIS 9.3. In this way, the GPS waypoint file for the autonomous robot was prepared in the office environment. A total 72 different waypoints were selected by the help of ArcGIS 9.3 software. We selected 24 different waypoints for each parcel. For each parcel, autonomous robot was steered to take colored stubble images and calculated stubble cover ratio for each point. All collected and calculated data was stored into the SQL Server 2005 database by the server software. Also, we collected stubble cover ratio using line transect method for each point to make a comparison between image processing and line transect methods.

RESULTS

During the experiment within the 12 ha field, geographical coordination and progress values for 72 waypoints (24 waypoints for each parcel) stubble cover ratios were collected. All collected and calculated data was stored into the SQL Server 2005 database. Stubble cover ratios for conventional tillage, reduced tillage and no-tillage parcels were presented in Tables 1, 2 and 3 respectively.

Table 1

Stubble cover ratio for conventional tillage

CONVENTIONAL				
ID	**UTMX (m)**	**UTMY (m)**	**Image Processing Stubble Ratio (%)**	**Line Transect Stubble Ratio (%)**
1	311587.43958575	4090445.59745670	9.45	8.00
2	311588.78989651	4090466.28897305	9.58	9.00
3	311592.64633438	4090492.84526968	0.58	1.00
4	311598.22981597	4090523.61852750	5.59	4.00
5	311605.18190164	4090555.84150662	4.63	6.00
6	311608.71679931	4090581.29486803	5.55	6.00
7	311616.77688887	4090623.29896298	6.62	5.00
8	311622.10033766	4090655.74312695	4.00	5.00
9	311626.48332920	4090692.64849608	6.23	6.00
10	311632.67605257	4090730.80878132	1.60	3.00
11	311637.75658769	4090759.00303756	4.69	4.00
12	311641.56766760	4090783.52521124	3.91	4.00
13	311654.44240964	4090788.23474503	1.28	2.00
14	311649.71556592	4090769.28330038	9.13	8.00
15	311642.42931725	4090742.06307526	2.75	4.00
16	311634.26270448	4090695.25097860	7.89	8.00
17	311629.42972347	4090664.83106732	6.67	8.00
18	311623.13779633	4090628.89314825	9.05	8.00
19	311616.29664186	4090601.66305724	6.70	7.00
20	311611.91555022	4090544.77620442	9.19	9.00
21	311604.46960952	4090503.68354406	3.11	2.00
22	311597.86360042	4090473.67304183	0.08	1.00
23	311593.84297772	4090439.71985438	3.71	3.00
24	311590.12956374	4090426.29633272	8.16	8.00
		Average	**5.42**	**5.38**
		Standard Mean	**2.935**	**2.568**

Table 2

Stubble cover ratio for reduced tillage

REDUCED				
ID	**UTMX (m)**	**UTMY (m)**	**Image Processing Stubble Ratio (%)**	**Line Transect Stubble Ratio (%)**
1	311599.62394921	4090432.56098397	33.13	35.00
2	311611.94197124	4090485.75634827	31.66	36.00
3	311619.40085796	4090520.74328382	37.68	34.00
4	311623.10810539	4090553.96338338	31.09	30.00
5	311628.91031377	4090581.21654480	39.87	41.00
6	311636.29043073	4090619.35046769	33.62	35.00
7	311643.38529764	4090664.70625012	35.47	38.00
8	311651.64008151	4090695.42022959	33.09	32.00

9	311657.91409236	4090743.93947172	39.80	40.00
10	311660.30727557	4090764.79285868	37.01	39.00
11	311664.26328097	4090782.46632565	37.33	36.00
12	311668.19601231	4090785.70926579	32.06	30.00
13	311662.11427351	4090752.54186120	32.33	30.00
14	311656.67542097	4090721.58034896	39.82	42.00
15	311653.65161267	4090699.07584227	39.90	39.00
16	311649.61758387	4090677.88885678	31.75	34.00
17	311646.70523433	4090653.71675734	31.82	33.00
18	311645.58966239	4090636.90530548	39.11	41.00
19	311640.85110191	4090610.73860264	38.03	40.00
20	311638.07550043	4090579.34794868	38.20	39.00
21	311631.53188012	4090545.45076159	37.62	36.00
22	311627.91085510	4090516.11402699	31.08	30.00
23	311623.25562308	4090480.32478714	34.81	38.00
24	311619.86851100	4090461.52862382	39.93	41.00
		Average	**35.68**	**36.21**
		Standard Mean	**3.328**	**3.934**

Table 3

Stubble cover ratio for no-till tillage

NO-TILL				
ID	**UTMX (m)**	**UTMY (m)**	**Image Processing Stubble Ratio (%)**	**Line Transect Stubble Ratio (%)**
1	311663.28041258	4090637.80768411	86.49	90.00
2	311669.63644382	4090690.02537524	91.78	90.00
3	311681.27254985	4090752.67163190	88.49	85.00
4	311667.74805646	4090651.76952780	92.79	95.00
5	311658.66776451	4090590.54665800	92.66	98.00
6	311654.70758780	4090572.68827240	92.94	91.00
7	311647.52451880	4090543.43060534	87.38	85.00
8	311623.67751137	4090425.73648267	87.25	86.00
9	311629.21299955	4090440.96969810	86.99	90.00
10	311639.75317765	4090501.05005475	91.80	90.00
11	311666.72077450	4090618.85995489	94.19	93.00
12	311677.26530431	4090712.61267984	87.24	90.00
13	311691.59607884	4090789.63017615	86.55	90.00
14	311696.22715629	4090777.50151976	94.48	98.00
15	311687.25241386	4090734.40759287	88.27	91.00
16	311681.14951623	4090706.97606332	86.79	85.00
17	311676.78999553	4090684.50120029	87.27	91.00
18	311676.35023050	4090671.37501384	94.36	93.00
19	311674.60410537	4090652.91243737	89.55	93.00
20	311670.13306282	4090632.10517250	88.75	85.00
21	311658.92221860	4090561.86394189	85.62	90.00
22	311650.68857623	4090525.41407316	93.98	90.00
23	311639.31608746	4090461.28189057	85.36	88.00
24	311634.63559014	4090431.04360955	88.16	89.00
		Average	**89.55**	**90.25**
		Standard Mean	**3.105**	**3.627**

No faults were detected either in the mechanical or software parts of the system during operation. The obtained data was stored in a format adaptable to the mapping software in the Microsoft SQL Server 2005 database. The database was transformed into the ArcGIS 9.3 mapping software. For the creation of the stubble cover ratio map, ordinary kriging interpolation was applied. Figure 7 illustrates image processing based stubble cover ratio map for each parcel in the experimental field.

As a result, average stubble cover ratios for conventional, reduced and no tillage parcels were 5.42% (±8.615), 35.68% (±11.077) and 89.55% (±9.641), respectively after image processing method. In line transect method, average stubble cover ratios for conventional, reduced and no tillage parcels were 5.38% (±6.592), 36.21% (±15.476) and 90.25% (±13.152), respectively. Data were subjected to statistical analysis using the t- test for each tillage system. There were no statistical difference between the image processing and line transects method for stubble cover ratio of each tillage system ($P>0.05$) (Table 4).

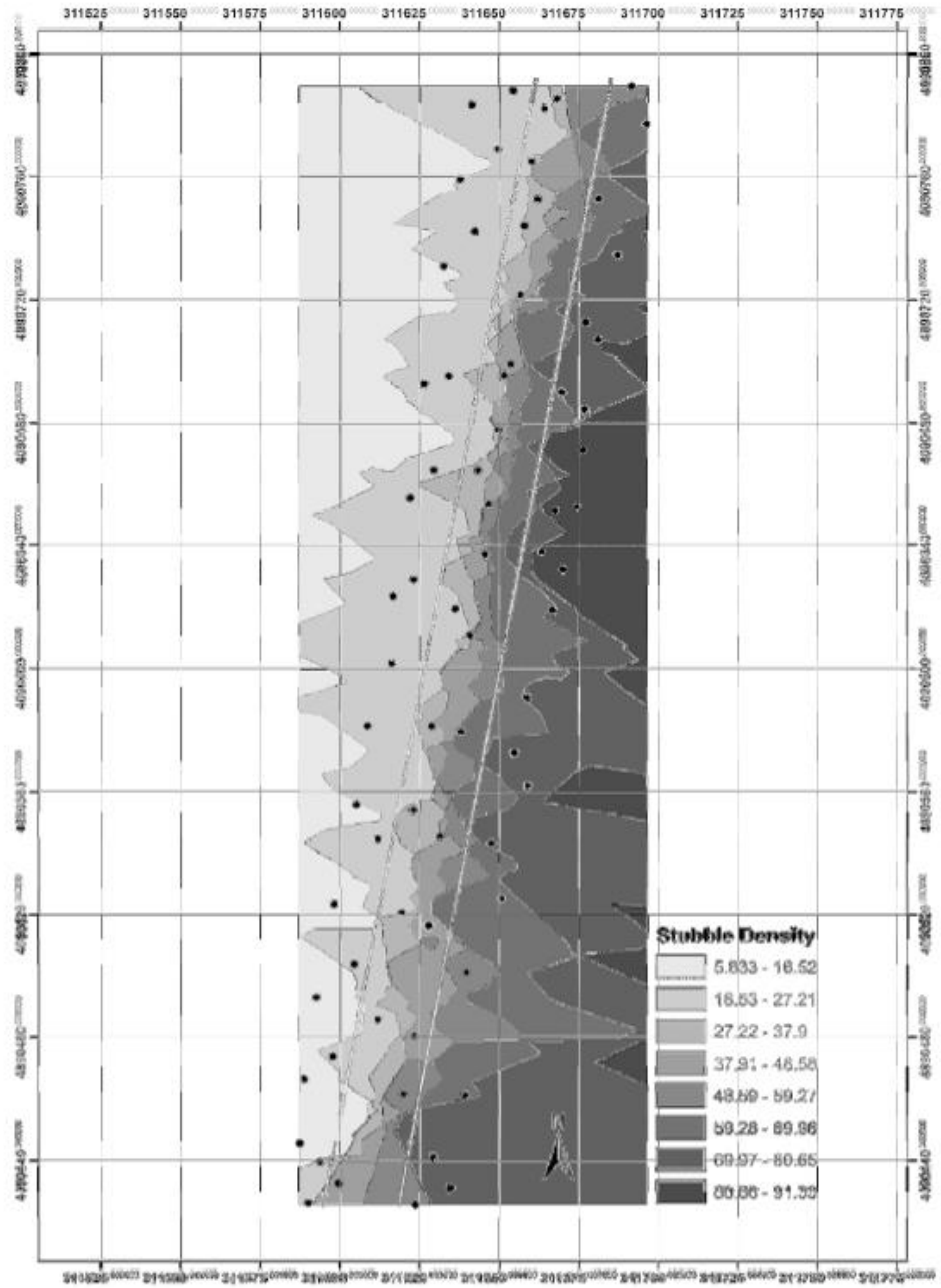

Fig. 7 - Stubble cover ratio map for three tillage methods

Table 4

T-test analyses

	Image Processing Stubble Ratio (%)	Line Transect Stubble Ratio (%)
Conventional Tillage		
Average	5.424	5.375
Standard error of the mean	8.615	6.592
Number of Point	24	24
Pearson Correlation	0.945	
Sig. (2-tailed)	**0.810**	
Reduced Tillage		
Average	35.676	36.208
Standard error of the mean	11.077	15.476
Number of Point	24	24
Pearson Correlation	0.862	
Sig. (2-tailed)	**0.204**	
No-till Tillage		
Average	89.548	90.250
Standard error of the mean	9.641	13.152
Number of Point	24	24
Pearson Correlation	0.624	
Sig. (2-tailed)	**0.257**	

The Conservation Technology Information Center (CTIC) has defined conservation tillage as any tillage and planting system that has more than 30% residue cover after planting; reduced-tillage as 15–30% residue cover; and intensive or conventional tillage as less than 15% residue cover (Daughtry, 2001). Stubble cover estimation is not only useful in planning field operations to maintain erosion control, but is sometimes needed to determine if a particular field qualifies for certain federal, state, or local conservation programs. For this reasons, stubble cover ratio should be determined to make effective management decisions. There are several methods for measuring stubble cover ratio. One of these methods is line transect. Laflen et al., (1981) reported that the line transect method has emerged as the preferred method for field use. Shelton & et al. (1991) reported that the line-transect method is one of the easiest method to use in the field to determine the percent residue cover on the surface. Currently, the most reliable technique for determining soil coverage is image analysis.

Among the different image analysis techniques, fractal image analysis (Velázquez-García et al., 2010), the use of fluorescent images (Daughtry et al., 1997), and computer-assisted analysis of images (Olmstead et al., 2004) are clear examples of the possibilities of image analysis (Jimenez et al., 2013). Korucu and Yurdagül (2013) were to use imaging method to determine of residue cover as affected by different soil tillage practices. Line transect and imaging technique were used to determine the amount of residue cover after each tillage application. T-test resulted in a high correlation (R^2=0.91) between line transect and imagery data in primary soil tillage. Pforte et al. (2012) compared various manual methods and image analysis methods, and obtained higher Pearson correlation coefficients of between 0.86 and 0.92. Image analysis has demonstrated its usefulness in determining the stubble cover ratio in comparison with visual estimation. Image processing may provide a more accurate, quick and extensive estimate of the stubble cover ratio. Also, image processing and GIS technologies are proving to be efficient tools for addressing problems of environment. In fact, image processing method is similar to the visual estimation method. Advantages of the image processing methods are fast, precision and reliability. But, image processing system should be mounted on the autonomous vehicle.

CONCLUSION

As final conclusions, this study determined and mapped the stubble cover ratio of the fields under conventional, no-till and reduced tillage systems using the online image processing method. High values of stubble cover ratios were obtained for the no-till tillage whereas low values for the conventional tillage system. The experimental results showed that the designed system works quite well in the field and the system is a practical tool for providing on-line stubble cover measurements. Maps are regarded as tools for processing coordinate data and also for data analysis and representation. Another important factor of the maps is their contribution in aiding users in making quick and reasonable decisions, for which the quality of the data gains importance. In this respect, to improving the map quality, number of spots should be increased (more than 24). This study contributes to further research for the development of on-line stubble cover measurements and mapping within the precision farming applications.

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AERODYNAMIC PERFORMANCE EVOLUTION OF FORWARD SWEPT HORIZONTAL AXIS WIND TURBINE BLADES
/
ÖNE DOĞRU EĞİMLİ YATAY EKSENLİ RÜZGÂR TÜRBİNİ KANATLARININ AERODİNAMİK PERFORMANSLARININ İNCELENMESİ

Asst. Ph.D. Stud. Eng. Kaya M. N.*[1], Prof. Ph.D. Eng. Köse F.[2]
[1] Karamanoglu Mehmetbey University, Engineering Faculty, Mechanical Engineering Department, Karaman, Turkey
[2] Selcuk University, Engineering Faculty, Mechanical Engineering Department, Konya, Turkey
Tel: +90 3382262000-5067; E-mail: mnumankaya@kmu.edu.tr

Keywords: *wind, turbine, blade, performance, sweep, twist*

ABSTRACT
Blades are the most important components of wind turbines in order to convert wind energy to mechanical energy. Various blade designs are available in the literature for horizontal axis wind turbine blades (HAWT) and swept wind turbine blades are one of them. This study investigates the aerodynamic performance of wind turbines with forward swept HAWT blades considering the wind turbine designed by Norwegian University of Science and Technology (NTNU) as a baseline. Changes in power coefficients and thrust forces are investigated for the tip speed ratio of 6 at a wind speed of 10 m/s. According to the results, it is obtained that some performance improvement can be achieved using forward swept wind turbine blades.

ÖZET
Kanatlar rüzgâr türbinlerinin en önemli bileşenlerindendir ve rüzgâr enerjisini mekanik enerjiye çevirmek için kullanılırlar. Literatürde Yatay Eksenli Rüzgâr Türbinleri için çeşitli kanat tasarımları mevcuttur ve eğimli rüzgâr türbini kanatları bunlardan biridir. Bu çalışmada Norveç Teknik Üniversitesi tarafından geliştirilen rüzgâr türbini baz alınarak öne doğru boyuna eğimli kanatlardaki aerodinamik performans incelenmiştir. Güç faktörü ve itme kuvvetindeki değişimler uç hız oranı 6 için 10 m/s rüzgâr hızında incelenmiştir. Sonuçlara göre bir miktar performans artışının öne doğru eğimli rüzgâr türbini kanatları ile sağlanabileceği belirlenmiştir.

INTRODUCTION
Wind energy is one of the most utilized leading renewable energy sources for sustainable power production. More and more wind power plants are installed in Turkey as well as around the world. Total installed wind power capacity has been 432 GW by the end of 2015 which has increased about 63 GW in one year [1]. The installed wind power capacity for Turkey has been 4694 MW by the end of 2015, however, the ministry of energy of Turkey has decelerated in the strategic plan for 2015-2019 an increase in installed renewable energy capacity by nearly twice compared to the value of 2013 [1,2].

There are numerous studies about horizontal axis wind turbine blade designs in the literature. Sweep-twist wind turbine blades were firstly introduced by Sandia National Laboratories of U.S. Energy Department. In the final report (2010) of the study, researchers presented analysis results of Sweep Twist Adaptive Rotor (STAR) blades [3]. In the report, they stated that the STAR technology provided significantly greater energy capture – about 10-12% compared to baseline Z48 turbines - without higher operating loads on the turbine. The results are also presented by Ashwill et al. (2010) in a conference [4]. Khalafallah et al. (2015) performed a Computational Fluid Dynamics (CFD) study of some factors affecting the performance of HAWT swept blades and concluded that some performance increase can be achieved using swept blades [5]. Sing and Ahmed studied on designing and performance testing of a small wind turbine rotor for low wind speed applications. A new airfoil was designed and the performance of a 2-bladed rotor for low Re application fitted to an Air-X marine 400 W wind turbine was tested at a wind speed range of 3-6 m/s. Authors stated that the new 2-bladed rotor produced more electrical power at the same freestream velocity in comparison with the baseline 3-bladed rotor [6]. Wang and Zhan (2013) investigated the performance of a micro-wind turbine using CFD and concluded that the performance of the wind rotor with semi-circular blades is comparable to that of the semi-cylindrical wind rotor, and is slightly lower than that of the helically twisted wind rotor [7]. Bai et al. (2013) designed a 10 kW horizontal axis wind turbine blade and performed aerodynamic investigation using numerical simulation of it. It has been reported that CFD is a good method compared to the improved Blade Element Momentum (BEM) theory method on the aerodynamic investigation of HAWT blades [8]. Koc et al. (2015) studied the hydrodynamic performance of a twin-blade hydrofoil numerically and experimentally in three dimensions for tip speed ratios ranging between 1.5 and 5.5. Authors reported that the optimum tip speed ratio of 3.5 for twin blade turbine is to low comparing the optimum tip speed ratio of 5.0 for the slat hydrofoil or standard hydrofoil turbine applications and added that the wind and hydrokinetic turbines with the twin blade hydrofoil can operate in lower wind and current speeds [9]. A detailed review of aerodynamic developments on small horizontal axis wind turbine blades is presented by Kartikeyan [10]. This study investigates the power performance of wind turbines with forward swept blades that are swept with various angels. NTNU wind turbine is used as a reference blade and CFD method is validated using the experimental results of this wind turbine.

MATERIAL AND METHOD

NTNU Wind Turbine Blade and designed swept blades

This wind turbine is designed by the researchers at the Norwegian University of Science and Technology (NTNU) using the S826 airfoil. The definition of the NTNU blade is given in Table 1 [11]. The wind turbine has three blades that have 0.9 m rotor diameter and zero pitch angle. Drawings of the NTNU blade is given in Fig. 1.

Table1

NTNU Blade definition [9]

r/R	c/R	α	r/R	c/R	α
0.01667	0.03	-	0.51667	0.10207	10.753
0.05	0.03	-	0.55	0.09696	9.8177
0.10889	0.03	-	0.58333	0.09229	8.8827
0.12222	0.11	38	0.61667	0.088	7.9877
0.15	0.18096	37.055	0.65	0.08407	7.2527
0.18333	0.17802	32.544	0.68333	0.08045	6.565
0.21667	0.17114	28.677	0.71667	0.0771	5.9187
0.25	0.1625	25.262	0.75	0.07401	5.3045
0.28333	0.15335	22.43	0.78333	0.07115	4.7185
0.31667	0.14434	19.988	0.81667	0.06849	4.1316
0.35	0.13578	18.034	0.85	0.06601	3.5439
0.38333	0.12782	16.349	0.88333	0.0637	2.9433
0.41667	0.1205	14.663	0.91667	0.06154	2.2185
0.45	0.11379	13.067	0.95	0.05951	1.097
0.48333	0.10766	11.829	0.98333	0.05761	-0.71674

Fig.1 – 3D Drawings of the NTNU blade

In order to test performance of the forward swept blades, various forward (in the direction of rotation) blades are designed. Two main factors are considered by designing swept blades: sweep start section (r/R) and offset at the blade tip (d/R) against the blade span. Forward swept blades have two beginning sections and four blade offsets that are r/R=0.25, 0.50 and d/R=0.05, 0.1, 0.15, 0.2, respectively. Figure 2 shows the designed forward swept blades.

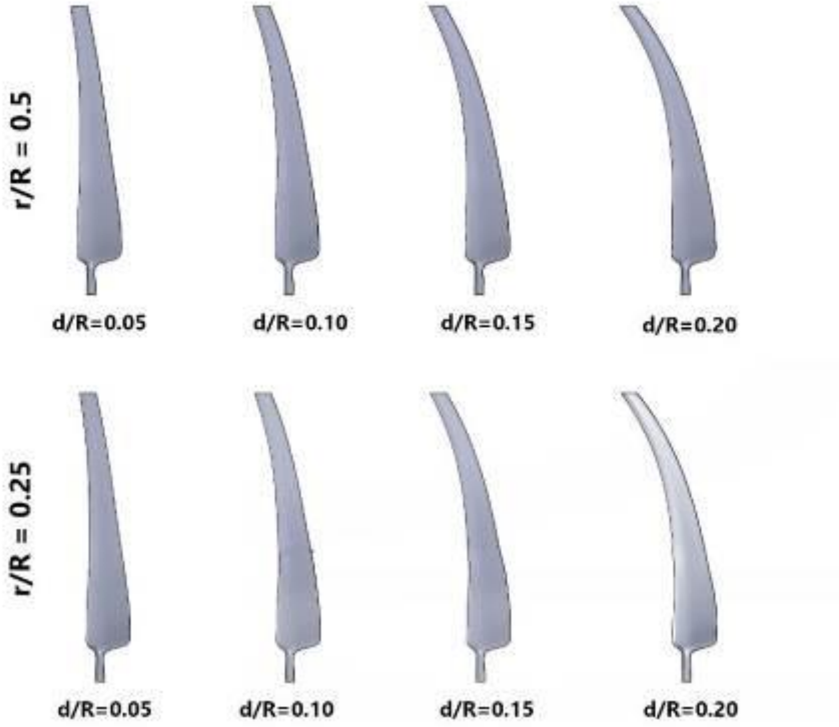

Fig.2 – Drawings of the designed forward swept blades

To calculate offsets of each airfoil, the method of Ashwill et al. (2010) which is given in Eq. 1 is used.

$$\left(\frac{\text{offset}}{\text{R}}\right) = 3.7 \times z^{3.656} \tag{1}$$

Numerical simulation

In this study, 3-D air flow around the wind turbine blade is simulated with ANSYS Fluent 16. The dimensions of the flow field are 12 R in the stream-wise direction extruded from a circle having 3 R dimension where R is the radius of the blade. The domain of flow field including boundary conditions is given in Fig. 3. Two reference frames that are stationary and moving are used in the model.

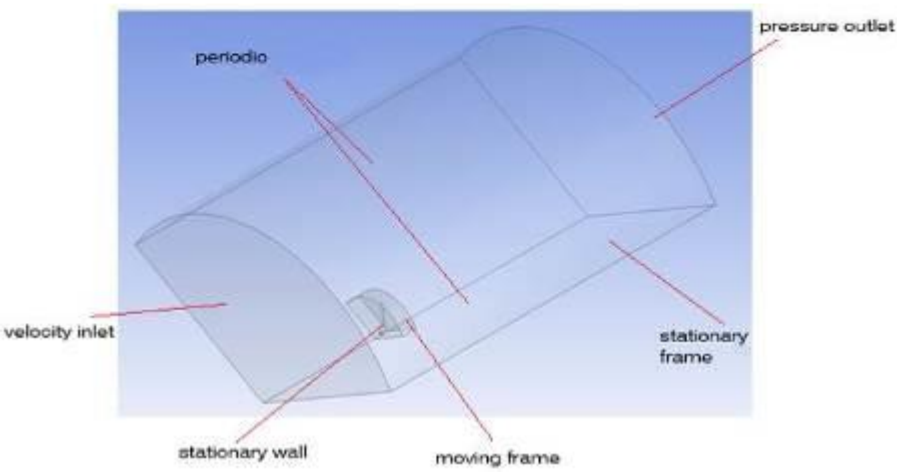

Fig. 3-Domain of the flow field and boundary conditions

Meshing of the fluid domain is performed using ANSYS meshing. The thickness of the first cell to the wall was kept at 2 x 10^{-5} m to obtain proper y+ value for the used turbulence model. In order to increase the mesh quality, sharp trailing edges of the blades are rounded. Mesh independence study is performed for various models containing different number of elements and a model containing 2.2 million elements is used. For CFD calculations, k- ω SST turbulence model is used.

k- ω SST turbulence model

This turbulence model combines both k - ε and k – ω models. The original k- ε turbulence model has the problem of over predicting the shear stress that might delay or prevent the separation where inverse pressure gradients are possessed, and the original k – ω model is very sensitive to free stream values that are specified outside the shear layer [12]. The original k – ω model is defined by the Equations 2 and 3 [12,13].

$$\frac{\partial(\rho k)}{\partial t}+\frac{\partial(\rho u_j k)}{\partial x_j}=P-\beta^{*}\rho\omega k+\frac{\partial}{\partial x_j}\left[\left(\mu+\sigma_k\frac{\rho k}{\omega}\right)\frac{\partial k}{\partial x_j}\right] \tag{2}$$

$$\frac{\partial(\rho\omega)}{\partial t}+\frac{\partial(\rho u_j\omega)}{\partial x_j}=\frac{\gamma\omega}{k}P-\beta\rho\omega^2+\frac{\partial}{\partial x_j}\left[\left(\mu+\sigma_\omega\frac{\rho k}{\omega}\right)\frac{\partial\omega}{\partial x_j}\right]+\frac{\rho\sigma_d}{\omega}\frac{\partial k}{\partial x_j}\frac{\partial\omega}{\partial x_j} \tag{3}$$

Validation of the solver

In order to validate the solver, experimental and CFD predictions of power coefficient data are compared. As mentioned before, k- ω SST turbulence model is used for the calculations. CFD predictions and experimental results are compared in Fig. 4. As it can be seen from the Figure, experimental and CFD results are in a very good agreement.

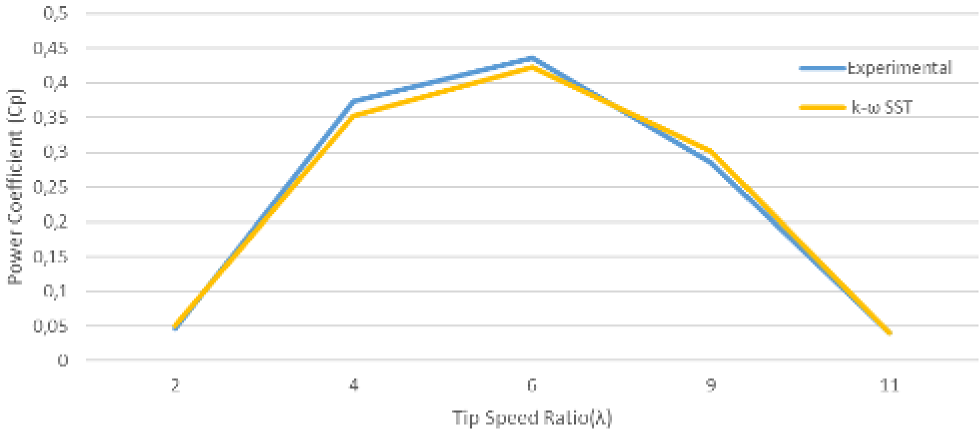

Fig.4 –Comparison of experimental and CFD predicted power coefficient results

RESULTS

CFD simulations were performed for the design tip speed ratio of 6 at the wind speed of 10 m/s. Change in capacity factors and thrust forces for the wind turbines with forward swept blades are compared to the values of baseline wind turbine. To make it easy to understand, an indication method to define swept blades is developed. In this method, two indices - "u" and y" - which define sweep start section (d/R) and blade tip offset (r/R) are used. For instance, "u25y10" indicates the blade which has 10% (d/R=0.1) offset at the tip and which has sweep start at 25% of span (r/R=0.25). In Fig. 5, power coefficients (Cp) of wind turbines with forward swept blades are compared to the baseline wind turbine. As it can be seen from the Figure, there are improvements in aerodynamic performance for wind turbines with some swept blades compared to the baseline. The wind turbine with the swept blade "u25y15" has the highest performance increase with a value of nearly 3%. However, it is also obtained that power output does not increase for every forward swept blade.

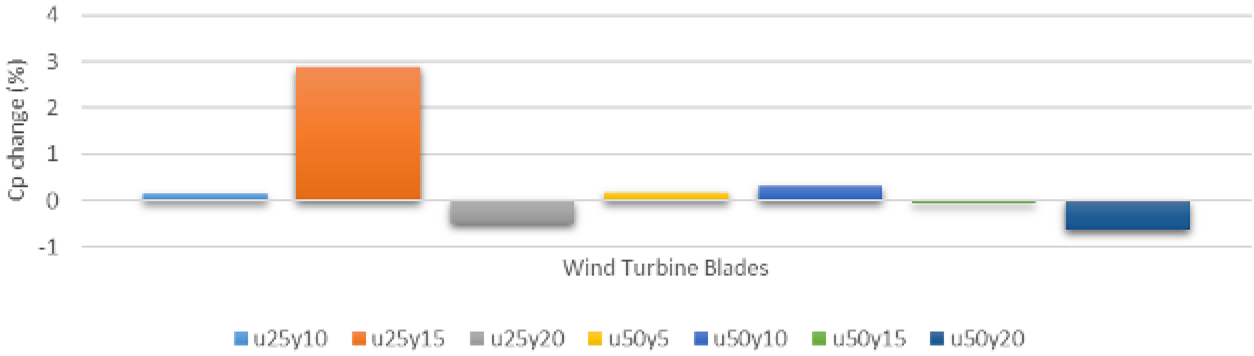

Fig.5 –Changes in power coefficients compared to the baseline blade

Fig 6. shows the change in thrust forces. As it can be seen from the Figure, thrust forces mostly decreases for the wind turbines with swept blades which causes also to a drop in power performance. For the wind the turbine with the swept blade "u25y15" there was an increase in thrust force similar to the increase in power coefficient.

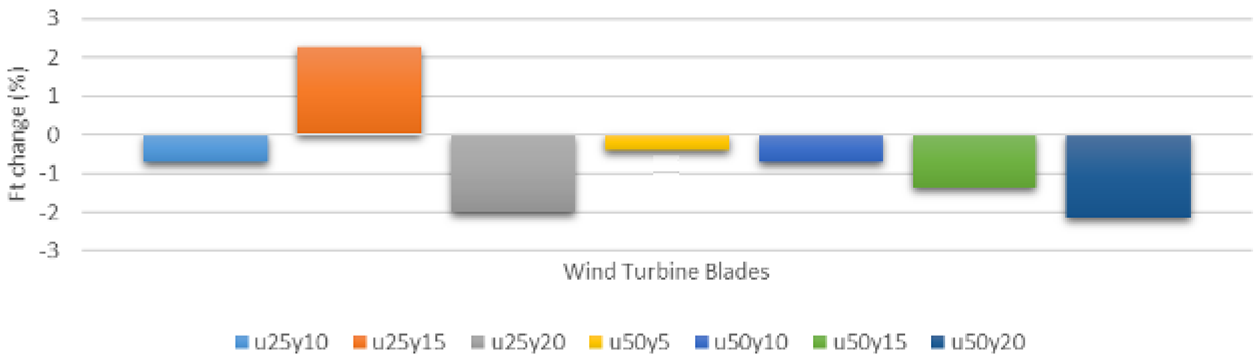

Fig.6 – Changes in thrust forces compared to the baseline blade

CONCLUSION

This present study investigates the aerodynamic performances of horizontal axis wind turbines with forward blades using the NTNU wind turbine as a reference. CFD simulations are performed for the wind turbines with forward swept blades that have two sweep start sections and four offset values. Highest power performance improvement has been obtained for the wind turbine with "u25y15" swept blades while the same wind turbine has the highest thrust force increment. It is obtained from the results that some performance improvement is possible with forward swept blades, however, generally improvement in performance causes to increase in thrust force. This can have an extra effect on wind turbine tower load and it should be considered in tower load calculations.

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IMPROVED TECHNOLOGY FOR OBTAINING FUNGAL BIOINSECTICIDES DESIGNED TO PROTECT AGRICULTURAL AND FORESTRY CROPS
/
TEHNOLOGIE OPTIMIZATĂ DE OBŢNERE A BIOPREPARATELOR INOCULANTE DESTINATE PROTECŢEI CULTURILOR AGRICOLE ŞI FORESTIERE

PhD.Stud.Eng. Fătu A. C.*, PhD.Stud.Biol. Dinu M. M., PhD.Biol. Andrei A. M.
Research-Development Institute for Plant Protection, Bucharest
Tel: 0212693234e-mail: cristina.fatu@icdpp.ro

Keywords: *entomopathogenic fungi, virulence, Beauveria, Melolontha*

ABSTRACT
Bioproducts based on entomopathogenic fungi are a sustainable alternative to chemical insecticides. Their large-scale use is conditioned by the good quality and adequate quantity of fungal bioinsecticide which can be cost-effectively mass-produced, and by its ability to induce mortality in the target pest population. The paper presents results of experiments aimed to optimize the mass production technology of fungal bioinsecticides, in two ways: by improving the quality of Beauveria conidia after successive passages through host insect, and by increasing the efficiency of fungal biomass production phase by shortening the period of colonization of the substrate (barley kernels) using a solid inoculum.

REZUMAT
Biopreparatele pe baza de fungi entomopatogenire prezintă o alternativă sustenabilă la insecticidele chimice. Utilizarea lor la scară mare este condiţionată, pe de o parte, de măsura în care bioinsecticidele fungice corespunzătoare din punct de vedere calitativ şi cantitativ, pot fi obţinute prin tehnologii eficiente de producer în masă, iar pe de altă parte de măsura în care insecticidul biologic induce mortalitate în populaţia de dăunători ţintă. In lucrare sunt prezentate rezultatele unor experimente care vizează optimizarea tehnologiei de obţinere a biopreparatelor fungice granulate prin utilizarea de tulpini fungice revirulentate prin insect gazdă, respective prin scurtarea perioadei de colonizare a substratului (boabe de orz) utilizand un inocul solid.

INTRODUCTION
Entomopathogenic fungi have two specific characteristics: pathogenicity and virulence. A fungal strain is pathogenic if it has the ability to cause a disease and it is virulent enough to penetrate into the host insect and to overcome its defensive reactions. Unlike pathogenicity, virulence is not a specific characteristic, but an individual feature of the strain. The virulence is a very unstable character influenced by various factors which may vary not only from one strain to another, but even for the same strain.

Unlike other microorganisms characterized by genetic uniformity, *Beauveria* is a genetically variable microorganism (*Fernandes et al., 2009, Li Gao, 2011, Maurer et al., 1997*), reported as a heterogeneous group of strains (*Wang et al., 2003*). Many fungal strains are not pathogenic or express only low virulence (*Rohde et al. 2006, Santoro et al. 2008*). If fungal strains are highly virulent, the mycosis develops faster and causes a greater mortality. The *Beauveria* strain virulence influences both the immediate and the long-term efficacy of the fungal application, considering their ability to colonize the target habitat. By using appropriate techniques, it is possible to select virulent strains and also to maintain or to improve the fungal virulence. Moreover, hyphomycete fungi may adapt to a particular host insect after forced passages through the species (*Ferron 1985*).The effect of nutrition on virulence of entomopathogenic fungi has been reported as well (Shah et al., 2005). Starvation conditions may also influence the virulence of entomopathogenic fungi, *in vitro* or *in vivo* (*Wang et al., 2002*).

The virulence of some autochthonous *Beauveria*sp. strains (*Andrei,1998a*) and the influence of preservation procedures on *Beauveria* strains virulence(*Andrei and Tudorache, 2007*) were subjects of scientific papers published in Romanian journals.

Methods for improving fungal virulence by using genetic, physical, chemical methods or biological processes were also described in many scientific papers. The successive passages through target insects for increasing the fungal virulence was described by *Alves and Pereira (1998), Azevedo (1998), Serafini et al. (2001)* and was demonstrated by *Steinkraus et al. (1991).Crecy et al. (2009), Scully and Bidochka (2005),* *Vandenberg and Cantone (2004)* presented studies which revealed the alteration of some phenotypic traits of fungal strains after successive *in vitro* and *in vivo* cultures. It is considered that conidia produced on insect cadavers have higher levels of virulence than conidia produced *in vitro* (*Shah et al., 2005, St. Leger et al., 1991*), but conidia production via passaging through insect hosts is unlikely to be an economical method (*Mohammadbeigi, 2012*).The "passage through the insect" method (serial in vivo passage) is only recommended to increase the virulence of fungal strains. Even most experiments have shown an increase in virulence of entomopathogenic fungi during serial *in vivo* passage, there are studies that do not confirm this (*Ignoffo et al., 1982*).

For producing bioinsecticides based on *Beauveria* sp., fungal strains could be mass produced using multiple methods for microbial fermentation: fermentation in liquid medium, fermentation on solid substrate and a combination of both (biphasic and triphasic systems). But the most common practice is solid substrate fermentation which implies an initial step of producing the inoculum by liquid fermentation followed by solid substrate fermentation.

In the present study it was investigated (i) the effect of *in vivo* passages on the virulence of some Romanian *Beauveriabrongniartii* strains and (ii) the effectiveness of a solid inoculum phase (aerial conidia on barley kernels) during the technological process designed for obtaining fungal bioinsecticides.

MATERIAL AND METHODS

Passages of Beauveriabrongniartii strains through the target-host

Two *B.brongniartii* strains (BbMm1/09 and BbgMm2/08) belonging to the entomopathogenic microorganisms collection of RDIPP were tested in order to obtain a fungal strain with increased virulence. Each strain was passaged through *M. melolontha* larvae two times consecutively after which they were cultivated in liquid media containing glucose, maize extract and salts, until sporulation was complete. Microbial cultures were allowed to settle for 24 hours, at 4^0C. The resulting biomass was used for preparing a conidial suspension, which was sprayed on *M. melolontha* larvae. After 2 hours of contact with the pathogen, the larvae were placed in experimental pots containing autoclaved soil, where oak trees were planted. After 15-20 days, the dead larvae were subjected to experimental protocol for re-isolation and microbiological purification of fungal strains. Fungal cultures obtained from these strains were tested on *M. melolontha* larvae. It was quantified the larval mortality. For control, *M. melolontha*larvae were infected with conidial suspension obtained before the two passages of BbMm1/09 and BbgMm2/08 through insect.

Bioinsecticide preparation

Multiplication of the monosporal fungal isolates BbMm1/09 in order to obtain the bioinsecticide, was made in two stages: (i) solid fungal inoculums was obtained by washing fresh,sporulated pure colonies with sterile distillated water amended with 0.01% Tween 80. The suspension was inoculated on sterile barley kernels in fermentation vessels and incubated at 25^0C; (ii) after 7 days, bags with barley kernels were inoculated with 1.6% solid fungal inoculum and incubated under stationary conditions 20 days, at 25^0C. Prior to inoculation, barley kernels were weighed, distributed in autoclavable plastic bags and sterilized (121^0C, 30 min.).

RESULTS

In order to study the influence of passages through insects on fungal virulence, *B. brongniartii*strains (fig. 1) were selected, considering their importance as a biological control agents of European cockchafers, an important pest in the Romanian forest nurseries (*Fătu et al., 2015*).

Fig. 1 - HealtyM.melolontha larvae (left) and B. brongniartii mycelium emerging from cadaver of M. melolontha larvae (center and right)

After two consecutive passages through *M. melolontha* larvae, it was registered a slightly increase of virulence ofBbMm1/09 and BbgMm2/08 strains. On average, the infectivity degree increased by 21% for BbgMm2/08 strain and by 17% for BbMm1/09 strains (fig.2). These values were confirmed by an increase in larval mortality: 1.2-1.6 times higher for BbgMm2/08 and 1-1.5 times higher for BbMm1/09. The increase in virulence was also confirmed by an increase of strains aggressiveness after successive passage through insects.Thus, the period required for fungal infection to occur was 1.3 times shorter (BbMm1 / 09) and 1.4 times shorter (BbgMm2 / 08) after applying treatments with these “new” strains.

Andrei and Tudorache (2007) studied how the virulence is modified after successive passages of some *Beauveria* sp. strains from RDIPP collection, using different methods. Thus, observations on the dynamics of insecticide activity of some indigenous *B. bassiana* strains successively transferred to agar culture medium revealed that, unlike the passage through insect, each transfer on artificial culture medium decreased the percentage of induced mortality for the test insect *Sitophilus granarius*.Four *B. bassiana* strains isolated from different hosts were evaluated: BbLd2\97 isolated from *Leptinotarsadecemlineata* larvae, strain BbTv1\87 isolated from *Trialeurodesvaporariorum* adult and BbC1\97 strain insolated from *Ceresa* sp.;it has been found that, regardless of origin and the initial infectivity of *B.bassiana* strains, their virulence was reduced to 2-4 times, after six successive passages over 18 months.Based on the results obtained, it was appreciated that significance of this decrease in virulence may vary from one strain to another. Also, the virulence of the same strain may vary from an insect species to another, depending on the degree of susceptibility. Thus, for some strains of *B. bassiana* was only a decline in virulence, for other strains was a total loss of virulence. The virulence of some strains isolated from *L. decemlineata*was all the greater as the number of passages on artificial medium was fewer. Thereby, a strain isolated from*L. decemlineata*and cultivated mainly on artificial medium, has the LC_{50}, 7.7 times higher compared to the same strain isolated from insect host, after four passages through the insect*(Andrei, 1998b)*.

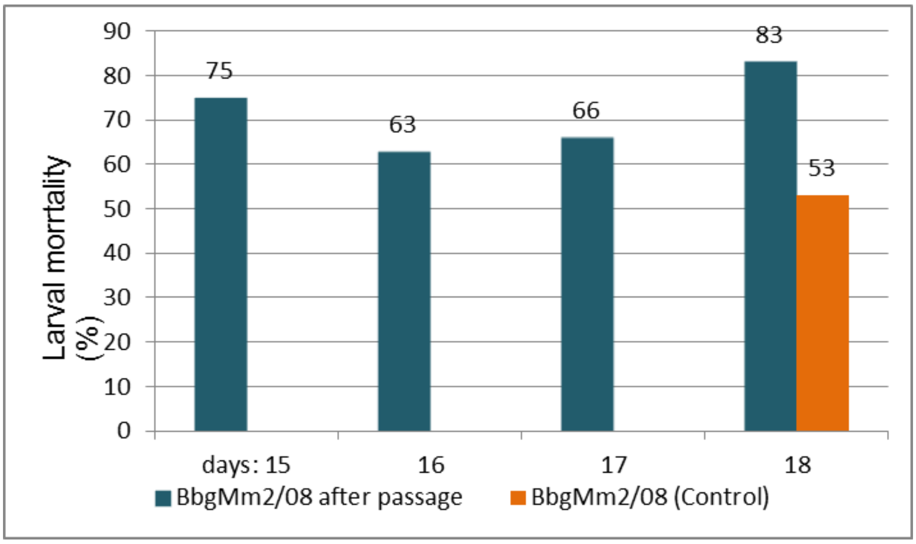
The decreasing in virulence caused by artificial subculturing was registered when potato-dextrose agar was used as artificial medium. This specification is necessary because a fungus grown on a special media maintains its virulence as high as in the case of passage through the insect. This was noticed also for monosporal isolations, from which spontaneous mutants resulted and preserved their virulence after subculturing on artificial medium, after 12 months of storage *(Samsinakowa et al., 1983).* Using an inadequate culture medium, in terms of nutritional requirements, is a method used for attenuation or a planned decrease in virulence of microorganisms.

There are studies aiming to evaluate the virulence of some isolates of *B. bassiana* and *M. anisopliae* by passage through artificial media and host insect. According to*Beigi (2012),* the virulence of both fungi reduced after the fourth subcultures *in vitro*, but after two passages through the grasshopper *Uvarovistia zebra* no significant enhancement in virulence of the fungi was registered.

Santoro et al. (2015) presented studies on the virulence of some *B. bassiana* strains after successive passages through the host insect *Alphitobiusdiaperinus* (Coleoptera: Tenebrionidae); it was reported an increased virulence of all strains by more than 100%, after the fifth-fifteenth passage.

Adames et al. (2010) observed that *M. anisopliae* conidia became more virulent to *Rhipicephalusmicroplus* (Acari: Ixodidae) after the fourth passage, and showed the highest virulence after the seventh passage.

Song and Feng (2011) reported that strains of *B. bassiana* showed a 3- to 4- fold increase in virulence after the second passage through *Nilaparvatalugens* (Hemiptera: Delphacidae), and subsequently remained unchanged after the third passage.



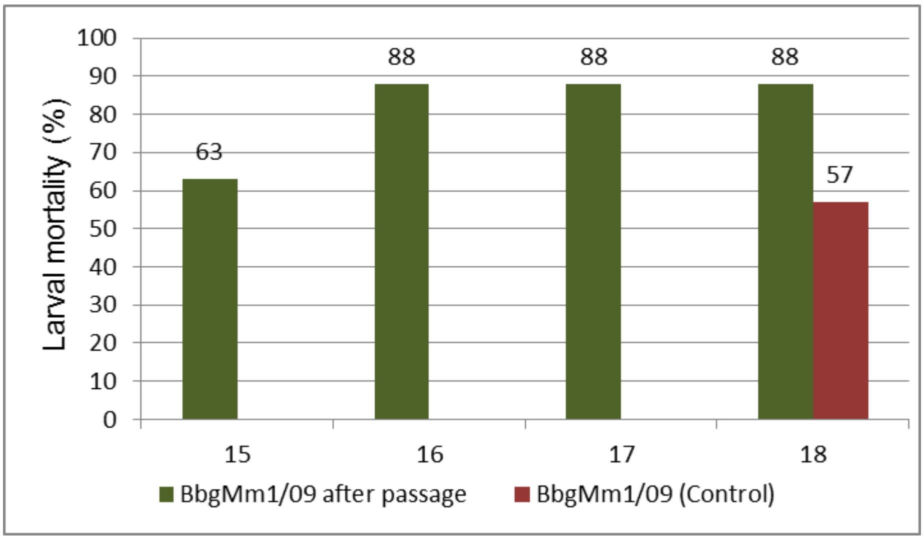


Fig. 2 - Larval mortality (M. melolontha) due to infection with in vivo passaged fungal strains

In the experimental improved technology, the solid substrate provides the support both for batch inoculum production and mass production of aerial conidia. Liquid phase batch inoculum was removed because it is the most expensive phase of technological process, being energy, chemicals, and reagents great consumer. Furthermore,for a microorganism to grow on a different substrate, passed from one culture medium to another, it is required a period of adjustment to the new "habitat" that it will colonize. For this optimized technological process, it was carried out to shorten the period of colonization of substrate (barley kernels) using a solid inoculum (barley covered with fungal mycelium), to which *B. brongniartii* is already adapted. In the optimized mass-production technology, 60 ml conidial suspension (3.6×10^{11} UFC/ml) was enough for obtaining 1 kg batch inoculum.

CONCLUSIONS

The present study was carried out on maximizing the efficiency of *B. brongniartii*mass-production, as an important step in successful utilization of entomopathogenic fungi.

The experimental results led to an optimized solution of the technological process for obtaining *B. brongniartii* biomass, the biologically active substance of fungal insecticides. According to the optimised technology, in the stage of source identification of biological material for obtaining bioinsecticides, indigenous *B. brongniartii* strains with increased level of virulence. This study revealed that passage of *B. brongniartii* strains through *M. melolontha*larvae is a suitable method for obtaining conidia with higher levels of virulence compared to conidia produced *in vitro*; increased virulence refers to a faster invasion of host due to a better conidia adhesion and a faster rate of germination. *M. melolontha*larvae represent a suitable host for *in vivo* passages.

In the dyphasic liquid-solid biomass-production technique, as an appropriate method for *B. brongniartii*mass production, it was used "batch inoculum" obtained on solid nutrient substrate. Technological process optimization by introducing "solid inoculum" involves lowering cost, maximizing the efficiency of fungal mass-production technology.

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OPTIMIZED TECHNOLOGY FOR MAIZE AND SUNFLOWER CROP PROTECTION / TEHNOLOGIE OPTIMIZATĂ DE PROTECŢIE A CULTURILOR DE PORUMB ŞI FLOAREA SOARELUI

PhD.Eng. Mincea C.*, PhD.Stud.Eng. Dudoiu R., Eng. Popa D.
Research-Development Institute for Plant Protection, Bucharest
E-mail: carmenmincea@yahoo.com

Key words: *seed treatment, integrated pest control, environment protection, soil pests, maize, sunflower*

ABSTRACT

Improved technology for protection of corn and sun flower crops consisted in using of the semi-wet foam procedure applied for seed treatment. This technology ensured a high coating rate of grains with the selected products, which led to: low percentage of grains and plants attacked by Agriotes sp. and, thus, a high number of plants saved at 25 days from their emergence, compared to the untreated control and significant decrease of Tanymecus dilaticollis attack on plants in first vegetation phases. Between the new applied technology for seed treatment and doses decrease for the tested products (based on thiamethoxam and imidaclopride) it has been established a synergism that led to the achievement of a very good protection for the two crops against the attack of soil pests.

REZUMAT

Pentru optimizarea tehnologiei de protectie a culturilor de porumb si floarea soarelui s-a folosit o metoda noua de tratare a semintelor, respectiv tratamentul semiumed cu spuma. Aceasta metoda a asigurat un grad de acoperire ridicat al boabelor cu produsele studiate, care s-a concretizat in: procent scazut de boabe si plante atacate de Agriotes sp., si implicit un numar crescut de plante salvate la 25 zile de la rasarire, comparativ cu martorul netratat si o scadere semnificativa a gradului de atac produs de specia Tanymecus dilaticollis asupra plantelor in primele faze de vegetatie.Intre tehnologia noua aplicata de tratare a semintelor si reducerea dozelor in cazul produselor studiate (tiametoxam si imidacloprid), s-a creat un sinergism care a determinat realizarea unei protectii foarte bune a celor doua culturi fata de atacul daunatorilor de sol.

INTRODUCTION

Maize and sunflower crops have been the subject of numerous studies developed in Romania and abroad, given their importance in terms of production potential and high nutritive value.

Research conducted over the years, led to the elucidation of several theoretical and applicative aspects regarding this two crops and allowed knowledge of the most adequate chemical means of protection, with minimum environmental impact and also, at the same time, enhancing the control of biological agents activity. The modern agricultural technologies promote integrated protection systems, which combine the factors involved in control of pest population within these two agro-ecosystems.

The state of art literature presents the benefits of plant protection products designed for seed treatment, referring to their efficacy, economical characteristics, environmental characteristics and their impact towards the user. It also presents data regarding the ecotoxicological aspects of selected products such as: low toxicity on useful organisms, high rate of decomposition in the environment, reduced mobility in soil and does not cause accumulation of residues in food or feed (*Mincea C., Fabritius K., Iliescu H., 2013)*

In order to develop an optimized technology for maize and sunflower crop protection were selected two products designed for seed treatment. The selection criteria for these products consisted in several aspects such as: a very good biological action in the control of target pests (*Tanymecus dilaticollis* and *Agriotes sp.*), systemic action, are highly recommended in risk management schemes for resistance development, have wide action spectrum and by localized treatment ensure adequate environmental protection.

The studies presented in this paper were performed within the Sectoral Program, targeting on technologies for plant protection with low consumption of pesticides, with low impact on the environment or agricultural products.

Referring to the impact of selected products towards user, they are considered as not dangerous, taking into consideration the small quantity of product used per ton of seeds and its packaging in suitable safety conditions. The paper presents the results of several studies regarding the optimization of maize and sunflower crop protection technologies, respectively:

1) Enhancing the treatment's quality by using a new method, more performant of seeds treatment

2) Reducing the used doses of the selected products in order to be included within the integrated protection schemes.

MATERIAL AND METHOD

In selecting the chemical insecticides, it was taken into account, among other aspects, their reduced impact on the environment, according to the requirements imposed by European regulations.

The selected insecticides for seed treatment used for the experiments are presented in table 1.

Table 1

Selected products for seed treatment

Commercial product	Active substance	Pest controlled	Crop	Dose (l p.c./tone seed)	Toxicity class
Cruiser 350 FS	thiamethoxam 350 g/l	*Tanymecus dilaticollis*	Maize	10	IV
			Sunflower	10	
		Agriotes spp.	Maize	10	
			Sunflower	10	
Gaucho 600 FS	imidaclopride 600 g/l	*Tanymecus dilaticollis*	Maize	8	III
			Sunflower	10	
		Agriotes spp.	Maize	6	
			Sunflower	10	

Thiamethoxam is a broad-spectrum, systemic insecticide, which means it is absorbed quickly by plants and transported to all of its parts, including pollen, where it acts to deter insect feeding *(MSDS for Thiamethoxam*). An insect can absorb it in its stomach after feeding, or through direct contact, including through its tracheal system. The compound gets in the way of information transfer between nerve cells by interfering with nicotinic acetylcholine receptors in the central nervous system, and eventually paralyzes the muscles of the insects.*("FAO Specifications and Evaluations for Agricultural Pesticides: Thiamethoxam",21 June 2000)*

Thiamethoxam improves plant vigour by triggering physiological reactions within the plant, which induce the expression of specific "functional proteins" involved in various stress defence mechanisms of the plant allowing it to better cope under tough growing conditions, such as "drought and heat stress leading to protein degradation, low pH, high soil salinity, free radicals from UV radiation, toxic levels of aluminium, wounding from pests, wind, hail, etc., virus attack".*(*Syngenta (2006). *"Thiamethoxam Vigour Effect". Retrieved 2011-10-11)*

The active substance was included in Annex I of 91/414/CEE Directive from 2001 and according to safety sheet data of the product used in this stage, it does not remain in soil or water, has medium soil mobility, is stable in standard conditions and non-sensitive under thermic aspect. Also, the product is non-toxic for aquatic organisms.

Imidaclopride is a systemic insecticide from the neonicotinoids class, which acts on the nicotinic receptor for acetylcholine, chlorinating process being responsible for inhibiting the degradation of acetylcholine-esterase. It is characterized by low toxicity towards majority of animals, others than insects, in accordance to the specificity for the mentioned receptor that can be often found in the nervous system of insects and zooplankton (exception for earth-worms and several fish species). This characteristic allows its use in low doses (55-140 gr/ha) in insects control. It has low pressure in vapours and it decomposes in inorganic molecule, by photolysis and microbial action. The half-life is 30 days in water and 27 days in soil, in anaerobic conditions. It is not persistent in technical sense of the word, but can have the half-life in soil, in anaerobic conditions, up to 997 days, which can create problems in possible water contamination, as long as it is leached gradually into a hypothetic soil reservoir (*Bonmatin JM. and colab.,2014)*.

If applied according to instructions, long term contamination is possible only after repeated applications, for several years. Applied on seed, enters during seed germination in rootlets, coleoptile, seedling strain, ensuring plantules' protection for at least 4 weeks.

The selected insecticides being in class III and IV of toxicity, maintain the seed' genetic potential, do not influent the germination, allow a quick and uniform emergence and increase plant vigour in the first phase of vegetation. In order to optimize the quality of seed treatment it was aimed to ensure an accurate dose application and a very high covering rate of the seed with selected products. For this, an important key factor consisted in choosing the treatment equipment. The treatment was conducted at Minerva Company, in

Calarasi County, using a modern device for seed treatment, a Rotostat Compact 2V brand, so far being the only device of this kind in our country.

This device uses a new generation procedure for treatment application, respectively foam treatment technology, by which is ensured dosage compliance and 100% covering rate. It is completely computerized, it doses the quantities automatically, comparatively to other seed treatment machines that cannot have such an accurate precision and can have variations regarding the covering rate. Unlike other equipment which simply mixes the treatment solution, this installation performs the treatment separately, in 2 phases, such as:

- In the first phase, it is performed the coating with a foam adjuvant (CET-M), dosed automatically for a better absorption of the active ingredient by the seed;
- In the second phase, it is performed the coating with the protection product, at a programmed time interval (3-5 seconds).

The device having computerized programming for quantity and flow of seed, adjuvant, used product, seed exposure time in contact with each product, it is obtained a perfect film, which ensures a 100% coating.

It has to be highlighted the fact that this type of treatment does not influence the seed' humidity compared to other equipment that use liquid treatment. Images from performing the treatment within this installation are presented in results chapter. Regarding the insecticides' doses used for seed treatment, the products were applied in 2 doses, one being the registered dose and the second dose, reduced by 20%.

From the soil pests the maize leaf weevil (*Tanymecus dilaticollis* Gyll) and wire worms (*Agriotes sp.)* cause major damages in sunflower and maize crops. Regarding *Tanymecus dilaticollis* species, during the last decades there were conducted biology and ecology researches, in order to develop a prevent and integrated control system (Georgescu E. and colab., 2013)

Within the ecological factors which influence the pest activity and prolificacy, temperature has a determinant role on the activity and damaging capacity of the species. It was observed that maize leaves at 8-10 days after emergence ensure the highest females prolificacy and eggs' fertility, although the insect is polyphaga.

Studies regarding the population evolution for this pest in different crops have shown that maize favours the most the insects' multiplication, ensuring the optimal larva development and favourite food for the adults. It exists the danger that field where there is grown maize the first year, located near fields cultivated with maize in monoculture or with other crops, which had premerger maize crop, to be very infested by *Tanymecus dilaticollis* and suffers severe crop losses.

The performed experiments will contribute to the improvement of chemical protection means for maize and sunflower crops, against the attack of soil pests, in terms of establishing integrated protection of these two crops agro-systems. Experimentation of the two optimized technological components was conducted in the pedoclimatic conditions of Research and Development for Agriculture Station Secuieni. There were placed two experimental plots, one for each crop.

Each trial consisted in 5 variants, in randomized block method, in 4 replicates, one experimental plot heaving 28 m^2. The maize hybrid used was T-200 and the sunflower hybrid – Coril, The trials were placed on a typical cambic chernozem with a pH of 6,29, humus content – 2,3; total nitrogen - 2,1; P2O5 – 39 ppm; K2O – 161 ppm. Premerger crop was wheat. The soil had a good infestation with *Agriotes*sp larvae, with a density between 7-9 larvae/m^2.

The tillage operations were conducted according to sunflower and maize crop technologies specific for Moldavia area. The sowing was performed with the drill for experimental fields; the seed were treated previously according to the described technology.

During the crop vegetation period it were assessed the wire worms' frequency of attack at grains undergoing germination process, attack frequency on plants with 3-5 leafs, the percentage of saved plants after treatment and the frequency and attack rate for Tanymecus *dilaticollis* . The data from these trials were statistically analysed, using analysis of variance. The pedoclimatic conditions have been favourable for the emergence, growth and development of sunflower and corn plants, but also for the emergence and evolution of pests (wire worms, maize leaf weevil, etc.).

RESULTS

The treatment of maize and sunflower seeds with the selected products was performed according to the described method; in the following images it can be observed the treatment equipment and a seeds selector of high performance.

Fig.1 - Seed treatment equipment ROTOSTAT COMPACT

Fig. 2 - Seed selector, brand MAROT

The results regarding the action of products based on thiamethoxam 350 g/l and imidaclopride 600 g/l, used as seed treatment for the control of wire worms and maize leaf weevil, in the two crops are presented in the tables below. Data in table 2 refers to the influence of the selected insecticides in maize crop protection against the attack of wire worms (*Agriotes* spp.).

Table 2

Insecticides effect in the control of Agriotes sp. in maize crop

No.	Product	Dose (l/t)	% emerged plants	F% attack on grain	F% plant attack	% rescued plants at 25 days
1.	Cruiser 350FS (thiamethoxam)	10	97 ***	3	1	96 ***
		8	94 ***	6	1	93 ***
2.	Gaucho 600FS (imidaclopride)	6	98 ***	2	0	98 ***
		5	97 ***	3	2	95 ***
3.	Untreated control	-	76	24	12	64

DL 5% = 2.36 3.74

1% = 3.84 4.65

0,5% = 5.29 6.01

Analysing the table data it can be observed that the attack frequency in grains undergoing germination on treated variants, was between 2 and 6%, comparative with the not treated control, where was recorded a 24% attack frequency. The attack frequency at plants with 3-5 leafs was 12% in untreated control variant and decreased at 1-2% in treated variants.

Data regarding the untreated control variant highlights an intense attack of *Agriotes.* sp larvae for maize crop. The percentage of saved plants at 25 days from emergence was between 93% and 98% in treated variants comparative to 64% recorded for untreated control. The statistical analysis of differences between the emerged plants percentage and plants saved at 25 days in treated variants comparative to control showed that these differences are very significant.

Results regarding the control of *Agriotes* sp. Larvae, using low doses, show a very good efficacy. It can be concluded that new technology used for seed treatment is better than the classic method.

Maize crop protection against the attack of *Tanymecus dilaticollis,* performed with selected products for seed treatment is presented in table 3.

Table 3

Insecticides effect in the control of *Tanymecus dilaticollis* in maize crop

No.	Product	Dose (l/t)	F %	I %	GA %	Difference GA %	Signification
1.	Cruiser 350FS (thiamethoxam)	10	5	2,67	0,13	-0,98	000
		8	7	2,79	0,20	-0,91	000
2.	Gaucho 600FS (imidaclopride)	8	5	2,42	0,12	-0,99	000
		6,5	8	2,68	0,21	-0,90	000
3.	Not treated control	-	20	5,54	1,11	-	-

DL 5% = 0.29
1% = 0.36
0.5% = 0.52

Assessment performed in maize trials showed that the frequency of plants attacked by *Tanymecus dilaticollis,* in treated variants had values between 5% and 8%, comparative with untreated control, where has been recorded a frequency of attacked plants of 20%. Knowing the frequency and intensity of the attack, it was calculated the attack rate of *Tanymecus dilaticollis* on plants. Table data show values of the attack rate between 0.12% and 0.21% in treated variants, the differences between treated variants and untreated control being negative significant.

Fig. 3 - *Tanymecus dilaticollis* attack on maize (control variant)

The results regarding the efficacy of the insecticides selected for seed treatment in sunflower crop protection against the attack of sol pests are presented in tables 4 and 5.

Table 4

Insecticides effect in the control of *Agriotes* sp.in sunflower crop

No.	Product	Dose (l/t)	% emerged plants	F% grain attack	F% plant attack	% rescued plants at 25 days
1.	Cruiser 350FS (thiamethoxam)	10	96 ***	4	1	95 ***
		8	95 ***	5	2	93 ***
2.	Gaucho 600FS (imidaclopride)	10	98 ***	4	0	96 ***
		8	94 ***	6	2	92 ***
3.	Not treated control	-	71	29	11	60

DL 5% = 4.26 4.47
1% = 5.42 5.67
0,5% = 6.76 6.94

The tables' data regarding the action of thiamethoxam and imidaclopride applied in seed treatment by semi-wet foam coating procedure, in optimized (lower) doses, have shown a very good efficacy of both products in control of wire worms larvae. The good results are highlighted by percentages of 95 and 96 saved plants at 25 days from emergence for the variants treated with registered doses and 92% and 93% for the optimized variants by applying lower doses, comparative to the results obtained in untreated control, where the percentage of saved plants was only 60.

Table 5

Insecticides effect in the control of *Tanymecus dilaticollis* in sunflower crop

No.	Product	Dose (l/t)	F %	I %	GA %	Difference GA %	Signification
1.	Cruiser 350FS (thiamethoxam)	10	8	2,15	0,17	-0,97	000
		8	11	2,21	0,24	-0,90	000
2.	Gaucho 600FS (imidaclopride)	10	7	2,13	0,15	-0,99	000
		8	9	2,32	0,20	-0,94	000
3.	Not treated control	-	17	6,73	1,14	-	-

DL 5% = 0.21
1% = 0.35
0.5% = 0.49

The insecticides' efficacy in control of *Tanymecus dilaticollis* adults, for sunflower field trial is presented in table 5. The table data highlight the good efficacy of products in both tested doses for the pest control. It can be observed that in all treated variants the rate of attack was significantly low comparative to untreated control.

CONCLUSIONS

Based on the results presented it can be drawn the following conclusions:

- ✓ The semi-wet foam seed treatment procedure applied for maize and sunflower ensured a high coating rate of grains with the selected products, which led to:
  - Low percentage of grains and plants attacked by *Agriotes* sp. and a high number of plants saved at 25 days from emergence comparative with the untreated control and
  - Significant decrease of *Tanymecus dilaticollis* rate of attack on plants in first vegetation phases.
- ✓ Between the new applied technology for seed treatment and doses decrease for the studies products (based on thiamethoxam and imidaclopride) it has been established a synergism that led to the achievement of a very good protection for the two crops against the attack of soil pests.

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CHAB CONCEPT IN SUSTAINABLE DEVELOPMENT OF AGRICULTURE
/
CONCEPTUL CHAB ÎN DEZVOLTAREA DURABILĂ A AGRICULTURII

Murad E. *1), Dumitrescu C. 2), Dragomir F. 3), Popescu M. 4)
[1]Biosystems Department, Politehnica University, Bucharest,[2] INOE2000-IHP, Bucharest
[3]Promeco SD SRL, Bucharest, [4] Incubus SRL, Bucharest
E-mail: gasmeruscmer@gmail.com

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ABSTRACT
The agricultural production and energy usage for agricultural processes are seasonal. The use of biomass as a renewable energy source is optimal in sustainable development of agriculture because it can be stored and used ***when and as it is necessary****. A current way of producing energy from biomass is concept CHAB (****C****ombined* ***H****eat* ***A****nd* ***B****iochar production) they produce heat and biochar (BC) with a negative balance of CO_2. BC is a charcoal produced from biomass pyrolysis in a substoichiometric environment. BC has a carbon content of 80-90%, high porosity and absorption capacity. CHAB may apply for high heat consumption agricultural sectors: greenhouses, dryers, broilers halls, technological spaces. BC is both economically and environmentally efficient, being used as a soil amendment for farming and as a filter medium for pollutants.*

REZUMAT
Producţia agricolă şi energia utilizată în procesele agricole au un caracter sezonier. Utilizarea biomasei ca sursă de energie regenerabilă este optimă în dezvoltarea durabilă a agriculturii deoarece se poate depozita şi utiliza ***când şi cât este necesar****. O modalitate actuală de producere energie din biomasă este conceptul CHAB (****C****ombined* ***H****eat* ***A****nd* ***B****iochar production)care produce căldură şi biochar (BC) cu bilanţ negativ de CO_2. BC este un cărbune obţinutdin piroliza biomasei într-un mediu substoichiometric.BC are un conţinut de carbon de 80-90%, o porozitate şi o capacitate mare de absorbţie. Conceptul CHAB se aplică în sectoarele agriculturiimari consumatoare de căldură: sere, uscătoare, hale de pui de carne, spaţii tehnologice. BC este eficient atât economic cât şi ecologic, fiind utilizat ca amendament pentru solurile agricole şi ca mediu filtrant pentru poluanţi.*

INTRODUCTION
Sustainable development of agriculture requires more green energy and maintaining and enhancing the productive capacity of the soil, the as low as possible use of mineral fertilizers in favour of compost, which correlated with the present environmental requirements results in the need to increase the residual biomass generated by agricultural activities.

As an alternative to current methods of thermal energy production from biomass it is proposed the CHAB concept (Combined Heat And Biochar production) which includes also the biochar (BC) generation. BC is a sterile organic material obtained from biomass pyrolysis in an oxygen-free environment or with a substoichiometric concentration, with a neutral or alkaline pH. It has a carbon content of 75-90% and it is characterized by high porosity and adsorption capacity. [5, 6, 7, 8, 20, 23]

BC is used primarily as an agricultural improver (conditioner) aimed to increase long-term fertility of agricultural soils, and secondarily as filtering material for air, gas and water. Built in soil it is the most economical and ecological way of sequestering at least 25% of biomass carbon, for extended periods between 100 to 1000 years [18]; it also has many other applications in the most various fields of human activity. [5, 17, 19]

Figure 1 depicts a layout on how to apply the CHAB concept for sustainable development purposes [20].

Present situation [A]: biomass is used predominantly for food, represented by the atmosphere (A) – food (F) loop. Meanwhile, energy (E) from fossil reserves (FR) adds more and more C to the atmosphere (A).

Energy from biomass [B]: solution with all energy coming from biomass. No fossil C is added to the atmosphere, but the amount of biological C that circulates through atmosphere via agriculture to techno-sphere has been hugely increased.

Concept CHAB [C]: in addition to the switchover to bio-based, part of atmospheric carbon is buried as biochar (BC). This extra stream is another addition to the demands for food (F) and energy (E). Carbon has entered a 'slow' C cycle: over millennial timescales is part of biologically active cycles.

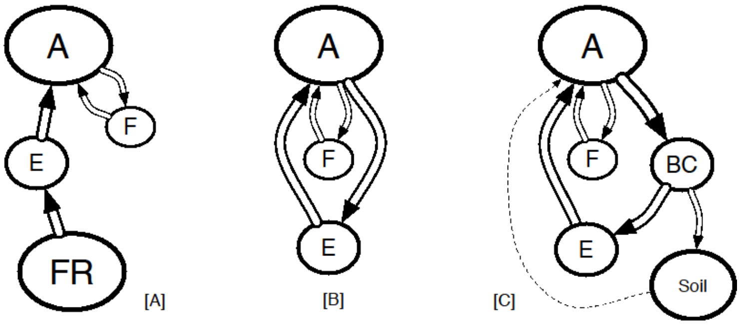

Fig. 1 - Towards sustainable development with additional carbon

Most studies have found beneficial effects from biochar use in agricultural production; in 58% of situations the agricultural yield was increased and in 37% of cases, no differences were found. A recent statistical meta-analysis of worldwide results derived a significant positive effect: 10% increase of the yield of agricultural production. The authors used data from several extensive, high quality studies focused on the overall impacts of using BC based on important factors such as soil pH, soil type, dose of fertilizer, raw material for BC, application rate and crop species. [1, 22, 25] In viticulture was found that BC does not significantly influence the quality of wine produced, but produces an important increase in soil water reserve and retention of phosphorus and nitrogen. [3, 9]

BC can be ecologically used in many other fields of activity. [17] Yet, using the CHAB concept requires the existence of a thermal energy user on site, where BC is produced. In summer, in agriculture, heat is used for drying products and technological hot water generation for domestic and technological purposes, and in winter, for heating solariums, greenhouses, broiler halls, technological spaces or houses. [4, 13, 14, 15, 16, 21]

MATERIALS AND METHODS

The Chab Concept

Anaerobic or substoichiometric processes of pyrolysis and gasification are used in order to produce BC and thermal energy. The fact that BC became a commodity leads to the technological solution that obtains a larger amount of biochar - 25-30% of the dry matter or 20-25% of the biomass at 20% moisture content. These pyrolysis processes, largely anaerobic, generate BC with high concentrations of VOCs (Volatile Organic Component) and molar ratios H/C and O/C at the upper limit allowed in BC certification. [18, 26]

It was found that the overall positive effects are achieved with a BC with a small concentration of VOC [11] and with greater absorption BET surface (m^2/g.bc) [2, 3, 10, 26]. These characteristics are determined by the pyrolysis and / or gasification of biomass experimented regimes. These issues have contributed to the extension of the CHAB concept to account for agricultural biomass residues in controlled aerobic pyrolysis processes, resulting BC with very low VOC and high BET (m^2/g.bc), yet at a production of 20-25% BC of dry biomass (db). [7, 8, 14, 16]

Due to the general interest in mitigating climate change and because of the irreversibility in soil incorporation, BC is marketed at very different prices ranging from 0.82 to 4.85 €/kg.bc dependent on the quality and local conditions, but with a European average of 680 €/t.bc. [6.23]

For thermal power ranging between 10 and 100 KWth, usual in most farms, the TLUD (Top Lit Up Draft) process of micro-gasification of biomass can be used. With TLUD procedure, a wide variety of agricultural biomass or other origin can be gasified if shredded to 10 - 50 mm and having humidity below 20%; these features enable the effective use of local sources of biomass and increase the agricultural farms' energy independence. Top quality BC can be obtained [18] and fuel gas without tar, which can be burned very clean or, after filtering and cooling, for supplying electric generators.

Minimal mechanical processing, transport distances below 15 km and natural ventilation drying lead to a very low cost of the generated thermal energy, estimated at a maximum of 5 €/GJ, which is six times less than the one obtained from diesel. [4, 10, 12].

TLUD power modules are characterized by a simple, inexpensive, easy to use construction and low technical training staff requirements. Depending on the power and its application, the TLUD energy module operation can be fully automated. Due to the gasification air flow rate control, the conversion yield of the fully gasified biomass is 93%. From the initially introduced into the reactor biomass, a proportion of 12-20% BC is obtained, depending on the biomass and the pyrolysis regime. The TLUD micro-gasification process ensures the turning to account of biomass waste from agriculture with low costs and high conversion yields, being indicated for local low power applications [12, 13, 15, 16, 21].

It clearly results the advantage of using local or regional minimum processed residual biomass, which is abundant and does not require long haul. By local storage, on site, a natural drying occurs without energy consumption. [6, 10, 14]

Sources of Agricultural Biomass Waste

Table 1 shows the main sources of agricultural biomass waste, their chemical composition and densities in chopped or ground dried and pelletized use version. [6, 10, 24]

Table 1

Residual agricultural waste characteristics

No.	Biomass	Volatile	Fixed Carbon	Ash	H.H.V.	Status	Crop Density	Bed Density
		[%]	[%]	[%]	MJ/kg	-	kg/m^3	kg/m^3
1	Tree prunings	75.0	24.0	1.0	19.0	shredded	550	300
2	Vine prunings	77.4	20.0	2.6	19.1	shredded	600	350
3	Corn stalks	77.2	19.3	5.5	17.7	shredded	350	150
4	Corn stalks	77.2	19.3	5.5	17.7	pellets	1000	600
5	Energetic grass	76.0	18.0	6.0	17.5	pellets	1000	600
6	Vegetable stalks	77.0	19.0	4.0	17.0	pellets	1000	600

For exemplification, Table 2 shows the properties of biochar and fully gasified biomass resulted from tree prunings and produced in the TLUD micro-gasification process. These values are used in the calculation of economic and environmental efficiency.

Table 2

Characteristics of the tree pruning micro-gasification

Feature	U.M.	Tree prunings	Biochar	Gasified biomass
Relative masse	%	*100*	*15*	*85*
Carbon	%	43,11	79.0	36,78
Oxygen	%	35,57	10,8	39,94
Hydrogen	%	5,12	2,20	5,63
Ash	%	1,20	8,00	0
Humidity	%	*15,00*	*0*	*17,65*
L.H.V	MJ/kg	15,30	22,40	14,05
Energy content	%	100	21,96	78,04

RESULTS

To assess economic and ecological use of CHAB concept for the thermal energy generation and biochar from biomass, it was analysed the use of biomass from tree prunings compared to pellets purchased on the market. It was taken as a basis the biomass produced and used in own farms with a production cost of 30 €/t and biomass purchase version with 50 €/t. The pellet analysis was done for three usual market prices: 120, 140 and 160 €/t.

For thermal power generation a TLUD module type GAZMER MGB 30/100, it was used with an estimated price of 750 Euro, with a useful life time of 5 years at an annual average load of 10 tonnes of biomass, leading to a depreciation rate of 15 €/t.bm. The operation, maintenance and repair expenditures were estimated at 20% of the depreciation, leading to operating costs of 18 €/t.bm. Thermal energy production costs are the sum between biomass price and operation expenses. The energy and gasification characteristics of the used biomass are shown in Table 2. The conversion yield of biomass into energy and BC is 0.91 and the one of the process without BC is 0.93. Table 3 indicates the comparative economic and environmental effects of using the CHAB concept in agricultural farms.

Table 3

Economic and ecologic effects evaluation

Feature	M.U.	Shredded biomass		Pellets		
Biomass price	€/t.bm	**30.0**	**50.0**	**120.0**	**140.0**	**160.0**
Depreciation energy module	€/t.bm	31.11	31.11	31.11	31.11	31.11
Total operating costs	€/t.bm	37.33	37.33	37.33	37.33	37.33
Production costs	€/t.bm	67.33	87.33	157.33	177.33	197.33
L.H.V for biomass	MJ/kg.bm	15.30	15.30	15.30	15.30	15.30
Average biochar production	kg.bc/kg.bm	0.15	0.15	0.15	0.15	0.15
L.H.V for gasified biomass	MJ.th/kg.bmg	14.00	14.00	15.50	15.50	15.50
Yield conversion without BC	MJ.th/MJ.bm	0.91	0.91	0.91	0.91	0.91
Yield conversion with BC	MJ.th/MJ.bm	0.93	0.93	0.93	0.93	0.93
Useful heat without BC	MWh/t.bm	3.87	3.87	4.30	4.30	4.30
Useful heat with BC	MWh/t.bm	3.07	3.08	3.41	3.41	3.41
Additional costs for BC	€/t.bc	25.00	25.00	25.00	25.00	25.00
Biochar price (EU medium)	€/t.bc	680	680	680	680	680
Biochar price (without VAT)	€/t.bc	567	567	567	567	567
Value of sale biochar	€/t.bm	81.25	81.67	81.67	81.67	81.67
Energy cost without BC	€/MWth	17.41	22.58	40.68	45.85	51.02
Energy cost with BC	€/MWth	-4.53	1.98	24.75	31.26	37.76
Reduce the price of heat[a]	%	126.0	91.24	39.16	31.84	25.99
BC price for zero energy cost	€/t.bc	538	698	1258	1418	1578
CO_2 sequestered in soil	$t.CO_2/t.bm$	0.440	0.440	0.440	0.440	0.440

(bm – biomass, bmg – gasified biomass, bc – biochar, th – thermic)
[a]considering profit

An important value for the study is the degree of turning to account of BC. An average price in EU countries [1] of 680 €/t.bc. was used; for handling and packaging we added other expenses summing 25 €/t.bc.

It appears that important cost reductions are obtained for thermal energy, on average by 145% when using minimum processed biomass and by 38% for pellets. In fact, CHAB use for thermal energy generation becomes a profitable activity both economically and environmentally, resulting in clear advantage for local or regional agricultural minimum processed biomass waste, which is abundant and does not require long distance transport. The local farm storage provides, in time, also a natural drying without additional energy consumption.

A yearly consumption of 10 t.bm results in annual sequestration of 4.4 t CO_2/year or 1 t C/year. CHAB application becomes clearly more economically profitable when green certificates for carbon sequestered are paid.

CONCLUSIONS

Simultaneous production of heat and biochar characterized by the current concept called CHAB is an economic and ecological way of turning to account the local and regional residual farming biomass in order to increase the energy independence of farms, grow their agricultural land productive potential and promote long term atmospheric carbon sequestration in soil.

Applying the concept CHAB results in a significant reduction in the cost of the necessary thermal energy, especially when using residual biomass shredded and dried naturally or forced. When biomass resources are used directly in own farms, the thermal energy can be obtained with negative cost, so operations gain a net profit, yet depending on the usage mode of BCH.

By incorporating biochar in agricultural soils, it is obtained a long lasting atmospheric carbon sequestration, on average about 440 kg.CO_2/t.bm, which is very economical and productive compared to other methods proposed and tested. The annual use of a GAZMER 30/100 module leads to a negative balance of about -4.4 t.CO_2/ year.

Gathering, chopping, transport, storage and distribution of locally harvested biomass are activities that increase employment of rural labour, producing new values that contribute to increasing incomes and living standards.

For powers ranging between 10 and 100 KWth, the micro-gasification process TLUD is recommended because thermal modules have a simple design, safe operation and a high overall yield in heat generation and a clean high quality biochar from a wide variety of biomass, becoming economically interesting for small and medium enterprises.

Further research development is needed on issues such as using biochar with higher efficiency that can be generated on farms and the set of agricultural machinery necessary for processing and use of biochar in agriculture.

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THE USE OF BIOPRODUCTS BASED ON MICROORGANISMS – POSSIBLE FACTOR FOR A SUSTAINABLE AGRICULTURE
/
UTILIZAREA BIOPRODUSELOR PE BAZĂ DE MICROORGANISME –UN POSIBIL FACTOR PENTRU O AGRICULTURĂ SUSTENABILĂ

Fendrihan S.
Research-Development Institute for Plant Protection, Bucharest
E-mail: ecologos23@yahoo.com

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ABSTRACT
Modern agriculture means mass industrial production of agricultural plants for food and fodder with high level productivity hybrids and varieties, mechanisation and modern equipment, application of chemicals and fertilizers. It has some side effects too, pollution of soil, water, destruction of biodiversity, and so on. In the last 50 years, many countries especially in course of development, tried to use bioproducts to supply their needs for fertilization and control of pests and pathogens using biotechnology, with the help of different beneficial microorganisms. This paper reviews this tendency and explains the achievements in this field of research and the dawn of a new era in international and national agriculture.

REZUMAT
Agricultura modernă înseamnă cultură industrială, de masă a plantelor agricole pentru hrana oamenilor şi a animalelor de fermă cu mare productivitate şi implică hibrizi şi soiuri performante, mecanizare şi echipamente moderne, aplicarea pesticidelor chimice şi fertilizantilor chimici. Ca efecte secundare sunt poluarea solului, a apei, distrugerea biodiversităţii. În ultimii 50-60 de ani multe ţări mai ales cele în curs de dezvoltare, caută să utilizeze bioprodusele pentru a acoperi nevoile de fertilizare şi combatere a dăunătorilor şi bolilor, prin biotechnologii, cu ajutorul diferitelor microorganisme benefice. Această lucrare sintetizează şi explică tendinţele şi realizările în acest domeniu de cercetare, a zorilor unei noi agriculturi la nivel internaţional şi naţional.

INTRODUCTION
The modern agriculture was conceived in the beginning of 20th century (even in some authors' opinion at an earlier date). Of course, here, we review the case of plant cultures. The amount of crop, the final purpose of the farmers, grew from one year to the other, despite the climatic and meteorological conditions. Due to population increased demography, climate change, the necessity to reduce pollution, increase of demand for eco and sanogene products, and, at the same time the costs of chemicals for agriculture, the trend is to implement the use of pesticides and fertilizers based on microorganisms in the technology of culture of many crops. This is combined with the trend in human nutrition of using sanogenetic products (without traces of chemicals).

MATERIAL AND METHOD
An intensive search in specialized literature revealed many little and medium sized companies which were evaluated on their bioproducts containing microorganisms and the tendency of development of this kind of new products.

RESULTS
<u>Scientific basis</u>

In soil, especially in rhizosphere, there is a huge community of microorganisms each having its role in the ecosystem. The huge scheme of relationship in the community and of these microbial communities with plants showed very complex and sensitive relations depending on many environmental factors and plants' microbial inner factors. They constitute together a structure that can be a stable interaction microbiome – plant (*Bandyopadhyay et al., 2016*).There are rhizosphere microorganisms, endophytes, symbionts that can have a beneficial role for cultivated plants and can be used in future biotechnologies (Ba*rea et al, 2005,* *Fendrihan, 2013*). There are some categories of microorganisms (bacteria and fungi) that can be used in agriculture as growth plant promoting bacteria the (PGPB) (*Fendrihan, 2013;Perez Montaño et al, 2014*), K-solubilizing bacteria (*Meena et al, 2014*), P-solubilizing bacteria (*Zaidi et al, 2009;Owen et al, 2014*), free Nitrogen fixers (Orr et al. 2011), symbionts Nitrogen fixers (*Cauwenberghe et al, 2016*), antagonistic bacteria to phytopathogens (*Solans et al., 2016*) and pests (Lacey et al, 2015). The fungi are used to enhance growth and development – Mycorrhiza (*Rouphael et al., 2015*) and to control pests (*de Faria et al, 2007*). That is why it is necessary to implement the new products in the strategy of ecological agriculture and in the agricultural systems (*Le Mire et al, 2016*) although there are some concerns and lack of trust in these methods. The bio-inoculants, as part of new agricultural production strategy, can modify some chemical properties of the soil like cellulase and dehydrogenase activity this last being enhanced after the application of bio fertilizers (*Piotrowska et al 2012*). Some mixtures of organic and bio fertilizers for example in banana plantlets grow from tissues cultures (*Kavoo-Mwangi et al., 2014*). Under the pressure of environment protection, the alternative to chemicals is the use of bio-inoculants alone or in combination with chemicals in reduced quantities (*Miransari, 2013*)

Biocontrol of pests

Fungi for biocontrol have been used for many years in order to control insect pests, like *Metarrhiziumanisopliae* and *Beauveriabassiana*. Other products contain *B brongniartii* and *Isariafumorosea* against various insects from *Orthoptera, Lepidoptera, Coleoptera* and so on (de Faria et al 2007). The entomopathogenic fungi and bacteria were subjected of co- evolution with hosts (*Joopet_Vilcinskas, 2016*). Zimmermann et al (2013) showed that not only fungi and bacteria are able to be bio-control agents, but some viruses too. There are some microbiological products in order to control the plants worm parasites *Meloidogyne* using the fungi *Trichodermaharzianum* and *T. album*, the bacteria *Bacillus megaterium* (*Radwanet al., 2012*).

Biocontrol of phytopathogens

The biocontrol of phytopathogens by antagonistic bacteria, like strains of *Bacillus subtillis* was tested in laboratory and in climatic chambers in different environmental conditions for antagonism against *Fusariumsolani* (*Dinu et al,. 2016*).Strains of actinomycetes are able to suppress *Streptomyces scabiae* activity in potato (*Tomihama et al., 2016*). The strains from *Bacillus, Lysinibacillus, Terribacillus, Paenibacillus* genera showed an antagonistic activity against main phytopathogens like *Alternaria* sp., *Botrytis cinerea*, *Fusariumoxy sporum* and *F. graminearum*, *Rhizoctonia* sp, and many others (*Fendrihan et al. 2016*). The cases of improving resistance in plants and of having antagonistic activity against phytopathogens generated a huge literature impossible to review here.

Biofertilization

In the strategy of sustainable agriculture an important point is the use of PGPR bacteria which can enhance crops (Vejan et al, 2016). They are able to release metabolites and different substances like siderophores, IAA, ACC, phytohormons, volatile organics QS molecules, enzymes (Bhattacharyya et al. 2012). Some cyanobacteria from genus *Anabaena* have such properties too, used in experiments for germination of rice seed (*Saadatnia et Riahi, 2009*) or for stimulation of growth of wheat (Swarnalakshmi et al,. 2013) and at the same time they can form a complex biofilm in soil together with other beneficial microorganisms like *Metarrhizium , Azotobacter, Serratia, Pseudomonas.*

N'cho and coauthors (2014) note that commercial products with mycorrhiza and bacteria are able to enhance the absorption of phosphorus from soil: Products were developed in Malaysia too based on *Azospirillum* and *Azorhizobium* (*Kairrudin, 2002*). The new bio-fertilizer products are very important for new agriculture and reduced costs of production (*Mohammadi et Sohrabi, 2012*).

Another category are the K solubilisation bacteria (*Meena et al. 2014*) the bacteria from *Bacillus* genus – *B circulans, B mucilaginosus, B edaphicus*, from *Acidothiobacillus, Paenibacillus*, and some fungi like *Aspergillus terreus.*

Commercial products

Generally speaking not many products have clear status, especially in USA and Europe were the legal matter is complicated for this kind of products, and especially because that huge multinational companies did not agree with it. That is why there are only a few companies authorised. Meanwhile, many companies from India, China, and other Asian countries produce and distribute huge amount of such bio-fertilizers and bio-pesticides.

Latvia

BIO 'N' MORE Azotobacter produced by SKS Bioproducts and Azotobacterin produced in Latvia by Bioefekt Ltd.

India

-C Max Bio sciences from India produced bio fertilizers with *Bacillus subtilis* and *B cereus.*

-Another company KN Biosciences offer K and P mobilizing bacteria products and free nitrogen fixing bacteria (*Azospirillum lipoferum*) and mycorrhizal fungi VAM Power. The same company issue some biocontrol products with *Verticillium lecani* (Vertici Power) and with *Beauvaria bassiana* (BB Power and Bevarin)

China

-Xingtai Sinobest Biotech Co., Ltd. Have some products containing *Bacillus mucilaginosus* as P solubilising bacteria

-Shandong Sukahan Bio-technology Co., Ltd. Produces Bio Organic Fertilizer with NPK Organic and Bacteria and many others BIO-GAIN ™ MicrobialFertilizer („is a microbial-based product containing a concentrated blend of non-pathogenic beneficial microorganisms, including condensate bacillus, huge bacillus, brown azotobacter, colloid bacillus, aspergillus oryzae, long handle trichodermin." - citation from company website).

-Hebei New Century Zhoutian Biotechnology Co., Ltd produced a mixture bio organic fertilizer bacteria /nitrogen fixation bacteria, potassium and phosphate dissolving bacteria with the commercial name F 3008G.*Trichoderma* containing product are produced by Hebei Nongwei Biological Science And Technology Co., Ltd.

-Baoyuan Bio-Agri Science & Technology (Shandong) Co., Ltd.produces bio fertilizer containing *Bacilus megaterium.* There are practically too many companies to cite.

Situation in Romania

Some products were issued and even used, being subjects of state office patents, and the researches in this field of activity practically started many years ago and went further with finding new strains for biocontrol and biofertilization. Some products like Trichosemin 25 PTS were used for control of phytopathogenic fungi.

The researchers performed in some projects experiments and many interesting strains of *Bacillus* were isolated (*Constantinescu et al., 2010*) and tested for their antagonistic characteristics in special *B subtilis*, *B amyloliquefaciens*, *B licheniformis* and *B. pumilus* (*Sicuia et al, 2014*), but other genera too. Especially, the *Bacillus* strains showed a huge diversity (*Sicuia et al, 2015*).

CONCLUSIONS

The microbes can help and constitute a solution to the problems of agriculture, used instead or together with chemical pesticide and fertilizers reducing pollution and costs.

The big number of products in the market shows the success of this activity and this can be the dawn of a new sustainable agriculture

Many efforts may be done to implement in the EU and in Romania the production of microbial fertilizers and bio pesticides and some standards for it and, in the same time, to determine the political staff to act in this direction.

NOTE

The names of the companies in the text are mentioned as examples not for advertising purposes.

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MODIFYING THE POTATO DIGGER CONVEYOR WITH ROLLS TO SUIT THE EGYPTIAN CONDITIONS

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تطوير الوسائد الدواره لحصيرة آلة تقليع البطاطس لتناسب الظروف الزراعيه المصريه.

Tarek H. Mohamed*[1] , Mokhtar C. Ahmed[1] ,Hanafi A.Radwan[2]
[1] *Researcher, Agric. Eng. Research Institute (AEnRI), Dokki, Giza, Egypt*
[2] *Senior Researcher, Agric. Eng. Research Institute (AEnRI), Dokki, Giza, Egypt*
Tel: +20105078582; E-mail: tarekqq@hotmail.com

Keywords*: *Potato digger, potato windrower, potato harvester

ABSTRACT

A conveyor with rolls was developed to avoid soil particles to enter the roll bearing by fitting the roll bearing housing outside the harvesting tunnel. Three sets of modified rolls with rod length of (180,200 and 220 mm) were manufactured and fitted on 3 potato diggers of the same model. The three diggers' performances were compared with a digger equipped with original rolls having the roll bearing located inside the conveyor rolls. Every 50 hours of operating roll wearing, digger field capacity un-harvested tubers, and tubers bruising type were measured for each digger. The results indicated that, the new modified rolls operated more hours the original rolls and did not need to change in some positions after 200 hours. Also, it has been found the position of roll fitting affecting the wearing rate of the roll head especially near the conveyor idler and the conveyor agitator. The modified rolls don't affect the performance of the digger field capacity, un-harvested tubers and tuber bruising. The results indicated that the optimum designed rode length was 92 mm (total length 180mm) with thickness of 30 mm that gave lowest roll wearing rate at all positions of fitting and did not affect the machine performance. The percentage of wearing was less than the original roll by 60% in some positions. The new modification was decreasing the maintenance costs for easily assembling and disassembling its parts in the field and did not need workshops or special tools. The modified locally manufactured one set of rolls (8 rolls) was 2720 L.E/season. Meanwhile, the cost of original one set of rolls was 8400L.E/season including replaced rolls saving 32.4% from purchasing cost.

الملخص العربى

تم تصميم وتصنيع الوسائد الدواره لحصيره آله تقليع البطاطس بطريقه تمنع دخول جزيئات التربة داخل الرولمان بلى الخاص بها عن طريق تركيب كراسى الرولمان بلى خارج نفق الحصاد بدلا من تركيبه داخل الرأس الدوارللوسائد. لذا تم تصميم و تصنيع ثلاثه مجموعات من الوسائد الدواره مزوده بأعمده دواره باطوال (180 و 200 و 220 ملليمتر) وتم تركيبها على ثلاثه الآت لتقليع البطاطس من نفس الطراز. وتمت مقارنة أداء الآت التقليع الثلاثه مع آله تقليع مجهزة بواسائد دوراه اصليه مركب فيها الرولمان بلى داخل الرأس الدوار. وتم كل 50 ساعة تشغيل قياس معدل التآكل للراس الدواربالجرام و السعة الحقلية لآلة التقليع (فدان / ساعة)و نسبه الدرنات الغير محصوده للفدان، وقياس نسبه كل نوع من الكدمات علي الدرنات للفدان لكل آله تقليع بطاطس علي حدي. وأشارت النتائج نجاح الوسائد الجديدة المعدلة في التشغيل وعدم تأثيرها على اداء آله الحصاد . وتتميزت الوسائد المطوره عن الوسائد الدواره الاصليه بعمرها الافتراضي الاطول. ووجد انها تعمل ساعات إضافية أكثر من الوسائد الأصلية وليست بحاجة الى تغيير عند تركيبها في بعض الاماكن . كما وجد أيضا، ان مكان تركيب الوسائد يؤثر على معدل تأكل الراس الدوار وذلك في اماكن زياده الاحمال وخاصه في بدايه حصيره التقليع وكذلك بالقرب من الهزاز . وأشارت النتائج إلى أن الطول الأمثل للعمود الدوار هو 180 ملليمتر مع سمك قدره 30 ملليمتر أعطت أقل معدل تأكل للراس الدوار في جميع المعاملات ولم يؤثر على أداء آلة الحصاد نفسها. وكانت نسبة التآكل في الوسائد المطوره أقل من الوسائد الأصلية بنسبة 60٪ في بعض المعاملات . كما ادي التعديل الجديد الى انخفاض تكاليف الصيانة لسهولة فك وتركيب ألاجزاء في الحقل وعدم احتياجه الى ورش متخصصه او أدوات خاصة للفك والتركيب. وكانت تكلفة طقم الوسائد المصنعة محليا(الطقم = 8 وسائد) 2720 جنيها في موسم تشغيل واحد بينما كانت تكلفة الطقم الأصلي من الوسائد الاصليه خلال موسم تشغيل واحد 8400 جنيها مصريا بما في ذلك استبدال الوسائد التالفه بتوفير قدره 32.4٪ من تكلفة الشراء.

INTRODUCTION

Potato *(Solanum tuberosum L.)* is considered one of the most important vegetables crops supplying human with carbohydrate. It is classified as the first alternative of grain crops to solve the shortage of food in some countries. (FAO statics, 2015) mentioned that Egypt produced 4,800,000 tons of potato tubers for local and export usage in 2014. Exported potato tubers must match importer specifications such as dimensions and free of bruising. Potato producers prefer to use one conveyer digger and disengage shakers and agitators to reduce tuber bruising. The ordinary method for using potato digger in Egypt is harvesting tubers by digger then collecting them manually, eye sorting, bagging in jumbo bags then immediately transferred to ports. Bruising is the most important factor that affects potato grade in trading. There are many reasons affecting on potato bruising especially at harvesting. One of these reasons is the action of the separation conveyor. (Zhou et al, 2015) mentioned that the most common potato harvesting method is using a potato harvester, depending on the bed type, which can dig out the potatoes from the bed. Soil and crop are transferred on to a series of sieves where they are sieved out.

(Srivastava, 2006) divided root harvesting machinery into bulk root crop harvesting and controlled root crop harvesting. The bulk root crop harvesting was digging the soil and the crop, while the controlled depend on harvesting only the crop. Potato harvesting is commercially achieved by bulk harvesting. Typically these machines unearth relatively large volumes of soil that contain the roots to be harvested. The machine is designed to separate these large volumes of soil from the potatoes. In principle, this machine moves through a defined volume of soil and engages the product by virtue of the product position within the volume of soil being processed. Once in the machine, the primary function is to sort the potatoes from the soil, soil clods, and stones as gently and completely as possible. Machine elements are designed to remove the soil quickly with as little damage as possible and elevate the clean potatoes into a storage or transport container. (Bishop and Maunder, 1980) mentioned that conveyor chain–belted, hook, and Linderman chains all have advantages and disadvantages. Chain durability can be significantly affected by soil and operating conditions. Belted chains generally cause the least amount of bruise damage, especially on secondary, side elevator, and boom conveyors, where potatoes often suffer injury due to link pinching, rollback, and bouncing. A disadvantage of belted chains is that they do not eliminate as much soil as a hook chain of the same pitch. All rollers on an individual conveyor should be of the same diameter, except where variation in roller size is used to lower drop height between conveyors. Roller size and mounting location should be such that humps in the conveyor bed are minimized to prevent tuber rollback. Using small conveyor bed rollers and head shaft sprockets will minimize the height and slope of the conveyor, resulting in reduced drop height and tuber rollback. Replace worn rollers as needed. Primary–On harvesters with split primary conveyor beds, cover the centre support bar with padding to reduce impact and move potatoes away from the chain link ends. This modification is especially valuable when a windrower is used in conjunction with the harvester because a larger portion of the tubers flow onto the centre of the primary conveyor. (Schweers et al, 2005) mentioned that if the tuber hits steel, the energy involved is absorbed by the tuber. The only way the tuber can dissipate this energy is by skinning, cutting, or bruising (damage of internal cells). If a tuber hits rubber, much of the energy is absorbed by the rubber, leaving very little to be dissipated through tuber damage. The potato tubers should be carried up by the draper chains at nearly the same speed as, or slightly faster (5 to 10 percent) than the machine forward movement. If the conveyors move too slowly, the tubers bunch up, causing mechanical problems and increasing damage due to bumping against each other. If the conveyors move too fast, the tubers also move rapidly. This means that when they hit each other tubers or a part of the machine, there is a higher probability for more damage. They carry soil as far up the draper chain as possible and still allow separation of the tubers from the soil. The soil on the chain provides a cushion for the tubers. (Thornton & Bohl, 1995) made studies and shown that bruising is minimized when conveyors are kept full of potatoes or full of potatoes and other material. Often the harvester ground speed is too slow for the conveyor speeds. Increasing ground speed by shifting the tractor transmission to a higher gear can speed up harvest, increase and smooth out the flow of tubers through the harvester, and reduce tuber damage. Individual conveyors are often at the wrong speed relative to the speed of the preceding or following conveyor. Adjust the ratio of the individual conveyors to each other and to the forward speed by changing the conveyor sprockets. Harvester operators should be taught to reduce bruising by managing the harvester properly. (Mohsenin, 1986) defined bruising as damage to plant tissue by external forces causing physical change in texture and/or eventual alteration of colour, flavour, and texture. Note that there are both physical (texture) and chemical (colour, flavour) aspects in potato bruising. The physical aspects involve physical damage to cell walls, cell membranes, or both; the chemical aspects involve chemical reactions that occur as a result of that damage. The blue-black or grey-black discoloration associated with black spot bruise is results of oxidation of tyrosine by polyphenol oxidize. (Lisa, 1989) mentioned that mechanical injuries are divided into external and internal types. Growers must be aware that the most visible injuries are not always the most serious, and the absence of external injury does not necessarily mean that the tubers are free from internal damage. There are three types of external injuries. Scuffing or skinning results from skin removal when tubers rub against other tubers or equipment. Flesh wounds such as cuts, slices, and gouges are usually incurred on the digger blade or at the edges of chains and elevators. Shatter bruises are single open cracks or star-shaped cracks caused by impact of cold tubers with hard surfaces. Shatter bruise increases as the temperature decreases. Black spot bruise is the most significant internal injury. Black spot bruises, usually about the size of a dime, form below the skin (which is unbroken) and therefore the damage is not readily apparent until the tuber is peeled or cut. They are not immediately apparent at harvest and may take several days to appear. Black spot results principally from impact, but also forms at pressure points on tubers in prolonged storage. The spots, more prevalent on the stem end, can discolour to blue, grey, black or brown and are unacceptable to processors and fresh consumers. Black spot bruise increases as the temperature at harvest increases. (Michael and William, 1998) mentioned that there are four major types of potato bruise damage: skinning, black spot bruise, shatter bruise, and pressure bruise. Black spot bruise occurs when the impact of a potato tuber against an object damages cells in the tissue just beneath the skin without actually breaking the skin. Within 24 to 48 hours interval, the damaged tissue turns dark grey to black in colour, but can be seen only after peeling the potato. (Baritelle et al, 1999) mentioned that it is possible for more than one type of bruise to be present in a given tuber, further complicating classification of the type of bruise has occurred. (Bishop and Maunder, 1980) indicated that the National Damage Survey used the following classification of external visible tuber damage; Scuffed is only skin broken no flesh damage. Peel damage to flesh, which can be removed by a stroke of 3 mm deep of a hand potato peeler. Severe damage is to flesh that cannot be removed by a 3 mm deep stroke of a hand peeler. Flesh damage in the peel and particularly in the severe category may take the form of cuts, gouges, splits or crushing. Bruising is the term applied to internal tissue damage which usually turns blue-black over a period of a few days. The damage index was developed as a tool for comparing the performance of different machines with respect to damage and is based on the amount of peel that has to be removed from the damaged tubers.

The common conveyors fabricated from steel bars fixed on rubber belts with different distance depend on the dimensional properties of the tubers varieties. The harvested materials include potato tubers and soil move on the bars towards backward of the digger. The conveyor takes its motion via a sprocket gears or hydraulic motor and the conveyor lay on a number of loading rolls. Under the Egyptian condition especially in sandy soil, the location of the bearing underneath the conveyor gave a chance to the fine soil materials to enter the bearing causing bearing clogging, and then the conveyor steel bars begin to wear the plastic roll cover. This problem effects directly on the machine performance and decreases the operation hours due to the lost time in changing this part. The aim of this research is developing an innovated loading rolls system suitable for the Egyptian condition by isolating the bearing away from the soil location under the conveyor and studying its effect on the performance on one of the common potato digger in Egypt Grimme RL1700.

MATERIAL AND METHOD

The main idea of the development was preventing the soil particles to enter the roll bearing by fitting the roll bearing housing outside the harvesting tunnel, inside the roll head in the original rolls.

(I) Machine equipped with original rolls:-

The original machine was one of the common usage diggers in Egypt, Grimme RL1700, made in Germany. It was classified as a high speed digger equipped with a long conveyor. The digger was trailed from the tractor rear trailer hitch and takes its power from tractor power take off at speed of 540 rpm to rotate the separation conveyor via a group of sprockets and chains from the main gearbox. The digger was equipped with a front soil cutting tools for two rows. The digger was easily adjusted to harvest potato tubers planted on distance between rows of 750 mm and 900 mm as well. Each row cutting tools were consisted of three digging shears, two side culture discs and depth adjustable Diablo roll. The separation conveyor dimensions were 2500 mm length and 1640 mm width. The harvesting tunnel width was 1700 mm. The distance between centres of the conveyor steel links was 35 mm. The links were fixed on 3 rubber belts with rivets. The machine was equipped with two rear pneumatic rubber wheels of 10.0/75×15. The distance between wheels was adjusted according to the row distance. Also, the machine was equipped with two hydraulic cylinders to engage or disengage the soil cutting tools to enter into the soil. Figure (1) shows a schematic diagram of the components of the original digger.

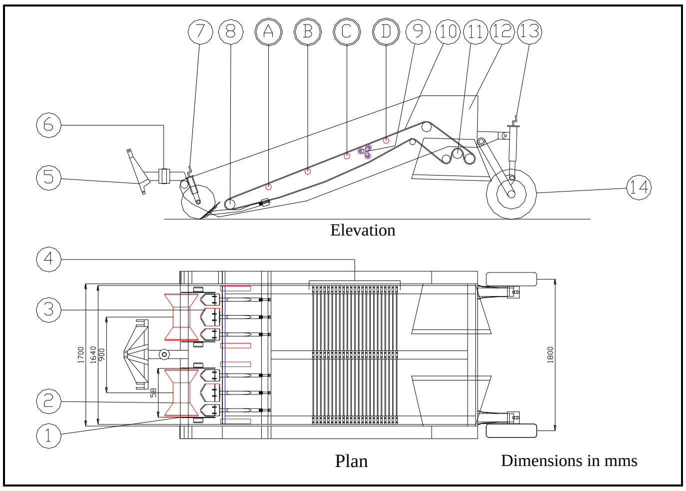


Fig.1 - Schematic diagram for the components of the original digger.

(1) Side culture discs, (2) Diablo roll ,(3) Digging shear, (4) separation conveyor links, (5)Three point hitch trailed device,(6) Horizontal articulated point, (7) Culture discs depth control, (8) Idler roll, (9) Conveyor agitator, (10) Separation conveyor, (11) Sprocket , (12) Side frame, (13) Conveyor tilting angle adjustment, (14) Rear wheel, [(A),(B),(C) and (D)] Conveyor rolls.

The soil layer was lifted by the digging shares. Then, the conveyor separated the tubers from the soil and other impurities and delivered the cleaned tubers gently again on the soil surface. Then, tubers were collected by handy labour. The original roll was consisted casted metal bearing housing coated with cylindrical shape anti-corrosion special polymer (Teflon). Each roll was rotated on a fixed steel rod with threaded end that supported on the digger side frame with locking nut. Two ball bearing sizes of 204 were installed inside the bearing housing and locked by front locking nut. The bearing front and rear cover were pressed to prevent dust to enter inside the bearing hosing. It is realized a clearance between the roll rode and the cover measured 0.5 mm. This clearance allowed the small particles of dust to enter the bearing hosing. Fig. (2) shows a schematic diagram of the components of the original rolls. Also, Fig. (3) shows the clearance between the roll rear cover and the roll.

(II)Machine equipped with modified rolls:-

The main idea of the rolls modification was changing the position of the bearing housing to prevent the small soil particles to enter inside the bearing. A new manufactured bearing housing holder was made from steel sheet with thickness of 8 mm and dimensions of (120 mm length × 113.5mm width × 51.1 mm height) cut by laser beam, bended by hydraulic metal bending machine and welded outer of the digger side frame in the same place of the original rolls.

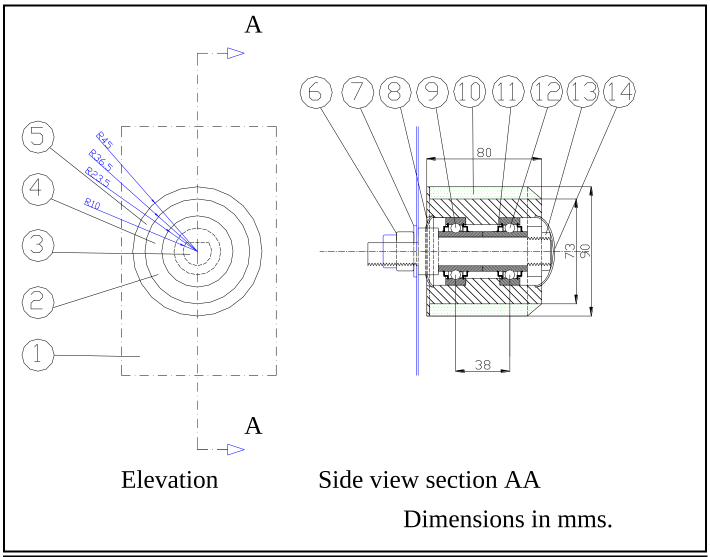


Fig.2 - Schematic of the components of the original rolls.
(1): Side machine frame, (2): Roll head, (3): Roll rod (5): Bearing housing, (6): Rear locking Nut, (7):Washer, (8): Rear roll side cover, (9):Rear ball bearing(10):Polymer coating , (11):Bearing gasket, (12):Front ball bearing, (13):Front locking nut, (14):Front roll side cover.

Fig.3 - The clearance between the roll rear cover and the roll.

Two roll bearing sizes of UC 306 were fixed on the bearing holder by four bolts and locked nuts. A new steel rod was designed to be capable to avoid bending at maximum rod length. It was machined by lathe with diameter of 30 mm and has a built in ring with diameter of 40 mm and thickness of 10mm. The rod passed through the inner side of the bearing then passed underneath the conveyor via an orifice on the digger side frame. A polymer (Teflon) roll head with the same dimensions of the original roll was machined by lathe and pressed in the right side of the threaded end of the rod and locked by lock nut. A steel spacer was placed between the bearing and the roll to adjust the distance between them. The new design was considered adequate for easy assembling and for maintaining during digging operation. Fig.(4) shows a schematic diagram of the modified roll and its components. Also, Fig. (5-A) and Fig. (5-B) show images of the modified roll and its manufactured components.

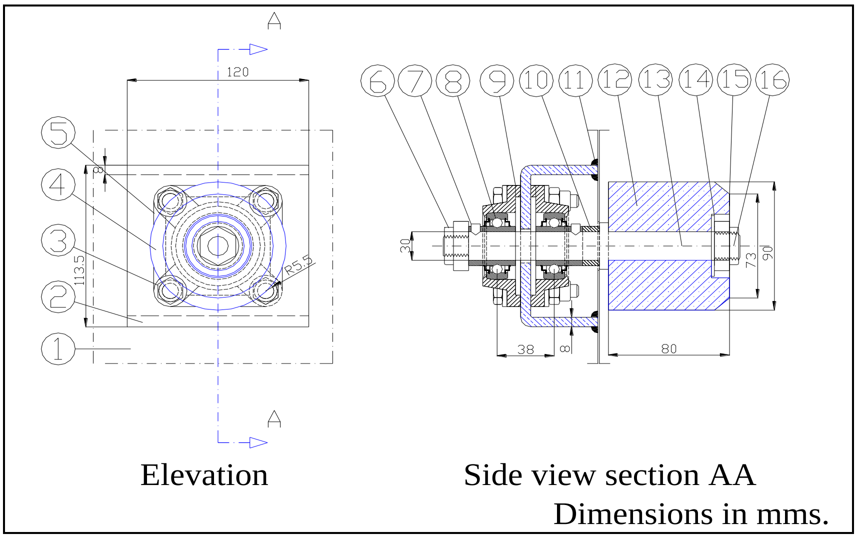


Fig.4 - Schematic diagram of the components of the modified rolls.

(1): Side machine frame , (2):Bearing holder, (3):Bearing Bolts support, (4):Roll head , (5):Bearing housing, (6): Rear locking nut, (7):Bearing lock, (8):ball bearing, (9):Bearing hosing, (10):Spacer (11):Welding (12):Polymer coating, (13):Roll hosing, (14):Roll rode, (15):Front locking nut, (16):Roll side cover.

(A)	(B)

Fig.5 - Image of the modified roll.

(A): Disassembled components of the modified rolls. (B): Assembled modified roll.

Theoretical analysis

The theoretical analysis was made to determine the suitable length and thickness of the roll rod.
The maximum weight on the conveyor can be determined by using the following expression:-

$$M = V \times \rho_{Bulk} = (d \times w \times L) \times \rho_{Bulk} \quad \text{………………………..} (2)$$

where:

M=Mass of the soil and tubers, kg

V= Volume of the tuber and soil above the conveyor.

d= Maximum digging soil thickness according to (Bosoi et al, 1991) = 250 mm

w = Conveyor width = 1640 mm

L= Conveyor working length = 2500 mm

ρ_{Bulk} = Maximum density of the soil and potato tubers (bulk density) according to (Bosoi et al, 1991) = 665 kg/m^3
The soil mass passed from the conveyor links during separation was neglected
M= (0.25×1.64×2.5)×665=681.625 kg
The conveyor slope angle $(\propto_e)$ was measured =(15^o)
$\propto_e < \varphi_s$ then $\propto_e = 20 to 22^o$ recommended angle by (Bosoi et al, 1991)
$\propto_e < \varphi_r$ then $\propto_e = 10 to 15^o$ recommended angle by (Bosoi et al, 1991)
where;
φ_s= the angle of friction for the soil over the metal.
φ_r= the angle of tubers rolling friction over the soil over the elevator surface.
Fig. (6) shows the forces affecting the conveyor roll.

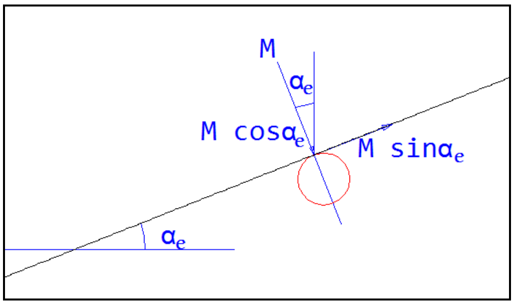


Fig.6 - Forces effect on the conveyor roll.

The dynamic load ($L_{dy.}$) on the conveyor can be determined by using Newton Second Law of Physics as the following expression:-
F (force) = m (mass) × a (acceleration)

$$L_{dy.} = M \times tan \propto_e \times (v_e^2/r)/g \text{..(3)}$$

M=Mass of the soil and tubers, (kg)
v_e=The velocity of the conveyor band ($v_e \geq v_m / \cos \propto_e$) where; v_m= Max. forward velocity of high speed digger. (Bosoi et al, 1991).
v_m was measured = up to 7 km/h
v_e was measured = 1.5 m/sec
g = acceleration of gravity =9.81 m/s^2
r= radius of driven sprocket, mm= 150 mm
$L_{dy.}$= $681.625 \times \tan 15 \times (1.5^2/0.15)/9.81$ = 892.15N
The dynamic load on each roll ($R_{dy.}$) can be calculated as :

$$R_{dy.} = L_{dy.}/n \text{............ (4)}$$

where;
n= number of load element = (8conveyor rolls) + (4sprocket+ 4 Idler) =16 load element
$R_{dy.}$=892.15/16= 55.75 N
The thickness of the bearing rod can be calculated from the equation at direct load on the bearing:-
The diameter of the transmission shaft was calculated according to ASME equation (*Hall et al, 1980*).
The diameter of the shaft (d_{shaft}) can be calculated according to equation (5) for solid shafts having little or no axial loading: _

$$d_{shaft}^3 = \frac{16}{\pi . \sigma_s} \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \text{......................... (5)}$$

where:
d_{shaft} = Shaft diameter
σ_s = Shear stress from tables for steel shafts,
K_b = Combined shock and (0) fatigue factor applied to bending moment,
K_t = Combined shock and fatigue factor applied to torsional moment,
M_t =Torsional moment, $N.m$; =0
M_b =Bending moment, $N.m$.= $L_{dy.} \times l_{s.max.}$

where:

$l_{s.max}$ = Maximum shaft length, mm.

By applying the (ASME code equation) for shaft design with the following data:

K_b **=2** K_t **=1.5**

σ_s **= 60 M Pa = 60** N/mm^2 M_b **=55.75 $\times$129.4=7215.26M Pa**

$$d_{shaft}^3 = \frac{16}{\pi .60}\sqrt{(2\times 7215.26)^2}$$

d_{shaft}= 10.7 mm

Calculated $d_{shaft} \times safety\ factor(2.5)$ = 10.7 ×2.5= 26.75 mm

The rod shaft diameter at maximum rode length ($l_{s.max}$) = the inner radius of the required bearing ≥30 mm. The maximum bending stress and deflection of the roll rod were calculated according to (Flugge, 1962) as the following:-

$$\text{Deflection} = \frac{W\times l_{s.max}{}^3}{3\times E\times MI} \text{.....................} \quad (6)$$

where:

W = applied force *(N)* = $R_{dy.}$, (1 psi =0.00689475728 N/mm^2)

$l_{s.max}$ = Maximum shaft length, mm.

E = Modulus of Elasticity in *psi* =30×10^6 *psi*

MI = Second Moment of Inertia

Moment of inertia was calculated as the following:-

$$MI = \frac{pi\times D^4}{64} \text{...........................} \quad (7)$$

where:

pi= From steel strength tables Tensile Strength for steel (SAE1018) = 45000 *psi*

$pi = 45000\ \ psi\ = (310\ MPa) = 310\ N/mm^2$

$1\ psi = 0.00689475728\ N/mm^2$

D= Diameter, mm.

$MI = \frac{310\times(30)^4}{64}$ = 3923437.5 N/mm^2

$$\text{Deflection} = \frac{55.75\times 129.4^3}{3\ \times 30\times 1000000\times 37.5} = 0.00000033893\ \ mm$$

Bending stress was computed by: 1 N/mm^2= 145.037*psi*

$$\text{Bending stress} = \frac{W\times l_{s.max}}{I/(0.5\ \times D)} \text{......................} (8)$$

$$= \frac{55.75\times 1000\times 145.037738007\ \times 129.4}{3923437.5/(0.5\ \times 30)} = 4000.22\ psi$$

Bearings selection:

The selection of a rolling bearing is made from the manufacturer's catalogue. Most of the bearing selection operations depend on the kind of the load (radial or axial load). All bearings were from roll bearings.

-Dynamic load rating equivalent load:-

- Equivalent dynamic load:-

According to FAG specification:

$$P_b = X\, F_r + Y.\, F_a \quad (N) \quad for\ \frac{F_a}{F_r} \le e \quad (X=1) \quad \text{......}(9)$$

where;

P_b= Equivalent dynamic load

F_r= The redial load acting on the bearing(load on two bearing)

$P_b = \frac{R_{dy.}}{2} = \frac{55.75}{2} = 27.875N$

F_a= Axial load acting on the bearing = *0*

X, Y , e= Factors (from tables depending on the type of the bearing)

$P_b = (1\times 27.875) + (Y \times 0)$

$P_b = 27.875\ N$

- Bearing life (L_b):

$$L_b = \left(\frac{C_b}{P_b}\right)^a \quad \textbf{millions of revolutions.................(10)}$$

where;

a $\equiv$ **3 for ball bearing, =** $\frac{10}{3}$ **for roller bearing.**

C_b $\equiv$ **Bearing load rating capacity (depends on the type of the bearing and manufacture).**

-Selection bearings:

Roll rotating speed per hour (n_{Roll}) was calculated as the following:-

$$n_{Roll} = \frac{v_e \times 100 \times 60 \times 60}{2\pi \times R_{r.}} \;........(11)$$

where:

v_e= The velocity of the conveyor band was measured =1.5 m/sec

$R_{r.}$ = Roll radius, mm.

$$n_{Roll} = \frac{1.5 \times 100 \times 60 \times 60}{2\pi \times 4.5} = 19108 \text{ rev./h}$$

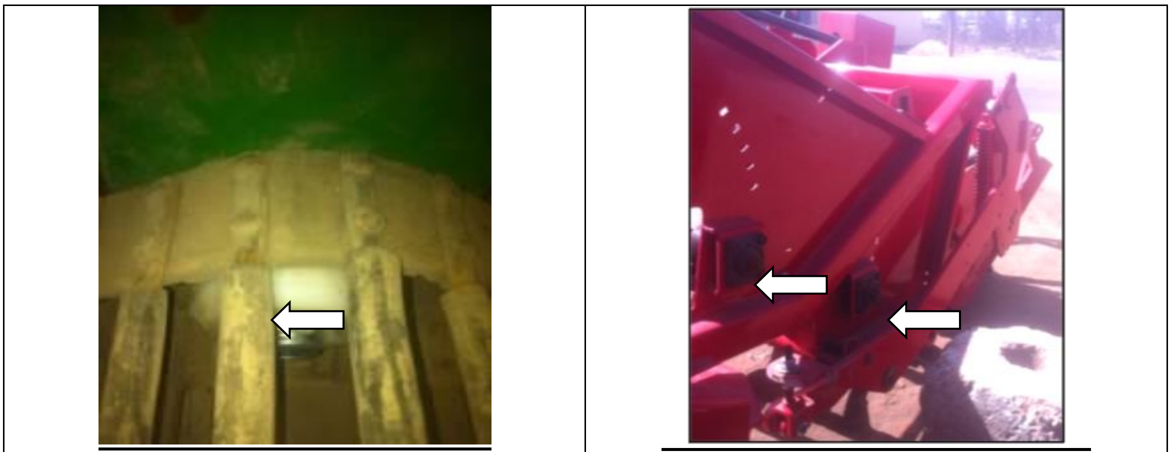
Table (1) shows the specification of the bearings that were used at the end of the rod.

Table 1

Bearings life (L) and specification

Ball bearing	**UC306**
Bearing life (L) (million revolution)	$L = \left(\frac{18700}{27.875}\right)^3$ **=(301,91) (million revolution)**
Life (hours)	$= \left(\frac{301.91 \times 10^6}{19108}\right)$ **=(15800) hours**
Bearing specification:-	
Inner shaft diameter (mm)	**30 mm**
Outer shaft diameter (mm)	**72 mm**
Bearing type	**Ball bearing**
Bearing number	**UC 306**

From calculations, the suitable rod diameter can avoid bending at maximum tested rod length of 30 mm and suitable bearing number is UC306. Fig. (7-A) shows a view for the conveyor rolls after modification underneath the conveyor; also Fig. (7-B) shows the bearing holder support outside the side digger chasses. Also, Fig. (8) shows the digger after modifying the conveyor rolls



(A) **(B)**

Fig.7 - Conveyor rolls after modification

(A): View of the modified roll from the inside of conveyor. (B): View of the modified rolls outside of the digger.

Fig.8 - Digger after modify the conveyor rolls

Measuring instruments:

1-Balance: to measure the mass of the harvested tubers, tubers bruising value. (accuracy of 10 g).

2-Balance: to measure the mass of the conveyor rolls before and after operation (accuracy of 0. 1 g).

3- Stop watch to record the consumed time during calculation digger field capacity at different experiments.

4- Steel tape: to measure the length of the harvested area and measure the rows length when measuring tuber bruising after harvesting.

5-Tractors: (Kubota tractor model M9000 and Landini tractor model Power farm 90) were used during experiments. Both tractors models engine horsepower was 90hp and equipped with narrow tires to move between 90 cm potato rows.

Testing procedure: The experiments were carried out in El-Behera governorate, Nobaria. The treatments were taken during harvesting potato planted in 900 mm rows distance. Three sets of new designed rolls were manufactured (eight rolls per set). Each Teflon roll head was weighed and marked before operation and every 50 hour of operation. The same procedure was made on new set of original rolls to measure the wearing in the polymer coating rolls head that indicated the status of the bearing. Each set was assembled in individual same model machine. At the same treatment (every 50 hours), tubers bruising and field capacity were measured under the same conditions. The bruising measurements were taken according to (Bishop and Maunder, 1980). In each treatment, a 10 meter long of two rows was taken and tuber bruising type was categorized and weighed.

Test factors: The following treatments were studied to evaluate parameters affecting on the performance of the modified digger rolls:-

(1) Actual rod length, mm (180, 200, and 220 mm).

The distance between bearing holder and roll was changed by assembling a square spacer with thickness of 8 mm. In the case of the assembled parts, always occurs the same distance between the original two ball bearings and the modified rolls in any position. Fig. (9-A) shows schematic diagram of the rod length of the conveyor rolls. Also, Fig. (9-B) shows the three positions of the bearing and distance between roll and bearing after manufacturing.

(2) Rolls position under the conveyor. The evaluation studied the effect of the position of the rolls on the bearing in location A, B, C, and D. (locations Shown in Fig. (1)).

Measurements and calculations: -

(1) Bearing life (h):- The conditions of the bearing were taken the indication of the wearing of the roll polymer cover by weighing it every 50 hours of operation.

(2) Harvesting evaluation: - The tubers bruising were taken every treatment. The bruising evaluation was measured according to (Bishop and Maunder, 1980) .The bruising results were taken on one of the most sensitive potato varieties for bruising (Spunta). Every 50 operating hours for each machine, the performances of the machines were measured. The damage index can be calculated taking a sample of tubers and separating them into undamaged, scuffed, peeled and severe classes. Then, the percentages are multiplied by the following factors:

Scuffed x 1 Peeler x 3 Severe x 7. ………… ……………..…. (12)

The total is the damage index. The index can also be expressed on a weight basis taking the weight in each class and expressing it as a percentage of the total weight of the sample. The individual classes are then multiplied by their appropriate factor. The un-harvested tubers weight was also measured during measuring bruising by looking for the un-harvested tubers in 10 meters.

(3) Machine field capacity. (Feddan/h):-

The potato digger field capacity was calculated from the following equation according to Abdou (1991):-

$$FC_d = A / t_c \qquad (13)$$

where:

FC_d= Digger field capacity, feddan /h;

A = Harvested area, feddan;

t_c = Total consumed time, h.

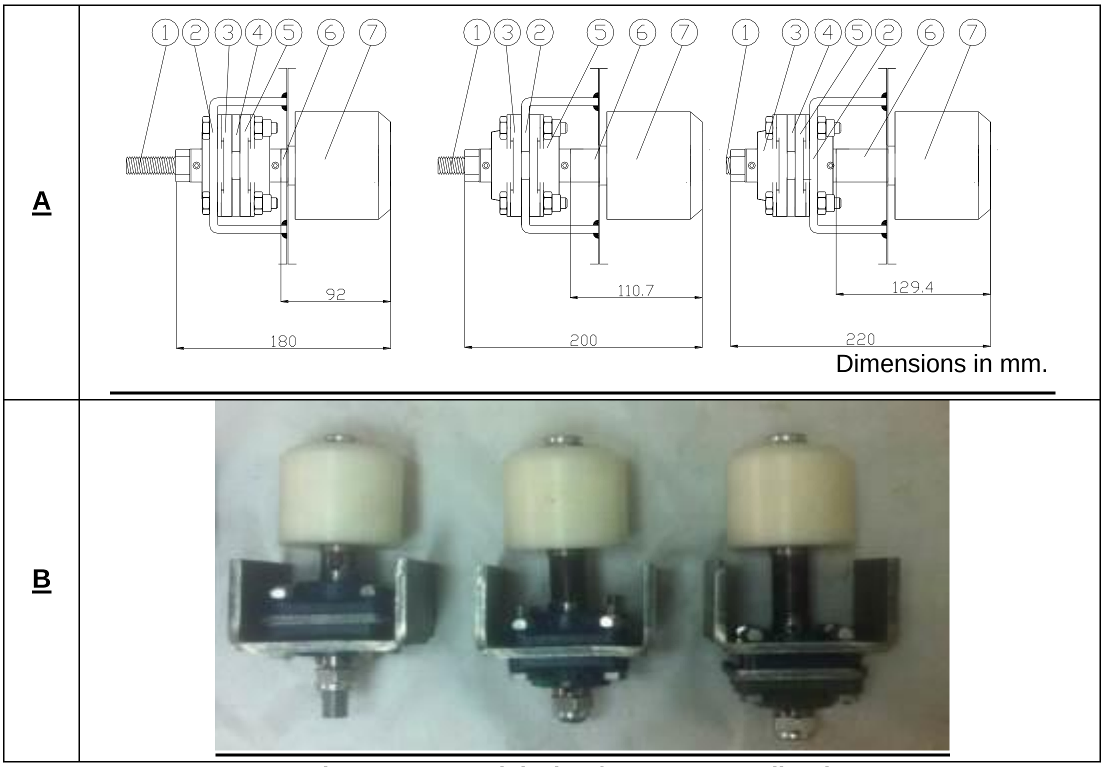


Fig.9 - Innovated design for conveyor roll rods

(A) Schematic diagram of the rod length of the conveyor rolls -(1):Threaded rod end, (2) : bearing holder, (3) : First bearing, (4) :Square spacer ,(5) : Second bearing ,(6) :Tube Spacer , (7) :Teflon roll head.

(B) Image shows the distance between roll head and bearing.

RESULTS

1.Testing the performance of the digger equipped with original conveyor rolls:-

1-1: Digger field capacity equipped with original rolls at different forward speed (FC_d) :-

The performance of the digger was affected by the length of the planted rows to decrease the numbers of tractors turns. The field capacity was calculated at four different forward speeds. The average measured field capacity was 0.61, 0.75, 0.95 and 1.35 feddan/h at forward speed of 1.58, 1.95, 2.29 and 3.5 km/h respectively. Fig. (13) shows the relation between the forward speed and the field capacity of the digger equipped with original conveyor rolls.

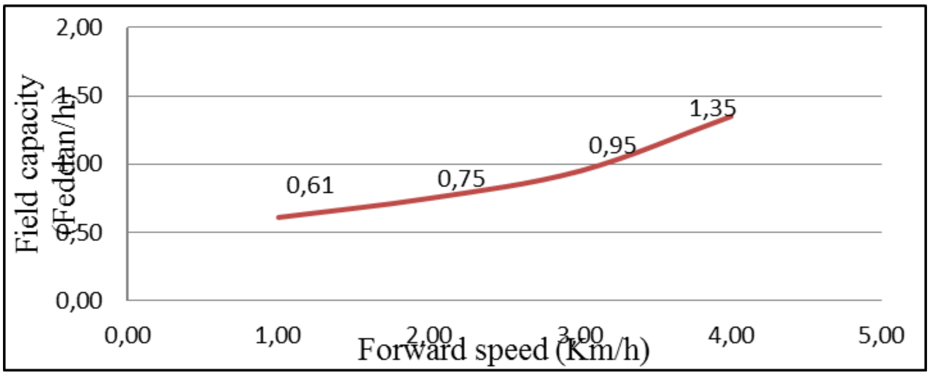


Fig.10 - Relation between forward speed and digger field capacity equipped with the original conveyor rolls.

From Fig.(10) it realized that the field capacity is directly proportional to the forward speed.

1-2: Effect of forward speed on un-harvested tuber (%):-

The measured un-harvested tuber (%) per feddan was (0.64, 0.94, 1.30 and 2.85 (%)) at selected forward speeds of (1.58, 1.95, 2.29 and 3.5 (km/h)) respectively. Table (1) shows the measured un-harvested tuber /feddan at selected forward speeds.

1-3: Effect of forward speed on tubers bruising (%):-

The tuber bruising was calculated at the same forward speeds. From the results, it was realized that the tuber peeling and scuffed percentage were increasing by increasing the forward speed. Also, it realized the severe percentage was decreasing at speed 2.29 km/h then increased at 3.5 km/h due to the increasing of the soil on the conveyor that makes a bed decreasing injured. Table (2) shows the different types of bruising (%) at selected forward speeds. Also, the total un-injured tubers percentage per feddan (was (99.56, 99.00, 98.37, 96.98 (%)) at selected forward speeds of (1.58, 1.95, 2.29 and 3.5 (km/h)) respectively. From the results, the optimum forward speed was 2.29 km/h that gave satisfied felid capacity 0.95 feddan/h, 1.3 % un-harvesting, and percentage 98.37% of un-injured tubers.

Table 2

Effect of forward speed on un-harvested tubers and bruising.

Forward speed (V_t)	Un-harvested (%/feddan)	Tubers bruising (%)/feddan				Un-injured tubers (%)/ feddan
		Peel	Severe	Scuffed	Bruising factor	
km/h						
1.58	0.64	0.13	0.26	0.64	0.44	99.56
1.95	0.94	0.19	0.31	0.81	1.00	99.00
2.29	1.30	0.26	0.34	0.88	1.63	98.37
3.5	2.85	0.51	0.32	0.90	3.02	96.98

2. Effect of the modified conveyor rolls on the performance of the digger:-

The experiments were taken at the optimum digging forward speed of (2.29) km/h with three sets of modified rolls with rod length of (180,200 and 220 mm) and one set of the original rolls (rod length =0 mm) at four positions (A, B, C, and D) of fitting on the conveyor shown in Fig. (1).The modified roll heads were weighted every 50 hour at all treatments and the complete original rolls were weighted.

2-1: Relation between the roll rod length, roll cover wearing and the position of fitting:-

-Generally, the results indicated that the roll wearing was increasing due to increasing the operating hours but the wearing rate value is differ in each treatment.

- The wearing rate of the original rolls (*0 position of the bearing*) at position (A) was extremely increased during operating hours. It was increased (1.5, 1.6, 1.7and 2.2) g every 50 of operated hours then, replaced after 200 hours. The relation was taken the same trend at position (C) until changed after 250 hours. At position (B) and (D) the original rolls, bearing life was reached to 300 h without changing but the wearing rate was very high and increased from (1.3,1.4,1.5,1.9,2.0and2.3(g/50 h)) at potion (B) and (1.2,1.3,1.4,1.7,2.0and 2.1(g/50h)) at position (D). Fig. (11) shows the relation between wear rate (gram/50hour), roll rod length, and position of fitting.

- The modified rolls with rod length of (*180,200and 220 mm length*) were taking the same trend of increasing the roll wearing during operating hours. Comparing the wearing value (g) for the modified rolls to the original rolls, it was realized that the wearing value was decreased. At position (A) after 50 operating hours, the wearing percentage of modified rolls was decreased to 60%, 33%, and 7% at rod length of 180,200 and 220 mm respectively comparing with the original rolls. The wearing values were taken the same trend at positions (B), (C) and (D). From the results, it realized the modified rolls capable to live over 300 hour in position (A) and (C) and not needed to replace comparing with original rolls in same positions. Also, the results indicated that the wearing rate (g/50 hours) was bigger in fitting position (A: *in the beginning of the conveyor where the conveyor loaded with soil*) and (C: *near the conveyor agitator*) than position (B) and (D).The results indicated that the rode length of 180 mm the head wearing percentage comparing to the original rolls at position (A) at (50,100,150,200,250,300 h) were (60.0%,43.7%,35.3% ,45.4% and the original replaced after 200h) respectively . The compared wearing percentages at position (B) after (50,100,150,200,250,300 h) were (38.5%, 42.9%, 33.3%, 47.4%, 25.0% and 26. 1%) respectively. Also, they were at position (C) after (50,100,150,200,250,300 h) were (28.6%, 40.0%, 31.3%, 42.1%, 22.7% and the original replaced after 250h) respectively. At position (D) after (50,100,150,200,250,300 h) were (33.3%, 23.1%, 21.4%, 47.1%, 40.0% and 28.6%) respectively. Also, The results indicated the rode length of 200 mm the head wearing results comparing to the original rolls at position (A) at (50,100,150,200,250,300 h) by(33.3%,31.3%,23.5% ,13.6% and the original replaced after 200h) respectively. The compared wearing percentages at position (B) after (50,100,150,200,250,300 h) were (30.8%, 28.6%, 20.0%, 31.6%, 5.0% and 17.4%) respectively. Also, they were at position (C) after (50,100,150,200,250,300 h) were (28.6%, 33.3%, 6.3%, 21.1%, 31.8% and the original replaced after 250h) respectively. At position (D) after (50,100,150,200,250,300 h) were (16.7%, 30.8%, 35.7%, 41.2%, 25.0% and 19.0%) respectively. Also, The results indicated the rode length of 220 mm the head wearing results comparing to the original rolls at position (A) at (50,100,150,200,250,300 h) by(6.7%,6.2%,-5.9% ,9.1% and the original replaced after 200h) respectively. The compared wearing percentages at position (B) after (50,100, 150, 200, 250, 300 h) were (-7.7%, -21.4%, -6.4%, 21.1%, 0.0% and 8.7%) respectively. Also, they were at position (C) after (50,100,150,200,250,300 h) were (7.1%, -20.0%, -18.7%, 5.3%, 0.0% and the original replaced after 250h) respectively. At position (D) after (50,100,150,200,250,300 h) were (-8.3%, -15.4%, -28.6%, 0.0%, 0.0% and 0.0%) respectively. **Fig. (11)** shows the relation between wearing rate (gram/ 50h) with roll rod length, roll cover wearing and the operation position.

2-2: Effect of the modified rolls on un-harvested tuber (%):-

Fig. (12-A) shows the measured un-harvested tubers values every 50 hours of operating. The minimum value of the un-harvested tuber (%) was (1% at rod length 180 mm), and the maximum value was (1.48 at rod length 220 mm). Also, from Fig. (12-A) it results that the un-harvested tubers percentage values are ranged only 0.5 % and unclear due the other mechanical parts condition or operating conditions. After one seasonal operating (300)h, the un-harvested tubers percentages of the diggers equipped with modified rolls were very near to the digger equipped with the original rolls. The un-harvested tubers percentages were (1.33, 1.40, 1.36, and 1.39) at rode length ((0) original, 180, 200, and 220 mm) respectively.

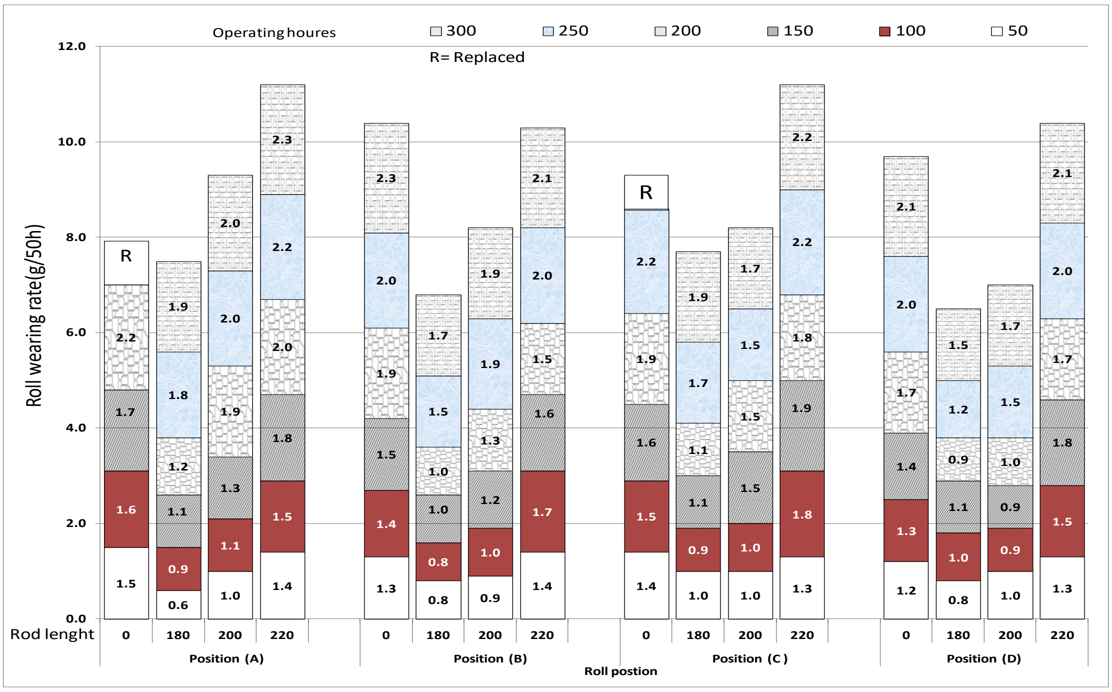


Fig.11 - Relation between wear rate (gram/50hour), roll rod length, and position of fitting.

2-3: Effect of the modified rolls on tubers bruising (%):-

Tuber bruising was measured every 50 hours of rolls operation. At all types of modified rolls, the results indicated that the tuber peeling was ranged from (0.26 % to 0.28 %) compared with (0.24% to 0.27% of the original rolls), severe injuries were ranged from 0.31 to 0.36 % compared with (0.0. 32% to 0.36% of the original rolls) and, scuffed injures were ranged from (0.76% to 0.96%) compared with (0.77% to 0.88% of the original rolls). Fig. (12-B) shows tubers bruising type percentage that were measured every 50 hours of operating. Also, Fig. (12-C) shows the measured uninjured tubers percentage; for every 50brusing types were measured hours of operating.

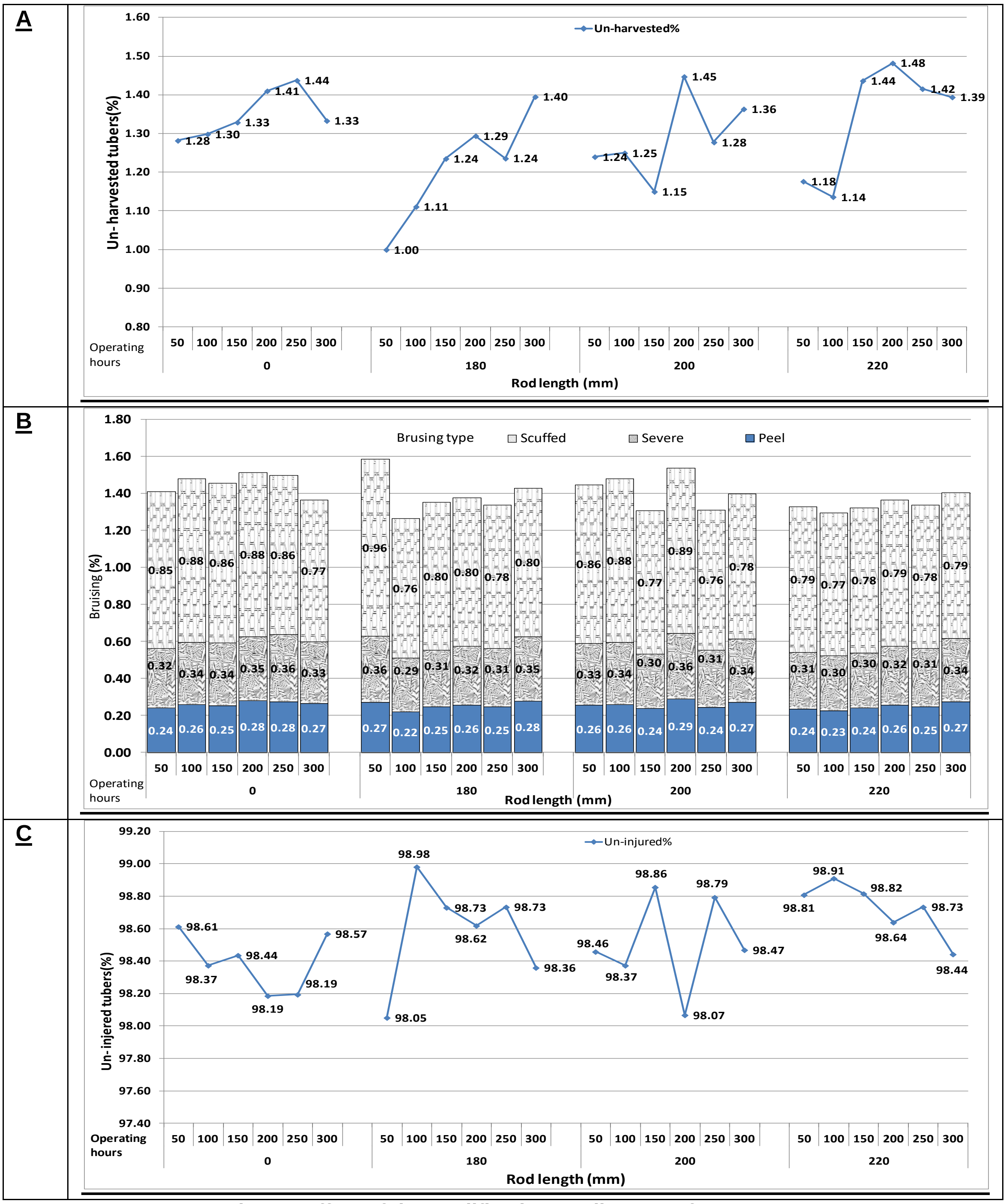


Fig.12 - Effect of the modification on digger performance

(A) Effect of modified rolls on un-harvested tuber (B): Effect of modified rolls on tuber bruising (%/Feddan). (C): Effect of modified rolls on un-injured tubers (%/Feddan)

2-3: Effect of the modified conveyor rolls on the field capacity.

The experiments were taken under the optimum digging forward speed of (2.29) km/h; the field capacity was almost the same field capacity of the digger equipped with the original rolls. This indicates the digger operated successfully with the modified rolls.

The results indicated that the optimum designed rod length is 180 mm (actual 92 mm) that generated the lowest wearing rate at all positions of fitting and did not affect the digger performance.

3-A comparison between the cost of the original and modified conveyor rolls: The cost of the locally manufactured roll was 340 L.E/roll; meanwhile the original roll price was 700 L.E/roll. On the other hand the modified rolls were distinguished of changing the worn-out part in field instead of sending the entire roll to a special workshop. This extremely reduced maintenance cost. The original one set of rolls (8 rolls) was 8400L.E/season including replaced rolls. Meanwhile, the locally modified rolls were 2720 L.E/season saving 32.4% from purchasing cost.

The obtained results can be summarized as follows:-

1- The digger could operate successfully with modified rolls with the same field capacity, un-harvested tuber ratio and bruising tuber ratio of the original rolls. The different in results were insignificant.

2- Avoiding the soil particles to reach the bearing by fitting it outside the digger chasses manages to increase the bearing life.

3- The modified rolls were able to operate without being replaced after 300 operating hours, while the original rolls were replaced in some fitting position after 200h.

4- The rod length is reversely proportional to the rolls wearing rate. This means, forces on the cantilever rod are very effective on bearing and increased due increasing rod length.

5-The new modification decreased the maintenance costs for easy assembling and disassembling its parts in the field and did not require workshops or special tools.

6-Optimum rod length from the edge of the bearing to end of the roll was (92 mm) with thickness of 30 mm and that generated the lowest roll wearing rate in all fitting positions.

The following conclusions and recommendations can be drawn:-

1- The modified rolls can be manufactured locally with common components instead of imported rolls or renewed rolls.

2-The modification is very important to the owners of potato digger harvesters and is suitable to fit to any conveyor digger and reduce the operating cost.

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CONSIDERATIONS ON CEREAL SEEDS TREATMENT USING A ROTATING DRUM EQUIPMENT
/
CONSIDERATII PRIVIND TRATAREA SEMINTELOR DE CEREALE UTILIZÂND UN ECHIPAMENT CU CUVĂ ROTATIVĂ

Ph.D.Stud.Eng. Zaica Al.*, Ph.D. Eng. Manea D., Ph.D. Eng. Paun A., Ph.D.Stud.Eng Nitu M., Ph.D.Stud.Eng Zaica A, Ph.D. Eng. Sorică C.
INMA Bucharest
Tel:0726147336; E-mail: zaica_alexandru@yahoo.com

Keywords: seed treatment, rotating drum, coating process, hydrolysed collagen.

ABSTRACT
This paper presents the results of experimental research with rotating drum equipment designed for technology for cereal seed treatment using insecticides, fungicides, herbicides, fertilizers, growth stimulators or mixtures of hydrolysed collagen and pesticides. In the experiments the following parameters were determined: the seed drums revolution, pump flow rate, the flow rate through the nozzle and the seed coating degree. The results of experimental research have resulted in the establishment of optimal operating parameters of the rotating drum equipment, so as to obtain the highest seed coating degree.

REZUMAT
Lucrarea prezintă rezultatele cercetărilor experimentale efectuate asupra unui echipament cu cuvă rotativă destinat tehnologiei de tratament a seminţelor de cereale, folosind insecto-fungicide, erbicide, fertilizanţi, biostimulatori sau amestecuri de pesticide şi hidrolizate de colagen. În cadrul experimentărilor s-au determinat următorii parametrii: turaţiile cuvei de seminţe, debitul pompei, debitul prin duză şi gradul de acoperire al seminţelor. Rezultatele cercetărilor experimentale au condus la stabilirea parametrilor optimi de funcţionare ai echipamentului cu cuvă rotativă, astfel încât să se obţină cel mai mare grad de acoperire al seminţelor.

INTRODUCTION
Seeds vary greatly in size, shape and colour. In many cases, seed size is small or irregular, making singularization and precision placement difficult. In addition, seeds should be protected from a range of pests that attack germination seeds or seedlings. Research efforts in alternative methods to chemical crop protection are currently being addressed worldwide especially with regards to food safety and environmental sustainability (Nicholas and Groot, 2013)

A viable alternative to increase efficiency is to use coating polymers by film-coating. In the film coating process, active material is allocated to the seeds without causing changes in shape and size (*Lagoa et al.*, 2012). That process provides greater fluidity and efficiency in sowing which enables distinguishing high value seeds. Moreover, pre-sowing physiological treatments (seed priming, fluid drilling etc.) for seed enhancement have a pivotal role in seed treatment technology (Sharma, 2015).

Seed-coating technologies can be employed for two purposes: they can facilitate mechanical sowing to achieve uniformity of plant spacing, and can act as a carrier for plant protectants. After sowing, seeds are still exposed to biotic and abiotic environmental factors (*Delouche*, 2005) and agricultural soils have many pathogenic microorganisms that may interact with seeds and seedlings (*Munkvold and O'Mara*, 2002) and can reduce their performance causing seed rot, seedling death or root rot (*Pinto*, *2000*). Phytophagous insects in the soil can also damage seedlings (*Girolami et al., 2009*), and significantly reduce the plant population. In this context, seed treatment is an alternative for improving seed and seedling performance. So materials can be applied in the target zone with minimal disruption to the soil ecology and environment (*Francisco et al., 2014*).

Film coating is a method adapted from the pharmaceutical and confectionery industries for uniform application of materials to seeds. The film forming formulation consists of a mixture of polymer, plasticizer and colorants (*Halamer, 1998 and Robani, 2015*), and formulations are commercially available, as they are ready-to-use liquids or prepared as dry powders (*Ni, 1997*). Application of the film-forming mixture results in uniform deposition of material on each seed with little variation among seeds (*Halmer, 1998*). The formed film may act as a physical barrier, which has been reported to reduce leaching of inhibitors from seed coverings and may restrict oxygen diffusion to the embryo (*Duan and Burris, 2008*).

However, the coating technology must be adapted to each species due to possible problems regarding germination (*Melo et al., 2015*), e.g., a decrease in water and gas availability as a result of the formation of physical barriers on the tegument

A standard pelleting pan has been adapted for application of film-coating polymers, and drying is achieved by applying forced warm air into the coating pan (*Taylor and Eckenrode, 1993*). A small-scale apparatus for seed-coating in fluidized bed has been described with controlled air velocity and temperature (*Burris et al., 1994*). Film coating is routinely performed in vented or perforated pans on a large-scale basis either on a batch or continuous system (*Halmer, 1998 and Robani, 1994*). The introduction of a continuous process vented-drum coating machine by Coating Machinery Systems (*Huxely, Iowa*) has expanded the use of film coating. This equipment is capable of continuous application of various polymer systems and components, while providing drying capacity to prevent the seed from hydrating. Capacities vary from 100 to 10,000 kg/h depending on seed type, and target weight gain.

MATERIAL AND METHOD

Description. Component parts

Rotating drum equipment for seed treatment, designed and developed by INMA Bucharest is intended for cereal seed treatment technology using insecticide, fungicides, herbicides, fertilizers, pesticides and growth stimulators or mixtures of hydrolysed collagen.

Technical equipment for seed treatment ETS (Fig. 1) has the following structure: framework (pos. 1) - welded construction with rectangular tubing provided with brackets and insurance for other component parts; seed hopper (pos. 2) - made of stainless steel with 5 mm thick, covered with an enamelled mantle and provided with a coupling flange on the shaft gear motor drive; the flange (pos. 3) with the shaft (pos. 4) are elements used for transmission of the motion from the motor reducer to the drum seed; - plate (pos. 5) which is fixed to the gear motor, is articulated on machine framework through a bolt (pos. 6), and with the adjuster (pos. 7) which is welded to the frame, provides adjustment of the angle of inclination of the assembly gear motor - seed drum within the limits of -90 ... + 90 °; gear motor (pos. 8); the carrier arm - the nozzle (pos. 9), provided with two systems of rotation of the spray body for adjusting the angle of spray in two orthogonal planes within the limits of -90 ... + 90 °; the device for application by spraying treating solutions (pos. 10) is composed of a tank made of stainless steel, a way valve, a drain valve, a pump, a pressure regulator debit, a manometer with glycerine, a mechanical agitator, an anti-drip valve body spray, fittings and sites; hot air generator (pos. 11); flexible tube made of aluminium (pos. 12) that directs the warm air inside the rotating drum; the electrical installation for power and control (pos. 13).

Fig. 1

Experimental model of technical equipment for seed treatment ETS

Way of operation:

- in the case of seed treatment with liquids

The amount of predetermined seeds is inserted into the drum and treatment solution in the liquid container. Adjust the working speed of drum by means of the frequency converter, the speed of stirring of the solution by means of mechanical stirrer and controls the pressure in the spraying device by means of the system pressure and flow.

The liquid pump takes the spray liquid from the solution tank and through the pressure regulator and flow, forward part of the spray solution to the nozzle and the excess solution is returned to the tank, thus achieving a further stirring of the solution.

After application of the appropriate amount of treatment solution over the mass seed in the drum, which is connected in rotation, the pump and the mechanical stirrer stops and the hot-air generator started. By means of the flexible tube, the hot air is directed into the seed drum, thus making the drying of the seed mass. After the time of drying is controlled manually stop the hot air generator and gear motor. Process is restarted with another batch of seeds.

- in the case of coating seeds

In the coating process, operations were carried out similarly to those described above, except that the moistening is carried out with a binder, followed by mixing the powder with a thin film based on insecticides, fungicides and growth stimulators and drying with hot air. The successive application of powdery mixtures is performed manually.

Table 1

Main constructive and functional features of ETS

Power supply		220 V, 50Hz
Gear motor	Electric engine power	0.75 kW
	Speed of electric motor	2770 rev/min
	Gear type	screw - worm gear
	Ratio reduction	1:5
Pump	type	With diaphragm
	Power supply	12 V cc
	Maximum flow rate	8 l/min
	Maximum pressure.	4 bar
Stirrer	type	Mechanical, with paddle
	Power supply	120 W
	maximum stirring capacity	5 l
	Stirring speed	adjustable, 200 -1000 rev/min
	Fluid viscosity	Up to 50.000 mPa*s
Hot air generator	power	3 kW
	Maximum flow rate	250 m^3/h
	Connection diameter	155 mm
Angle inclination of rotating drum		-90° ... +90°
Mixing tank capacity		3.6 l
Dimensions	length	1120 mm
	width	1360 mm
	height	1180 mm
Mass		103 kg

Adjustments needed to be made for proper operation of technical equipment for seed treatment are:
- Adjusting the inclination angle of the seed hopper – is run manually by sliding the adjustment screw along the semi-circular sector and fixing the position by tightening the nut;
- Controlling the speed of seeds drum - is performed using the controls frequency converter;
- The stirrer speed of the solution – is performed with mechanical stirrer commands;
- the pressure adjustment in spraying facility- is performed manually using pressure and flow regulator.

Tests for technical equipment for seed treatment were conducted in June 2016 at the headquarters INMA Bucharest in the Department for tests tractors and machinery in agriculture and food industry.

To determine the quality of the processed product before treatment the following characteristics of samples of seed were determined: level of impurities, degree of the breach, humidity and hectolitre weight (Fig. 2). The values obtained are presented in Table 2.

determining the level of impurities *determining the level of breaches*

Fig. 2 - Aspects during determining the characteristics of seeds

Table 2

The characteristics of seeds

Den. No.	Characteristics	Unit of measurement	No. of sample	Value
1.	Humidity	%	PI	12.63
			PII	12.10
			PIII	12.01
			Average	12.25
2.	Physical purity	%	PI	99.67
			PII	99.78
			PIII	99.51
			Average	99.65
3.	Breaches	%	PI	3.1162
			PII	2.9725
			PIII	3.0071
			Average	3.0300
4.	Hectolitre mass	%	PI	75.67
			PII	74.98
			PIII	75.16
			Average	75.27

The substance used during treatment of experimental research has been Vitavax 200 FF (colourless) was added to the green pigment (tartrazine E 102 Brilliant Blue FCF E 133 +).

Measurements were performed at least 500 seeds per sample in 3 repetitions. A seed is considered treated if the outer surface is covered at least 90% with the chemical treated, according to the international standard ISTA seed testing (sampling).

Determination for seed drums revolution

In determining for seed drum revolution was taken into account recommendations from the literature regarding the angles of the drum seed;

Such measurements were made for angles of 20 °, 25 °, 30 °, 35 °, 40 °.

For each of inclination angle of the drum seed, the speed was measured with electronic tachometer 461 895 EXTECH, the output shaft of the gear motor, in the three repeats (Fig. 3). The frequency for each speed was read on the display of the frequency converter.

Fig. 3 - Aspect during revolution measurement output shaft of the gear motor, using electronic tachometer

Determination of pump flow

The pump rate was determined by the volumetric method, the collection and measuring of the liquid with cylinder for 1 minute, while the pump is working at a working pressure comprised between 0-4 bar. Samples were made at pressures of 0.5; 1; 1.5; 2; 2.5; 3; 3.5; 4 bar. For each three pressure measurements were made of the flow rate and the average values were calculated.

Determination of flow through the nozzle

The flow rate through the nozzle was determined by Herbst nozzle tester (Fig. 4), the pressures at which the measurements were made for the pump flow, respectively: 0.5; 1; 1.5; 2; 2.5; 3; 3.5 and 4 bars. For each pressure measurements were made three. Were determined and then the average values of the flow in the nozzle. The amount of liquid in litres, which flows through the nozzle for 1 minute that is the actual flow through the nozzle. According to EN ISO 16122-2 SR: 2015 this value must not be deviate by more than ± 15% of the flow rate of the nozzle manufacturer, the maximum working pressure.

Fig. 4 Measurement of flow through the nozzle by using the nozzle tester

Determination of the seed coating degree

The coverage degree (Ga) was determined using the following formula:

$$Ga = (n_s / n_t) \times 100\ (\%),$$

Where: ns - number of treated seeds; nt - total number of seeds in the sample.

RESULTS

The results obtained from the measurements for determining the seed drum revolution are presented in Table 3.

Table 3

The results obtained in the determination of drum seed speeds

Tilt angle: 20°						
Frequency (Hz)	**9.3**	**9.1**	**9.0**	**8.8**	**8.5**	**8.2**
Speed (rev/min)	50	45	40	35	30	25
Tilt angle: 25°						
Frequency (Hz)	**8.9**	**8.7**	**8.6**	**8.5**	**8.2**	**7.9**
Speed (rev/min)	54	49	44	36	30	20
Tilt angle: 30°						
Frequency (Hz)	**8.8**	**8.5**	**8.3**	**8.0**	**7.9**	**7.7**
Speed (rev/min)	58	53	48	43	30	20

Tilt angle: 35°						
Frequency (Hz)	**7.7**	**7.5**	**7.3**	**7.1**	**7.0**	**7.9**
Speed (rev/min)	50	45	40	35	30	20
Tilt angle: 40°						
Frequency (Hz)	**7.2**	**7.0**	**6.8**	**6.6**	**6.4**	**6.2**
Speed (rev/min)	52	47	42	37	32	10

In tests it has been observed that, for each angle of inclination of drum seed there is a minimum speed at which the seeds begin to adhere to the wall of the drum and the centrifugal force to be driven in rotation, without further carry out the homogenization of the mass of seeds. The values of these speeds are indicated in table 3 on a yellow background, and chart their variation depending on the angle of inclination is shown in figure 5. Can be seen from figure 5 the decreasing trend of minimum speed with increasing angle of the drum.

In conclusion, the optimal speed range of seed drum is between 10 rev / min and 35 rev / min, readable the corresponding frequency range converter between 6.2 Hz and 8.8 Hz.

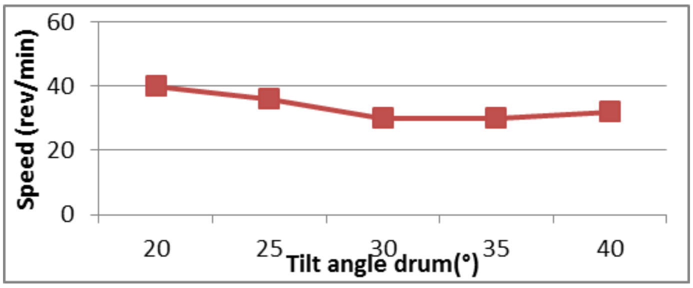

Fig. 5 - Minimum speed variation with angle inclination of the drum

Pump flow diagram according to the pressure variation is shown in Figure 6. By analysing this diagram, there is achieved that the pump flow rates between 2.1 and 6.48 l / min satisfying the functional requirements of the device.

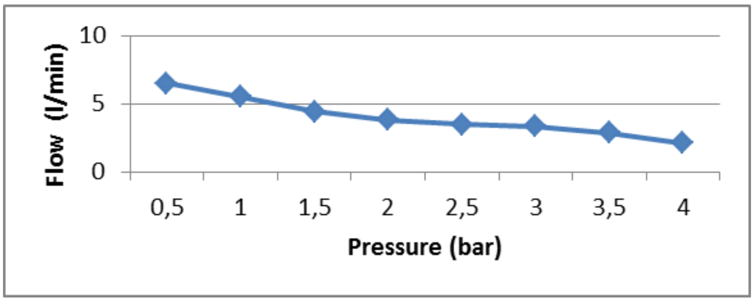

Fig. 6 - The variation of the pump flow according the pressure

The results of the measurements obtained to determine the flow rate through the nozzle are shown in Table 4. By comparing the values obtained from measurements given in the catalogue of the manufacturer of nozzles (Arag), it was held that this requirement is satisfied.

Table 4

The average values of the flow rate on the nozzle

Pressure (bar)	0.5	1	1.5	2	2.5	3	3.5	4
Flow through the nozzle (l/min)	0.31	0.48	0.6	0.68	0.77	0.86	0.96	1.08

Table 5

Experimental results obtained for determining the coverage degree

Angle inclination of drum (°)	Rotation speed (rev/min)	repetition	Coated seeds (Sample taken)		Treated seeds (Minimum 90% of the seed surface covered)		Untreated seeds (Less than 90% of the seed surface covered)		**The degree of coverage (%)**
			Number of collected seeds	Quantity (g)	number	quantity (g)	number	quantity (g)	
20	25	1	500	183	414	152	86	31	**82.8**
		2	500	180	429	152	71	28	**85.8**
		3	500	179	432	152	68	27	**86.4**
	30	1	500	182	394	143	106	39	**78.8**
		2	500	191	402	146	98	45	**80.4**
		3	500	190	396	144	104	46	**79.2**
	35	1	500	183	373	137	127	46	**74.6**
		2	500	184	382	140	118	44	**76.4**
		3	500	188	378	154	122	34	**75.6**
25	20	1	500	199	456	181	44	18	**91.2**
		2	500	195	462	180	38	15	**92.4**
		3	500	183	462	169	36	14	**92.8**
	30	1	500	193	439	169	61	24	**87.8**
		2	500	192	424	162	76	30	**84.8**
		3	500	190	431	163	69	27	**86.2**
30	20	1	500	187	487	182	13	5	**97.4**
		2	500	199	469	185	31	14	**93.8**
		3	500	179	482	173	18	6	**96.4**
35	20	1	500	180	421	149	79	31	**84.2**
		2	500	190	428	160	72	30	**85.6**
		3	500	179	429	151	71	28	**85.8**
40	10	1	500	183	401	144	99	39	**80.2**
		2	500	179	404	141	96	38	**80.8**
		3	500	192	416	160	87	34	**82.6**

Fig. 7 - Seed sample treated with ETS equipment

CONCLUSIONS

Main conclusions from the research of experimental seed treatment equipment ETS are:

- Optimal speed range of seed tank is between 10 rev / min and 35 rev / min, read the appropriate frequency range frequency converter between 6.2 Hz and 8.8 Hz;
- The highest values for coverage of the seeds were obtained for the angle of 30 ° and drum speed of 20 rev / min;
- Values of 90% for the coating of seeds were obtained and the angle of inclination of the drum by 25 ° and the speed of 20 rev / min;

- The degree of coating of the seeds decreases with increasing speed, at the same angle of inclination of the drum seed.

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MICROBIOLOGICAL MONITORING OF WATER SUPPLY BY THE DETECTION AND COUNTING OF *Escherichia coli* AND COLIFORM BACTERIA USING THE MEMBRANE FILTRATION METHOD
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MONITORIZAREA MICROBIOLOGICĂ A APEI DE ALIMENTARE PRIN DETECŢIA ŞI, NUMĂRAREA Escherichia coli ŞI A BACTERIILOR COLIFORME UTILIZÂND METODA FILTRĂRII PRIN MEMBRANĂ

Lect. Ph.D. Eng. Safta V.V.*[1)], Eng. Ciucă V.-C.[2)]
[1)] Universities Polytechnic Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
[2)] N.S. ''Pasteur Institute" Bucharest / Romania
Tel: 0724017310; E-mail: saftavictorviorel@yahoo.com

Keywords: *microbiological monitoring, water supply, Escherichia coli, coliform bacteria, detection, counting, membrane filtration method*

ABSTRACT
In the paper is presented a study of microbiological monitoring of water supply from the deep wells of the National Society "INSTITUTUL PASTEUR" S.A. from Bucharest, by detection and counting of Escherichia coli and coliform bacteria using the membrane filtration method. The membrane filtration method is a reference method for detection and counting of Escherichia coli and coliform bacteria being standardized in our country (SR EN ISO 9308-1). The method consists of two parts, the standard reference test and optional quick test, tests that can be performed in parallel and is indicated to be applied to the microbiological control of water intended for human consumption.

REZUMAT
În lucrare este prezentat un studiu de monitorizare microbiologică a apei de alimentare provenite de la puţurile de mare adâncime ale Societăţii Naţionale "INSTITUTUL PASTEUR" S.A. din Bucureşti prin detecţia şi numărarea Escherichia coli şi bacteriilor coliforme totale utilizând metoda filtrării prin membrană. Metoda filtrării prin membrană este o metodă de referinţă pentru detecţia şi numărarea Escherichia coli şi bacteriilor coliforme totale, fiind standardizată în ţara noastră (SR EN ISO 9308-1). Metoda constă din două părţi, testul standard de referinţă şi testul rapid opţional, teste care se pot efectua în paralel şi este indicat a fi aplicată la controlul microbiologic al apei destinate pentru consumul uman.

INTRODUCTION
Coliform bacteria, *Escherichia coli*, enterococci, clostridium perfringens are microorganisms from the environment whose presence in water can cause waterborne diseases.

From them, the fecal coliform bacteria are a group of bacteria that are passed through the fecal excrement of humans, livestock, and wildlife. From this group, the most representative bacteria after how often they are found are *Escherichia coli*.

Fecal coliform bacteria can reach and contaminate surface or groundwater under the influence of the floods or of the water infiltration-percolation, formed after rainfall or melting snow which come in contact and carry human or animal wastes therein. Such situations can arise when row domestic wastewater is discharged directly into ditches or natural waterways, or by infiltrations from sewers or by poor farming practices such as spreading of manure and other natural fertilizers on land during rainy periods or washing animals in surface watercourses. Always the presence of *Escherichia coli* in water is a strong after recent sewage or animal waste contamination.

If these contaminated surface waters or ground waters are used as sources for the water supply systems and the water supply is not treated properly, coliform bacteria or *Escherichia coli* can get into the human drinking water. It can be mentioned that there are many different strains of *Escherichia* coli and from them the most severe is *E. coli* O157:H7, which produces a strong toxin that can cause severe illness. Symptoms of the ingestion of contaminated water with coliform bacteria vary widely, from no visible effects up to cramps and diarrhea. To the sensitive categories, especially children under 5, elderly and people with weak immune systems, the infection can cause haemolytic uremic syndrome (HUS).

It results that the presence and intensity of fecal pollution is an important factor in assessing the quality of water bodies and an infectious risk for the human health.

Therefore the presence of *Escherichia coli* and total coliform bacteria in the water supply are key indicators of the water quality, in microbiological point of view, essential to determine its possible uses. Inspection of water supply for the presence of Escherichia coli gives an indication of fecal pollution. However, the inspection of the water supply for the presence of coliform bacteria can be more difficult to interpret because of the possible presence of coliform bacteria living in soil or surface water, which are not always of intestinal origin. Thus, the presence of coliform bacteria in the water supply samples, even though is not a proof of the fecal contamination, may indicate a contamination due to improper treatment or distribution. In this case, the identification of the detected strains may provide an indication of their origin.

In this regard, the water supply systems, especially those that use surface water sources, need to be equipped with facilities to monitor and protect against bacterial contamination.

The filtration membrane method used for the detection and counting of Escherichia coli and total coliform in water has been intensively studied worldwide [Barrell 1992, Clark et al. 1991, Dufour et al.1981, Eckner 1998, Havelaar et al. 1988, Schets et al. 1991, Schets et al. 1993], as such or in comparison to other methods for detection and counting, imposing itself and being validated like a reference method and standardized at world and European level.

In the present paper is presented a study of microbiological monitoring of water supply from the deep wells of the National Society "INSTITUTUL PASTEUR" S.A. from Bucharest, by detection and counting of Escherichia coli and coliform bacteria using the membrane filtration method.

MATERIAL AND METHOD

The method of detection and counting of Escherichia coli and coliform bacteria, which is based on membrane filtration, is subject to the Romanian standard SR EN ISO 9308-1, which is identical to the European standard EN ISO 9308-1: 2000.

The method consists of two parts, the standard reference test and optional quick test, tests that can be performed in parallel and is indicated to be applied to the microbiological control of water intended for human consumption, but can be also applied to other types of water, as long as the suspended matter or background flora does not interfere with the filtration, target cultures and their counting.

It is noted that the coliforms are Gram-negative bacteria in form of rods, which are not spore-forming, which give a negative reaction to the oxidase test, which are capable of aerobic and facultative anaerobic growth in the presence of bile salts (or other surface-active agents with similar growth-inhibiting properties) and are able to ferment lactose with production of acid and aldehyde in incubation conditions for a period of 48 hours, at a temperature of 36 ± 2°C. *Escherichia coli* are coliform bacteria capable of producing indole from tryptophan within 21 ± 3 hours at a temperature of 44 ± 0.5°C, possess β- glucuronidase enzyme, give a positive result at the methyl red test and can decarboxylate L-glutamic acid, without producing acetyl methyl carbinol, using the citrate as the only carbon source, or by growing in KCN bouillon.

The standard test consists of the membrane filtration of the water samples, the incubation of the membrane in a selective medium, followed by a biochemical characterization of the typical lactose-positive colonies, which lead to the detection and counting of coliforms and *Escherichia coli* within 2-3 days. The standard test has a low selectivity, allowing the identification of bacteria injured and is suitable mainly for the disinfected water control, but also for other potable waters with low bacterial numbers.

The quick test for the detection of *Escherichia coli* in 24 hours is used in special cases when the analysis results are needed quickly and is based on membrane filtration, followed by cultivation in certain conditions and calculation of the number of *Escherichia coli* of the sample.

If both tests, the standard test and the quick test, are performed in parallel, the end result for *Escherichia coli* should be the higher result of the two tests.

The equipment suitable to apply these methods is generally the usual microbiological laboratory equipment and particularly:

- sterilizing steam or flame equipment;
- incubator or water bath, capable of being maintained at the temperature of 36±2ºC;
- incubator or water bath, capable of being maintained at the temperature of 44±0.5ºC;
- pH-meter with accuracy of ± 0.1
- membrane filtration apparatus, according ISO 8199;
- sterile membrane filters, with cellulose-ester in composition, with diameter of approximately 47 or 50 mm, with filtration features equivalent to a nominal pore diameter of 0,45 mm and preferably with grid;
- laboratory glassware;

- forceps with rounded tips for handling membranes;
- UV lamp with a wavelength of 254 nm (mercury low pressure lamp);
- filter paper disks with a diameter of at least 47 mm.

The membrane filtration apparatus used in the experimental study is composed of a Multibranch Filtration System and a Diaphragms Vacuum Pump. The Multibranch Filtration System [*Sartorius* 16824/28/31/32 Multibranch Filtration System, Directions for Use, 2005] is equipped with 3 or 6 filter units (see figure 1) that can be operated individually or simultaneously. Each filtration unit comprises a funnel (with a lid), a membrane filter holder (adjustable for membrane filters with diameter of 47 or 50 mm) and a tap for individual operation of each unit. The funnels with volumes of 500 or 100 ml have convenient level marks in order to simplify filtration of premeasured quantities of samples. To note that the system is made of stainless steel.

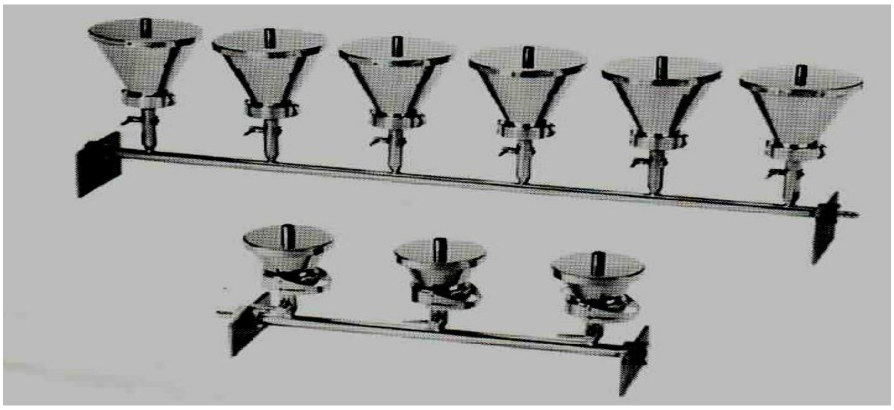

Fig.1 - 6-Branch Filtration System with 500 mm Funnels and 3-Branch Filtration System with 100 mm Funnels [*Sartorius* 16824/28/31/32 Multibranch Filtration System, Directions for Use, 2005**]**

The Diaphragm Vacuum Pump [*Sartorius* 16612/16615 Diaphragm Vacuum Pump, Operating Instructions, 2005] is specially designed for operating together with the membrane filtration system presented above (see Figure 2), providing a pumping air flow of 26 l/min (at atmospheric pressure) and a vacuum level of 13 mbar (10 torr). It has a highly durable, quiet and very safe operation.

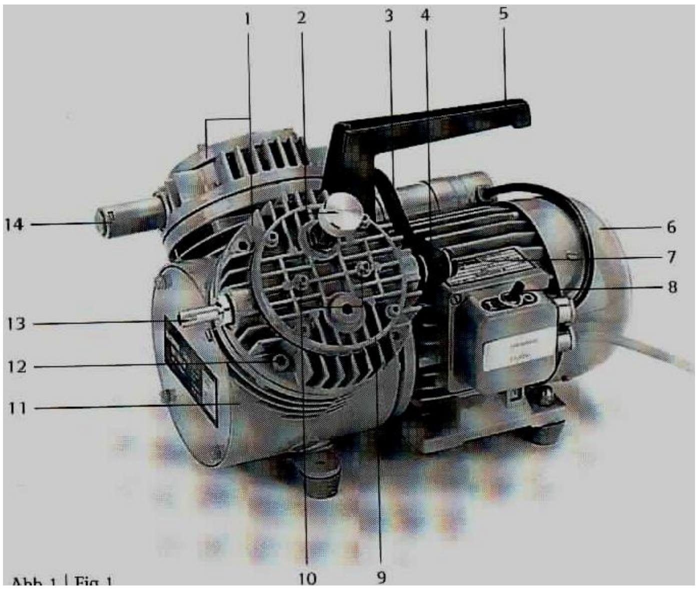

Fig.2 - Diaphragm Vacuum Pump [*Sartorius* 16612/16615 Diaphragm Vacuum Pump, Operating Instructions, 2005**]**

1 - diaphragm heads; 2 - reducing valve; 3 - connecting tube; 4 - threaded nut; 5 -carrying handle; 6 - end cover plate (for fan); 7- manufacturer's label; 8 - power switch; 9 - cover plate; 10 - Allen screws; 11 - housing; 12 - Allen screws; 13 - vacuum connection; 14 - air exhaust

RESULTS

The study of microbiological monitoring of water supply from the deep wells of the National Society "INSTITUTUL PASTEUR" S.A. from Bucharest, by detection and counting of Escherichia coli and coliform bacteria using the membrane filtration method was done for the wells number 1, 4, 6 and 9, for two months (September-October 2015) at weekly intervals, comparing the resulting microbiological parameters through laboratory tests with permissible limit values set by legislation for drinking water quality (Law 458/2002 and Law 311/2004).

The water samples were taken in accordance with ISO 5667-1, ISO 5667-2 and ISO 5667-3.

The examination of the samples began immediately after the sampling.

For the preparation, filtration and inoculation on specific culture media they were followed the instructions specified in ISO 8199 and ISO 6887-1.

Filtration was carried out for 100 ml of samples (see figure 3) through membrane filters, with cellulose ester composition, having diameter of 47 mm, nominal pore diameter of 0,45 µm and grid (see figure 4)

Fig.3 - Aspects from the filtration of water samples

For all the samples they were carried out in parallel the standard test and the quick test. In this regard, after filtration of samples (see figure 4), the membrane filters from the standard test were incubated on an agar selective with lactose medium TTC at 36 ± 2°C for 21 ± 3 hours, while the membrane filters from the quick test were incubated in two steps, first on an agar medium containing casein (tryptic digest) TSA at 36 ± 2°C for 4 hours, then on an agar medium containing casein and bile salts TBA, without air between the membrane filters and the media, at 44 ± 0.5°C for 19-20 hours, .

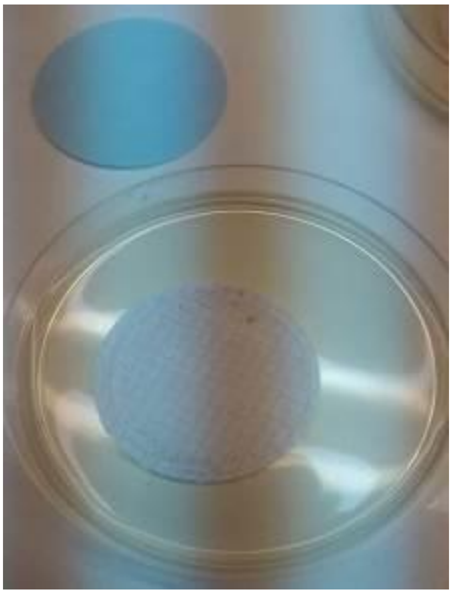

Fig.4 - Aspects of the setting of the membranes on the culture medium

After incubation, the suitable membrane filters from both tests were examined and enumerated as lactose-positive bacteria all the characteristic colonies, indifferent of size, presenting a yellow development in the media below the membrane (see Figure 5).

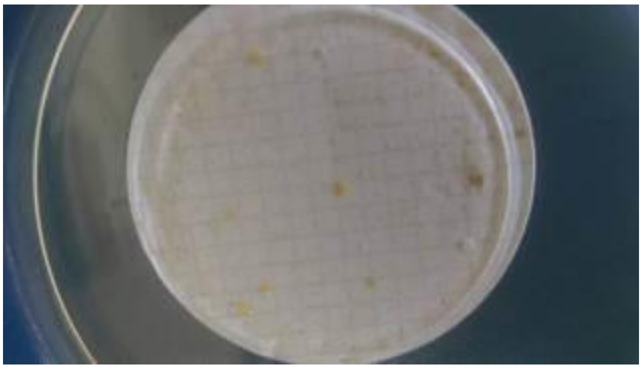

Fig.5 - Aspects of the examination and counting of the lactose-positive bacteria colonies

To the standard test, for the detection of *Escherichia coli* were performed oxidase and indole tests. In this respect, sub-cultures from at least 10 characteristic obtained colonies have been developed on a non-selective agar medium, respectively, on a tryptophan bouillon.

So, to the oxidase test, the subcultures were incubated on nonselective agar medium at 36 ± 2°C for 21 ± 2 hours. Then, they were put 2 - 3 drops of oxidase reagent on the filter paper. Using a glass rod it was collected a part of the colony and was plated on the filter paper. Deep purple-blue colour development within 30 seconds was considered as a positive reaction.

Table 1

Results of the monitoring for the detection of coliforms and *Escherichia coli* in water supply

No	Sample	Date of the entry into control of the samples	Results Referential: SR EN ISO 9308-1/2004/AC2009	
			Coliform bacteria , UFC/100ml	*Escherichia coli*, UFC/100ml
1.	Well 1	7.09.2015	50	3
	Well 4		71	7
	Well 6		0	0
	Well 9		0	0
2.	Well 1	14.09.2015	52	2
	Well 4		68	5
	Well 6		0	0
	Well 9		0	0
3.	Well 1	21.09.2015	50	1
	Well 4		72	6
	Well 6		0	0
	Well 9		0	0
4.	Well 1	28.09.2015	51	2
	Well 4		70	8
	Well 6		0	0
	Well 9		0	0
5.	Well 1	5.10.2015	53	3
	Well 4		69	6
	Well 6		0	0
	Well 9		0	0
6.	Well 1	12.10.2015	50	4
	Well 4		74	9
	Well 6		0	0
	Well 9		0	0
7.	Well 1	19.10.2015	54	2
	Well 4		67	8
	Well 6		0	0
	Well 9		0	0
8.	Well 1	26.10.2015	52	3
	Well 4		71	7
	Well 6		0	0
	Well 9		0	0

To the indole test, the tubes containing tryptophan bouillon medium were incubated at 44 ± 0.5°C, for 21 ± 3 hours and it was examined indole production by the addition of 0.2 ml of Kovacs reagent. Development of a red- burgundy colour at the surface of the bouillon confirms the production of indole.

After the oxidase and indole tests they were enumerated as coliform colonies all the colonies that had oxidase reaction negative and as *Escherichia coli,* all the colonies that had oxidase reaction negative and indole reaction positive.

To the quick test, after incubation on the two agar media, TSA, respectively TBA, which were combined into a bilayer on a single plate, the membrane was placed on a disk of filter paper saturated with a reagent for indole and was irradiated with UV lamp for 20 minutes. All the colonies from the membrane filter which were coloured red are considered as *Escherichia coli*.

Starting from the number of characteristic colonies from the membrane filters and taking the into consideration the results of the carried out confirmation tests, they were calculated the numbers of coliform bacteria, lactose-positive bacteria and *Escherichia coli* presents in 100 ml of water supply sample. It is to note that when the standard test and the quick test are performed simultaneously it is considered that the final result for *Escherichia coli* is the highest result of the individual results of the two tests.

The results of the microbiological monitoring study of the water supply from the deep wells of the National Society "INSTITUTUL PASTEUR" S.A. from Bucharest for the detection and counting of Escherichia coli and total coliform bacteria are presented in Table 1.

CONCLUSIONS

In the paper is presented a study of microbiological monitoring of water supply from the deep wells of the National Society "INSTITUTUL PASTEUR" S.A. from Bucharest, by detection and counting of Escherichia coli and coliform bacteria using the membrane filtration method.

The method of detection and counting of Escherichia coli and coliform bacteria, which is based on membrane filtration, is subject to the Romanian standard SR EN ISO 9308-1. The method consists of two parts, *the standard reference test* and *the optional quick test*, tests that were performed in parallel for all the sample of the study.

After analysing the study results, it results that in the samples of water supply from the wells 6 and 9 are absent coliform bacteria and *Escherichia coli*, while in the samples of water supply from the wells 1 and 4 are present coliforms and *Escherichia coli*. This means that the water supply from the wells 6 and 9 is conform to the bacteriological indicators imposed by legislation for drinking water, while the water supply from the wells 1 and 4 is not conform to the bacteriological indicators imposed by legislation for water drinking and should be subjected to a disinfection treatment.

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EXPERIMENTAL INVESTIGATION OF A WATER PUMPING SYSTEM DRIVEN BY WIND AND SOLAR ENERGY FOR IRRIGATION PURPOSE
/
RÜZGAR VE GÜNEŞ ENERJİSİ İLE ÇALIŞAN SULAMA AMAÇLI SU POMPALAMA SİSTEMİNİN DENEYSEL İNCELENMESİ

As.Ph.D.Stud.Eng. Aksoy M. H.*, Assist. Prof. Ph.D. Eng.Kose F., Prof. Ph.D. Eng.Ozgoren M.
Selcuk University, Engineering Faculty, Mechanical Engineering Department, 42003, Konya, Turkey
Tel: +90 5552027321; E-mail: muharremaksoy@selcuk.edu.tr

Keywords: *hybrid, irrigation, photovoltaic, solar energy, water pumping, wind energy*

ABSTRACT
In this study, an experimental research for agricultural irrigation was completed for a renewable hybrid power generation system consisting of photovoltaic (PV) panels and wind turbine which can be considered as an alternative to diesel generators used for pumping applications. It was observed that the daily mean of produced electricity by the system in July was enough to pump daily average 44.1 m^3/day of water from the depth of 2.5 m and totally 1368 m3 of water during the month. It was calculated that the amount of pumped water is sufficient to meet water need of the agricultural products that were 12.4 decares (da) of sugar beet, 13.0 da of potatoes, 13.4 da of corn, 13.6 da green bean and 10.8 da of sun flower with the drip irrigation method.

ABSTRACT
Bu çalışmadagüneşpanelleriverüzgartürbinindenoluşantarımsalsulamaamaçlıhibritbiryenilenebilirenerjiüretimsistemisupompalamauygulamalarındadizeljeneratörlerealternatifolarakdeğerlendirilmiştir. YapılandeneyselölçümlerdeTemmuzayıiçinkurulansistemin 2,5 m derinliktengünlükortalama 44,1 m3aylıktoplamise 1368m3 supompalamakiçinyeterliolmuştur. Çıkarılanbusuyun 12,4dekarşekerpancarı 13 dekarpatates, 13,4 dekarmısır, 13,6 dekaryeşilfasülyeve 10,8 dekarayçiçeğiiçinyeterlioIduğugörülmüştür.

INTRODUCTION
Water is the primary source of life for mankind and one of the most basic necessities for development. The rural demand for water has increased six fold, at the same time the average rainfall has decreased dramatically in many arid countries in the last decade (Cosgrove, 2000). Albeit groundwater seems to be the only solution of the mentioned issue, it encounters some obstacles since the water table level is decreasing, making traditional pumping applications ever further difficult (Bakelli et al. 2011).

Some of the land used for agriculture in the world and also in Turkey has no access to an electricity grid. Therefore, mechanical power from tractors or diesel generators facilitates the irrigation from wells, streams or canals. For instance, seventy million farms in India use diesel powered irrigation systems. As a consequence, a large amount of energy is consumed during the pumping application causing an increase in the product cost.

As water pumping has a long history, many methods have been developed to pump water with a minimum effort. These methods have employed a variety of power sources, namely human energy, animal power, hydro power, wind power, solar power and fossil fuels for small generators. Water has been pumped by using mechanical power of wind energy for centuries (Kose et al, 2009, Genc 2011) and by using solar energy for the last half century (Vick, 2012).

For different regions and locations, climatic conditions including solar radiation and wind speed are always changing (Yaniktepe, 2013). Owing to that fact, the application of devices powered by PV panels or wind turbines reveals some shortcomings. Hybrid application systems are promising substitutions which diminish this unwanted instability. Renewable hybrid systems are combination of renewable technologies or supported with conventional systems. As the wind and PV technologies advance, the hybrid systems are becoming more promising, more reliable and cheaper than stand-alone wind or PV systems (Güneyand Onat, 2011). Hybrid systems improve load factors and save maintenance and replacement costs, as the renewable resource components complement each other (Bekele, 2012). Renewable hybrid systems can provide a reliable power source for many applications including water pumping.

In addition, the installed capacity of hybrid systems is not designed for the worst-case scenarios due to the fact that power does not come from a single source, fact that reduces the installation cost of the power system. A deal of research has been carried out on wind, solar and hybrid energy systems. Some of them are related to stand alone hybrid usage of renewable energy sources (Aissou et al. 2015), size optimization (Ma et al. 2015), economics of the hybrid systems (Mohamed et al. 2015), seawater desalination (SmaouiandKrichen, 2014), size optimization (González et al. 2015), home/village/industrial usage (Bekele, 2010), and household application (Panayiotou et al. 2011).

In the literature some studies are concerned with the usage of renewables for the water pumping purpose (TharaniandDahiya 2016); however, it is not encountered in any study that does evaluate the adequacy of water in agricultural areas using solar/wind based hybrid power generation system.

MATERIAL AND METHOD

The experimental setup was established in the premises of Konya Selcuk University Technology Development Zone at 38 °00'06.80" North 32°30'31.70" East coordinates at an altitude of 1136 meters. All the components of the hybrid power station are integrated with solar and wind energy for irrigation purposes as illustrated in Figure 1. As it can be seen, the produced electricity via the PV modules with a total 480 W capacity and the wind turbine with a 1500 W capacity are regulated by their individual charge controllers and are stored in the battery bank. Four pieces of 12 V and 200 Ah batteries were wired in a serial/parallel arrangement to deliver 300 Ah at 24 V with a total capacity of 9600 Ah. Then, the electricity was transmitted to the pump in order to pump the water from a well to a storage tank. During this process the PV charge controller has a significant role and measures all electrical properties: voltage and current values of input, output and battery group; the occupancy rate of a battery group, consumption of the pump and all data stored in a data logger during the experiment. In addition to DC electricity line, the stored electricity is inverted to 220V by a 3000 W capacity inverter for AC powered systems. Generated electricity by both wind turbine and PV panels, and electricity consumption of the pump were recorded by the data loggers during the experiment. The wind speed and solar radiation were also measured by a cup anemometer at height of 10.5 m and a pyranometer in 10 minutes intervals for further process.

The volume flow rate of pumped water and its outlet pressure were also measured by a turbine type flowmeter and by a pressure sensor at 1 sec. intervals. The cut-in, rated and cut-off wind speed of the wind turbine were 3.6 m/s, 12.5 m/s and 20 m/s, respectively. All measured variables and their accuracies are given in Table 1. In the experiments a DC-driven pump with head height of 5 m and volume flow rate of 5 m3 was used. PV panels were established on a designed rotating mechanism to change the PV panels' angle from 0° degrees to 80° degrees on horizontal axis. The purpose of this establishment was to adjust the mechanism to get the highest amount of solar radiation on PV surfaces. The Maximum Power Point Tracking (MPPT) was included in the charge controller of the PV system for extracting maximum available power from PV. All electronic devices and batteries were collected in a sheet metal cabinet to protect from environmental conditions.

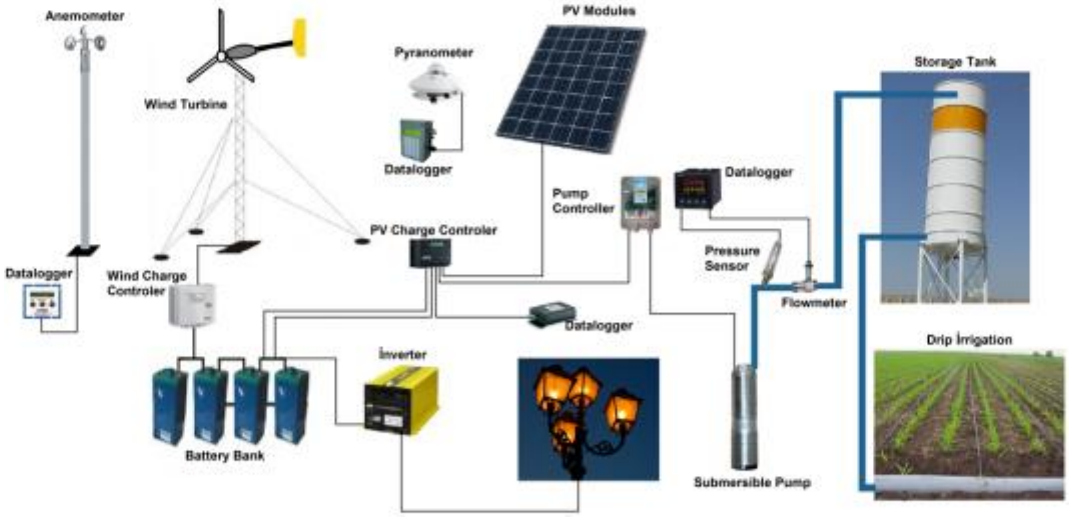

Fig.1 – Schematic view of the hybrid drip irrigation system

Fig.2 – PV–wind based hybrid power plant in the garden of Konya Selcuk University Technology Development Zone

The output power of the PV panels

The output power of the PV generator $\dot{P}_{pv}$ is given by the following equation (Markvart, 2000):

$$\dot{P}_{pv} = A_{Pv} I_s \eta_{pv} \quad (1)$$

where η_{pv} is the PV panel's total efficiency, A_{Pv} is the total area of the PV panels (m^2) and I_s represents the amount of solar radiation on tilted module plane (W/m^2). The tilt angle of the PV module is arranged according to the site latitude and

The power output of wind turbine

The fundamental equation governing the electrical power capture of the wind turbine generator is given by [38].

$$\dot{P}_w = 0.5 \rho_a A_w \eta_w V^3 \quad (2)$$

Where ρ_a is the air density (kg/m^3), A_w is the area swept by the rotor blades, V is the average wind velocity (m/s), η_w represents overall efficiency of wind turbine and is calculated according to the power produced by the wind turbine and measured wind speed distribution of the region.

The volumetric flow rate of pumped water

The ideal hydraulic power to drive a pump depends on the mass flow rate, the liquid density and the differential height. It is explained that either it is the static lift from one height to another, or the friction head loss component of the system can be calculated as follows:

$$\dot{Q} = (\dot{P}_h \eta_p)/(\rho_w g h) \quad (3)$$

where $\dot{P}_h$ is the power needed by the pump and it is generated by the hybrid system for this application. $\dot{Q}$ is the volumetric flow rate (m^3/s), ρ_w is density of pumped water (kg/m^3), g is gravitational acceleration (m/s^2), h is the manometric head including all minor and major pressure losses (m) and η_p is the overall pump efficiency.

Irrigation need

There are a lot of irrigation applications such as a conventional surface, a sprinkler, a drip irrigation method etc. The methods apart from the drip irrigation one cause more evaporation of water and, thus, wasting a great amount of water. The drip irrigation requires higher costs of investment; notwithstanding, it is especially preferred to use in greenhouse and garden applications and to grow higher economic valued crops due to its less labour need. In order to determine the monthly irrigation demand it was necessary to know the average monthly rainfall of a region (Vick, 2010).

$$IN = WN - NR \quad (4)$$

The irrigation water need of any crop *(IN)* in each month is the difference between the crop water need *(WN)* and the natural rainfall amount during the growing season *(NR)*.

RESULTS

The water need of the crops reaches a peak in summer months. To consider irrigation via the solar and wind energy, the most important time interval is the summer season when the water need of the crops reaches a maximum. In this study, the daily mean total radiation (Id) was measured as 6480 W/ (m^2day), 7737 W/(m^2day) and 7100 W/(m^2day) in June, July and August respectively with a pyranometer oriented towards south and tilted at optimum angles surface such as the PV panels. It is observed that July is the month when the highest solar radiation occurred, and is the peak irrigation water needed month for many crops in Konya province.

Cumulative variation of the electric energy generation by wind turbine (Pw), by PV panels (P_{PV}) and by the hybrid system consisting of a combination of the two systems (P_h) are given by in Figure 3. As it can be seen, the wind turbine produces more electricity during the night compared to the daytime hours. Similarly, the PV panels generate energy only during daytime hours and reach its maximum value at noon hours. Wind power can be integrated with solar power successfully resulting in the better continuity of electricity generation. The daily average total energy production by the wind turbine and PV panels were determined as 3685 Wh/day and 2841 Wh/day, respectively. The hybrid system can generate electric energy during the whole day when compared with single wind and solar energy system.

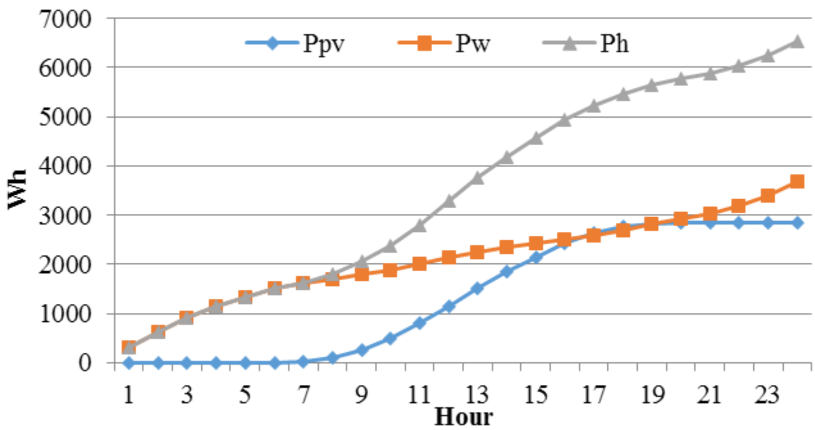

Fig.3 – Cumulative variation of electric energy generation of the wind, solar and hybrid system in July

It was demonstrated that the daily mean produced electricity by the system in July was enough to pump daily average 44.1 m^3/day of water from 2.5 m depth and totally 1368 m^3 during the month, which was the most irrigation needed month along a growing season of many crops in Konya. Figure 4 shows the hourly variation of average pumped water during July. It is displayed that the pumped water amount in the evening and night times were lower than the average need when just wind power was available. The pumped water amount was increased after 8:00 by the support of the solar power to the wind power. The volume flow rate of the water was over 3 m^3/h in the afternoon and it tended to decrease after 17:00. Then wind power and the stored electricity in the batteries provided energy to pump water till sunrise.

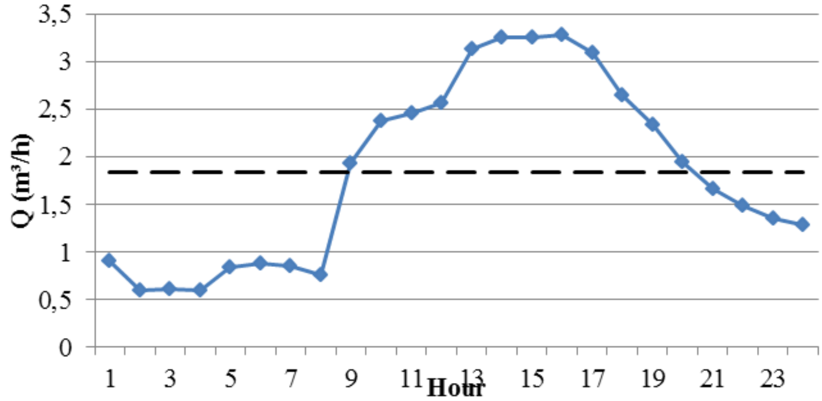

Fig.4– Hourly average variation of pumped water in July

Figure 5 presents the monthly irrigation water need that is calculated by subtracting the effective rainfall amounts from the crop water need for all crops during each month of the growing season. For instance, a sugar beet crop grown in Konya has a total growing season of 180 days and its monthly water needs from April to September vary between 30.0 mmWc in April, 53.8 mmWc in May, 197.2 mmWc in June, 227.3 mmWc in July, 217.3 mmWc in August and 132.8 mmWc in September. The cumulative water need of the sugar beet through the growing season (April-September) is 858.4 mmWc. The average rainfall data between 1970-2010 for the area where the crops considered to be grown have been obtained from the Turkish Meteorological Office as 37.5 mmWc in April, 40.5 mmWc in May, 23.2 mmWc in June, 7.8 mmWc in July, 5.6 mmWc in August and 10.6 mmWc in September with the total amount of 124.6 mmWc along the growing season. The monthly irrigation water need for a sugar beet was calculated by the difference between the crop water need and the natural rainfall. The use of irrigation in April is unnecessary owing to efficient rainfall. The monthly irrigation water needs changes 12.5 mmWc in May, 176.3 mmWc in June, 219.9 mmWc in July, 212.1 mmWc in August and 121.6 mmWc in September. The irrigation need of a sugar beet over the total growing season was 742.4 mmWc per growing season. It can be concluded that the irrigation water need reaches its peak in July for sugar beet. If the sugar beet is the only crop grown in the area, the irrigation would have to be designed in such a way that it should supply a net water layer of 219.9 mmWc to the whole covered area in July as shown in Figure 5. Total irrigation water needs for the other crops such as a corn, a potato, a sun flower and a green bean per growing season were found to be 509.3 mmWc, 480.9 mmWc 587.7 mmWc and 402.3 mmWc, respectively. The maximum irrigation needs of the all crops were 203.4 mmWc for a corn, 211.2 mmWc for a potato, 219.9 mmWc for a sugar beet, 251.2 mmWc for a sun flower in July, which was the peak irrigation water need month as seen in Figure 5.

The amount of pumping water per a growing season was converted into water requirement of the different crops per growing season by conventional and drip irrigation methods in Table 1. It can be concluded that the drip irrigation method for all considered crops can provide two times more field for the water requirement of the related crops than the conventional irrigation system. Drip irrigation systems reduce the loss of water by conveying or evaporation, and achieve the highest irrigation efficiency up to 90%.

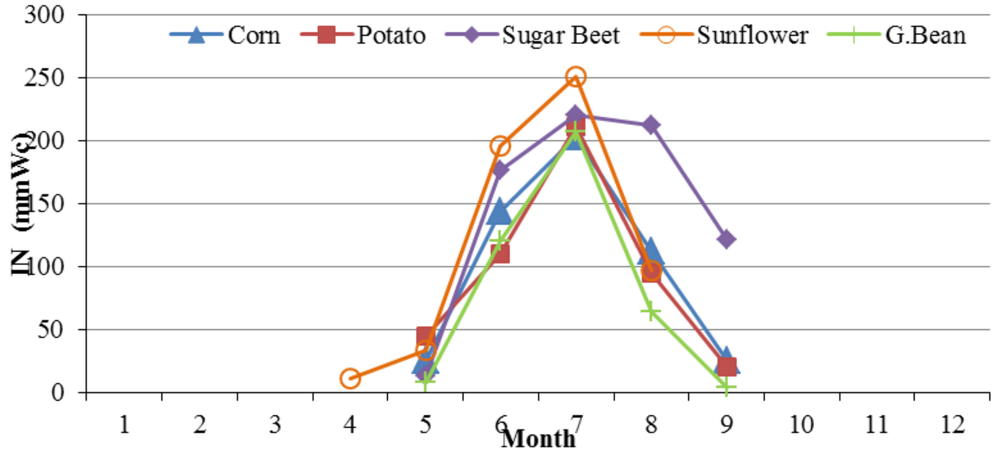

Fig.5 – Average irrigation needs of different crops for Konya province along the growing season

Table 1

Comparison of conventional and drip irrigation systems for the total land area in Decares (1000 m^2).

	Corn	Potato	Sugar beet	Sun Flower	Green Bean
Conventional Irrigation	6.7	6.5	6.2	5.4	6.6
Drip Irrigation	13.4	13.0	12.4	10.8	13.6

CONCLUSIONS

In this work, performance characteristics of the small-scale PV/Wind based hybrid electric supply system for the water pumping application in Konya province is presented. The hybrid system consisting of a 1500 W wind turbine and 480 W PV panels were established in the open area of Selcuk University Technology Development Zone in Konya, Turkey. Generated electricity was stored in a battery group and was used to power a 300 W DC-driven submersible pump under 2.5 m depth of the ground level. It was seen that the wind power can be integrated with the solar power successfully providing constant electricity generation. It was demonstrated that totally 1368 m^3 water was pumped during July when was the highest demand for irrigation during growing season. It was calculated that the amount of pumped water was enough to meet water need of the crops that were 12.4 decares (da) of a sugar beet, 13.0 da of a potato, 13.4 da of a corn, 13.6 da of a green bean and 10.8 da of a sun flower. It was demonstrated that the drip irrigation method for all considered crops could satisfy the water requirement of two time larger field than the conventional irrigation system.

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EXPERIMENTAL FLOW STRUCTURES IN A CENTRIFUGAL PUMP VIA PIV
/
SANTRİFÜJ BİR POMPADA AKIŞ KARAKTERİŞTİKLERİNİN PIV İLE DENEYSEL İNCELENMESİ

As.Ph.D.Stud.Eng. Aksoy M. H.*[1)], Prof. Ph.D. Eng.Ozgoren M.[1)]
As. Ph.D. Stud. Lect. Eng. Babayigit O.[2)]Lect. Eng.Kocaaslan O. [3)]
[1)]Selcuk University, Engineering Faculty, Mechanical Engineering Department, 42003, Konya, Turkey;
[2)]*Selcuk University Hadim Vocational School, Hadim, Konya, Turkey;*
[3)]*Selcuk University Huglu Vocational School, Huglu, Konya, Turkey*
Tel: +90 5552027321; E-mail: muharremaksoy@selcuk.edu.tr

Keywords: *PIV, Pump, impeller, CFD*

ABSTRACT
In this study a specific pump system was established to make an experimental investigation based on Particle Image Velocimetry (PIV) measurements on the first stage of a tree-stage centrifugal pump. The volume flow rate and manometric head at 1425 rpm on the experiments were varied between 2.99m^3/h - 9.46m^3/h and 13.3m - 6.0m, respectively. The phase-averaged global and relative velocity vector fields, global and relative velocity contours, turbulence kinetic energy contours and vorticity contours at half span plane of the pump impeller were presented. It is demonstrated that the flow characteristics of the centrifugal pump by PIV can provide useful information for both designing new pump and validation of the CFD studies.

ÖZET
Bu çalışmada, belirli bir pompa test sistemi kurularak parçacık görüntülemeli hız ölçme yöntemi (PIV) ile üç kademelisantrifüj pompanın ilk kademesinde incelemeler yapılmıştır.Deneylerde 1425 rpm'dehacimsel debi ve manometrik basma yüksekliği sırasıyla 2.99m3/h-9.46m3/h ve 13.3m-6,0 m arasında değişmektedir.Faz-ortalamalı mutlak ve bağıl hız vektör alanları,mutlak ve bağıl hız konturları, türbülans kinetik enerji konturları, girdap konturları çarkın orta yüksekliği için sunulmuştur.PIV ile elde edilensantrifüj pompa akış özelliklerinin CFD çalışmalarının doğrulanması için ve yeni pompa tasarımı için kullanılabileceği görülmüştür.

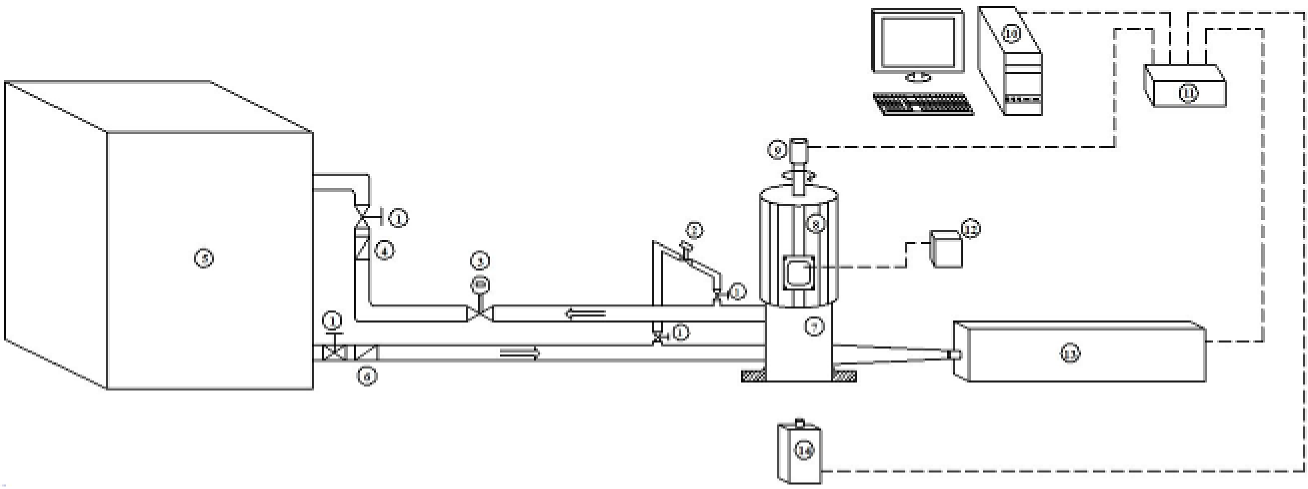
INTRODUCTION
Centrifugal pumps are used in a wide range of applications for the purpose of water supply, industrial applications, waste pump, water treatment, irrigation systems, and much more (Kose and Kaya 2013). The internal flow that develops in a pump predetermined by the geometry, can negatively affect the pump performance in terms of efficiency, vibration and noise, especially at off-design conditions (Nataraj and Singh, 2003). It is of great importance to determine the internal flow in a centrifugal pump as an experimental study to obtain any improvement in the pump efficiency to save energy (Babayigit et al. 2015, Kaya et al. 2008, Kocaaslan et al. 2016).

The measurement of interflow structure in centrifugal pumps is one of the most interested research areas. In the past, some measurement techniques, pressure probes and hot-wire anemometry have been applied in strive for accurate quantitative flow descriptions. These methods have provided some fundamental knowledge of flow characteristics in centrifugal pumps (Nataraj and Singh, 2003, Baldiet al.1996, Sharp et al. 2011). However, most of them are intrusive techniques, with some disadvantages such as the space limitation, probe interference, and equipment precision, etc. The Particle Image Velocimetry (PIV) technique is a powerful method which offers more detailed knowledge of local and phase-averaged features of the complex flow fields and turbulent flows through a pump impeller (Zhaoet al. 2009,Aksoy et al. 2014).

In the literature there are some studies concerning the internal flow of centrifugal pumps. Stickland et al. (2003) investigated the flow patterns between the blades of a centrifugal impeller by PIV method. They managed to obtain the flow field relative to a centrifugal impeller. Choi et al. (2004) performed an experiment using the PIV system to investigate the internal flow pattern in a centrifugal pump with semi-open impellers. The experiment was performed at the non-dimensional specific speed of 0.24. Furthermore, the experiment was conducted separately for two different impellers: one equipped with six radial blades and the other with four conventional backward-swept blades, and their efficiency was compared. The impeller with six radial blades has complex fluid flow with reverse flow and secondary flow. Moreover, the absolute tangential velocities are higher in the first impeller. Notwithstanding, it obtains the more effective head. Another paper has addressed the problem of the unsteady phenomena occurring in a vaneless diffuser of a radial pump. It was investigated experimentally by PIV system and pressure transducers. The flow was determined at three different heights in diffuser; whereas the pressure was measured on the shroud wall of the diffuser as well as on the suction pipe of the pump. The spectral analyses of instabilities and non-linear interaction mechanisms between different unsteady structures were investigated by the classical Fourier analysis and the high-order spectral analyses, respectively (Dazin et al 2011). Keller et al. have done an experimental study concerns unsteady flows in a centrifugal pump with vaneless volute. The tested transparent pump has a 2D-shaped geometry and the impeller has 6 arc-shaped backward-curved blades. Their results were presented on the in-plane as phase-averaged relative and absolute velocities, turbulent kinetic energy and vorticity fields. In this study, a specific pump test rig was established in PIV laboratory of Selcuk University Department of Mechanical Engineering to make two-dimensional PIV measurements on a multistage pump.

MATERIAL AND METHOD

The test rig established for PIV experiments consisting of a tank open to atmosphere, a suction valve, filter, a centrifugal pump, a discharge pipe and a discharge valve. In the circuit, water was re-circulated by a pump with having frequency converter during the experiment. Pumping head, flow rate and rotational speed were measured by differential pressure transducer, paddle wheel flow meter, and shaft mounted encoder, respectively. In addition the electricity consumption of the pump is also measured on the pump driver. The schematic views of the TR-PIV and pump system with components are shown in Figure 1. Nd:YAG laser that was placed in perpendicular to the axis of the impeller was used to illuminate the flow field. An encoder depending on revolution speed triggered the camera to take image and calculate the phase-averaged flow patterns. Laser sheet thickness was less than 1 mm. A CMOS camera with resolution of 1632 x 1200 pixels was used to record the images. The timer box (pulse synchronizer) is also used whose trigger timing accuracy is up to 1 ns and can be triggered by an external signal. The operational mode of the laser and the camera, the trigger delay time and the interval of double-trigger can be controlled by Dynamic Studio software. The photograph of the test rig is given in Figure 2.



1 Valves	2 Pressure sensors	3 Flow meter	4 Check valve	5 Water tank	6 Filter
7 Pump stages	8 Motor	9 Encoder	10 Computer	11 Synchronizer	12 Pump Controller
		13 Laser	14 Camera		

Fig.1 – Schematic view of the closed-loop pump

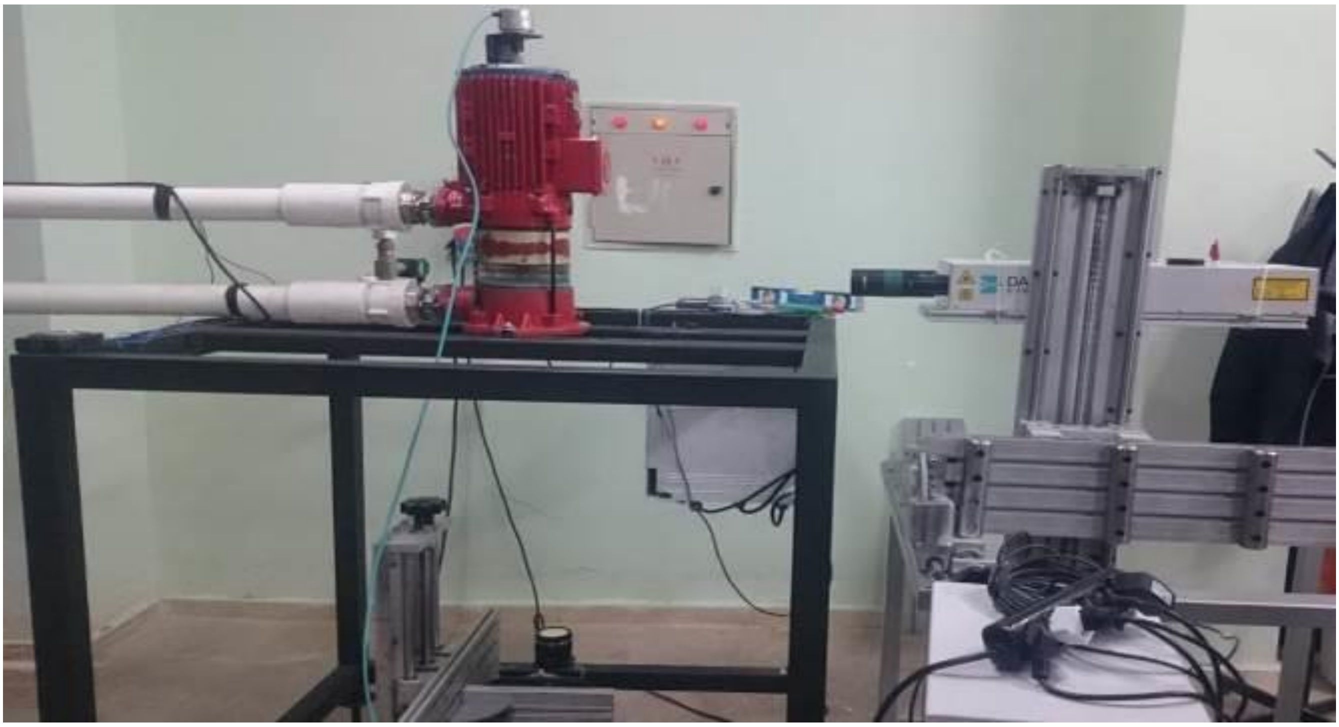


Fig.2 – The PIV-Pump test rig

The densities of the particles and water were close enough, and the suspended seeding silver coated hollow glass sphere particles with a diameter of 10 µm in the flow. Furthermore, the high-image-density criterion was formed by ensuring that a minimum of 10 particles were contained within the interrogation area. Dynamic Studio software employing the adaptive correlation algorithm including proper filters was used for computing the raw displacement vector field from the particle image data. An interrogation window of 32 x 32 pixels in the image was selected and an image masking was applied to process just one passage of the impeller. During the interrogation process, an overlap of 50% was employed in order to satisfy the Nyquist criterion. Patterns of instantaneous measurements with a 500 images consisting of a continuous series were taken to calculate the time-averaged patterns of the flow structure. The images are processed by local mean smoothing median test, minimum peak head relative to peak and average filter validations. A code is also developed on Matlab to convert the exported global velocity data to the impeller relative system. Tecplot software is used for post-processing the flow features after exported from Dynamic Studio software. Boundaries of impellers are taken by Solidworks software and added to experimental results after processing.

In this study, a new designed three stage centrifugal pump with vertical shaft SPL-100 shown in Figure 3 manufactured by Sempa Company was investigated. The impeller under investigation consists of six single-arc-profile curvature backward swept blades. The width of the impeller's inlet and outlet were 8.5 mm, and 7.2 mm, respectively. The detailed parameters of the impeller can be found in Table 1. In order to be convenient to measure flow fields in the impeller, material of the impeller, diffuser and the bottom section of the pump on the suction side were made of plexiglas. In order to reduce the visual noise from the reflection of Plexiglas and background, other stages, sections, and metallic surfaces of the pump are painted black and coated by ceramic before assembly. Shaft sleeve on the outmost of the impeller on regular pump was not used to avoid reflection or lens effect to the laser sheet. The impeller stages are directly lap-mounted one by other. In addition the measurement was taken on the first impeller that laser illuminates. So the reflectivity of laser and having different reflectivity index is assumed not affect the laser sheet.

On the last decade, PIV measurement in centrifugal pumps just focused on the flow in only one impeller passage rather than all passages, and less attention is paid to the rotation and z-axis to the influence of internal flow [Ling et al 2015]. The PIV measurement of internal flow in the centrifugal pump was performed in only one impeller passage as shown dashed in Figure 4.

Table 1

Technical specifications of the impeller

impeller inlet diameter	D_0 (mm)	46.5
blade inlet diameter	D_1(mm)	42.6
breadth of impeller at inlet	b_1(mm)	8.5
breadth of impeller at outlet	b_2(mm)	7.2
Shaft diameter	D_m(mm)	18.15
hub impeller diameter	D_g(mm)	25.5
outlet impeller diameter	D_2(mm)	123.5
blade inlet / suction angle,	β_{1k}	22°
blade outlet/discharge angle	β_{2k}	26.4°
Wall thickness of blade	e (mm)	2.1
number of the blades	Z	6

Fig.3 – The examined pump SPL-100

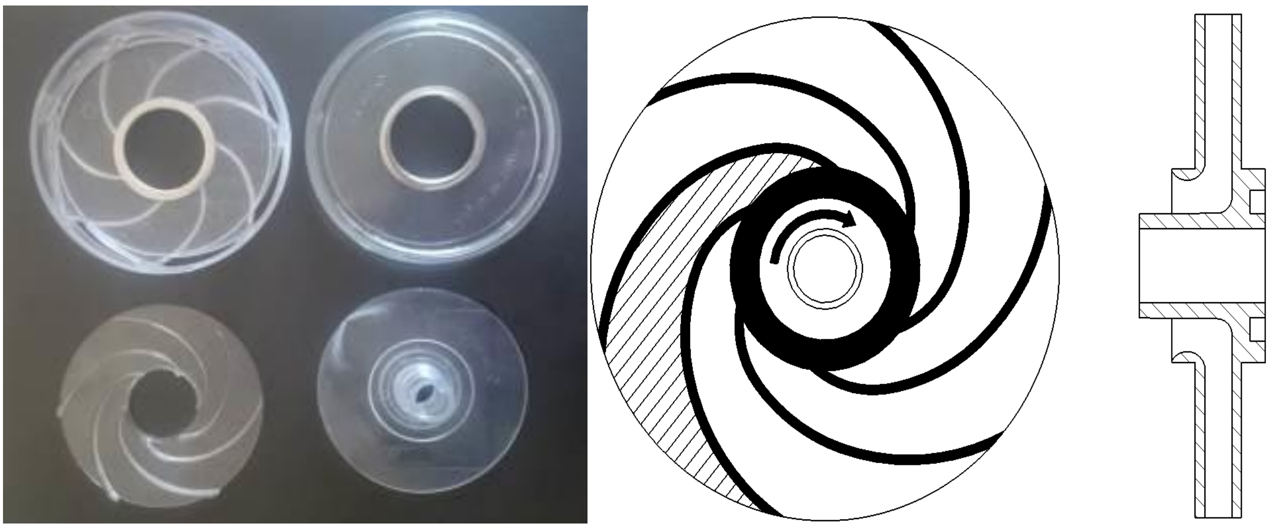


Fig.4 – Impeller parts and sketch of phase averaged measurement region

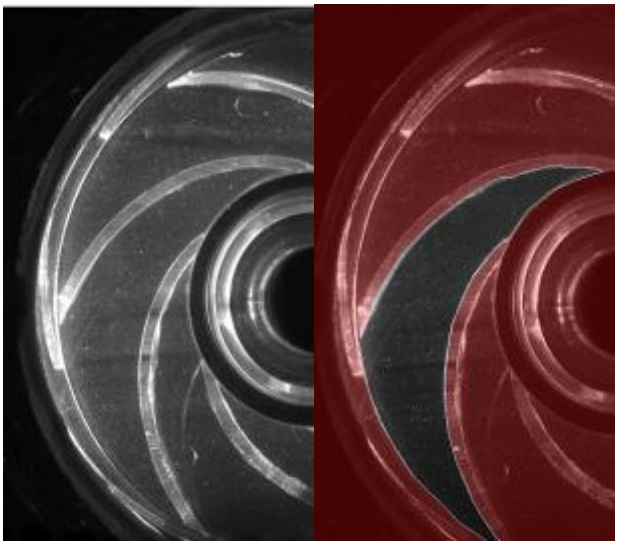


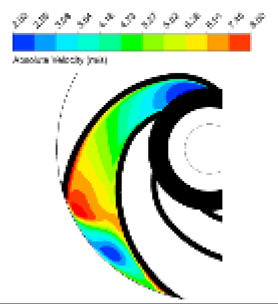
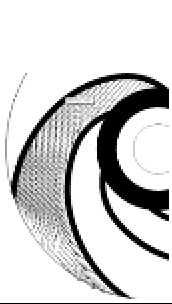
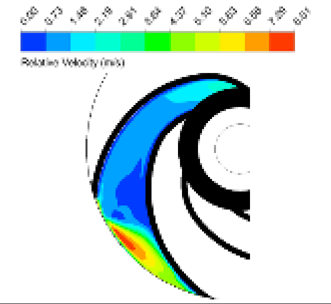
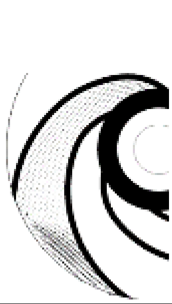
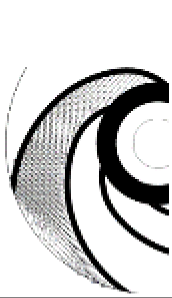
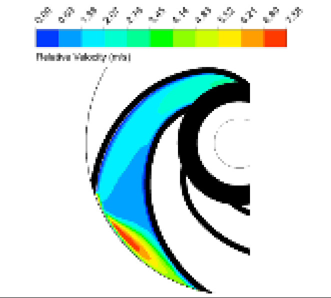
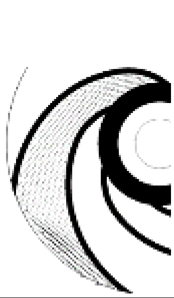
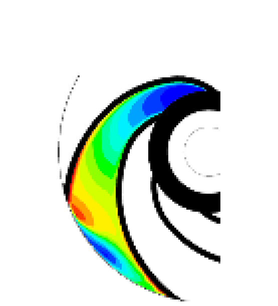
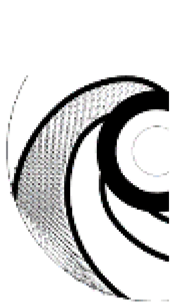
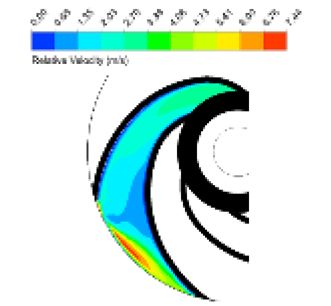
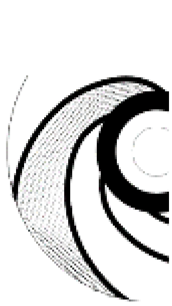
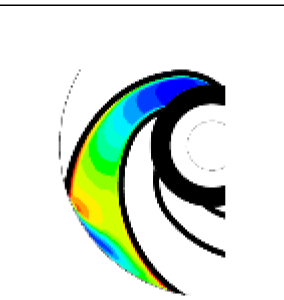
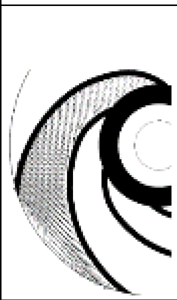
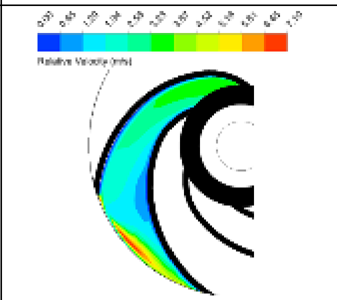
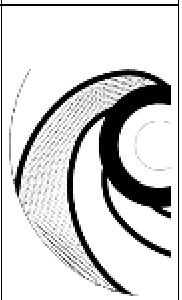
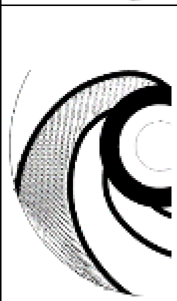
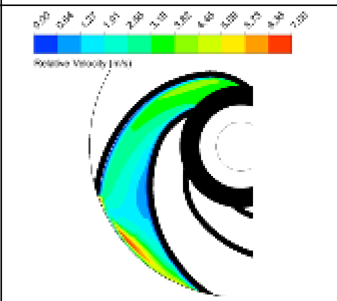
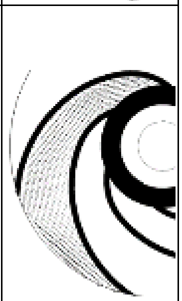
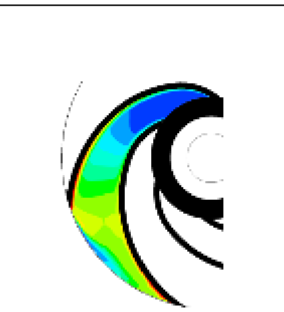
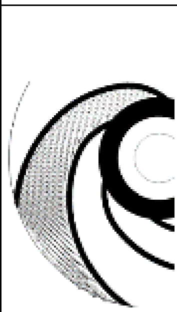
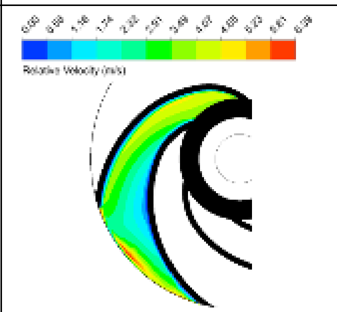
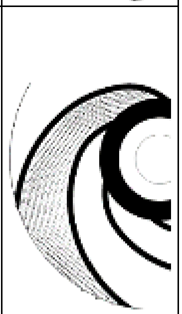
Fig.5 – Particle view by camera in experiments and vector masked passage of impeller

The CMOS camera was located below the pump and face upwards while the laser was placed to the orthogonal to the camera. To obtain phase-averaged results, an encoder that provided an external trigger to run simultaneously the camera and laser was located to the pump shaft and the signal was transmitted to the timer box. Both instantaneous and phase-averaged velocity fields and turbulence quantities were obtained in a blade passage region of the centrifugal pump. Pump was run at 1425 rpm for this presented study. Time between two laser pulses was taken 200 ns to catch the particle movement through the passage.

RESULTS AND DISCUSSIONS

The data presented here are shown to verify the ability to acquire measurements of the flow field in the impeller of the centrifugal pump. A more elegant measurement that was repeated 500 times in the flow field is presented on phase-averaged values in Figure 6 and 7. The phase-averaged absolute velocity vectors and vector contours at different flow rates at half span plane of the pump impeller are given in Column I and II in Figure 6 respectively. The blade rotation is clockwise direction, so suction side of blade is just below upper blade and pressure side is just above lower blade. Within the blade passage, velocity is relative to the impeller rotation. As seen the velocity gradients occur between the blades which cause the rotational flow field. The velocity vectors are about the perpendicular to the blade profile. The absolute velocities are given in the one scale changes between 2-9 m/s inside of the impeller. The velocity increases gradually from inlet of the pump to the outlet. It is seen that the fluid basically flows through the suction side near the impeller inlet about the same working condition. At low flow rates a high absolute velocity regions occur near the discharge regions just below the suction side. These low regions can also be seen in velocity vectors as reverse flow at the discharge side due to the effect of diffuser. The position of the diffuser blade can be seen in Figure 5.

The phase-averaged relative velocity vectors and vector contours at different flow rates at half span plane of the pump impeller are presented in Column III and IV in Figure 6, respectively. The relative velocity representation is more meaningful to see the design and fluid-structure interaction in pump. It is seen that the stream basically flows through the suction side near the impeller and follows the curvature of the blade surface. There is a low speed area that can be seen at the inlet section of the blade passage at low flow rates. However this area disappeared with the increasing flow rates and also high velocity areas occurred near the suction side at the impeller inlet. The relative velocity distribution is not as expected at low flow rates, however, it becomes more regular by increasing flow rates. The effect of the diffuser is stronger in low flow rates. The velocity distribution is higher close to suction side than the pressure side of the blade at all flow rates. It is demonstrated that vector fields become more regular patterns on high flow rates.

$\dot{Q}$(m³/h)	I	II	III	IV
2.99				
4.12				
4.72				
5.45				
5.81				
6.75				

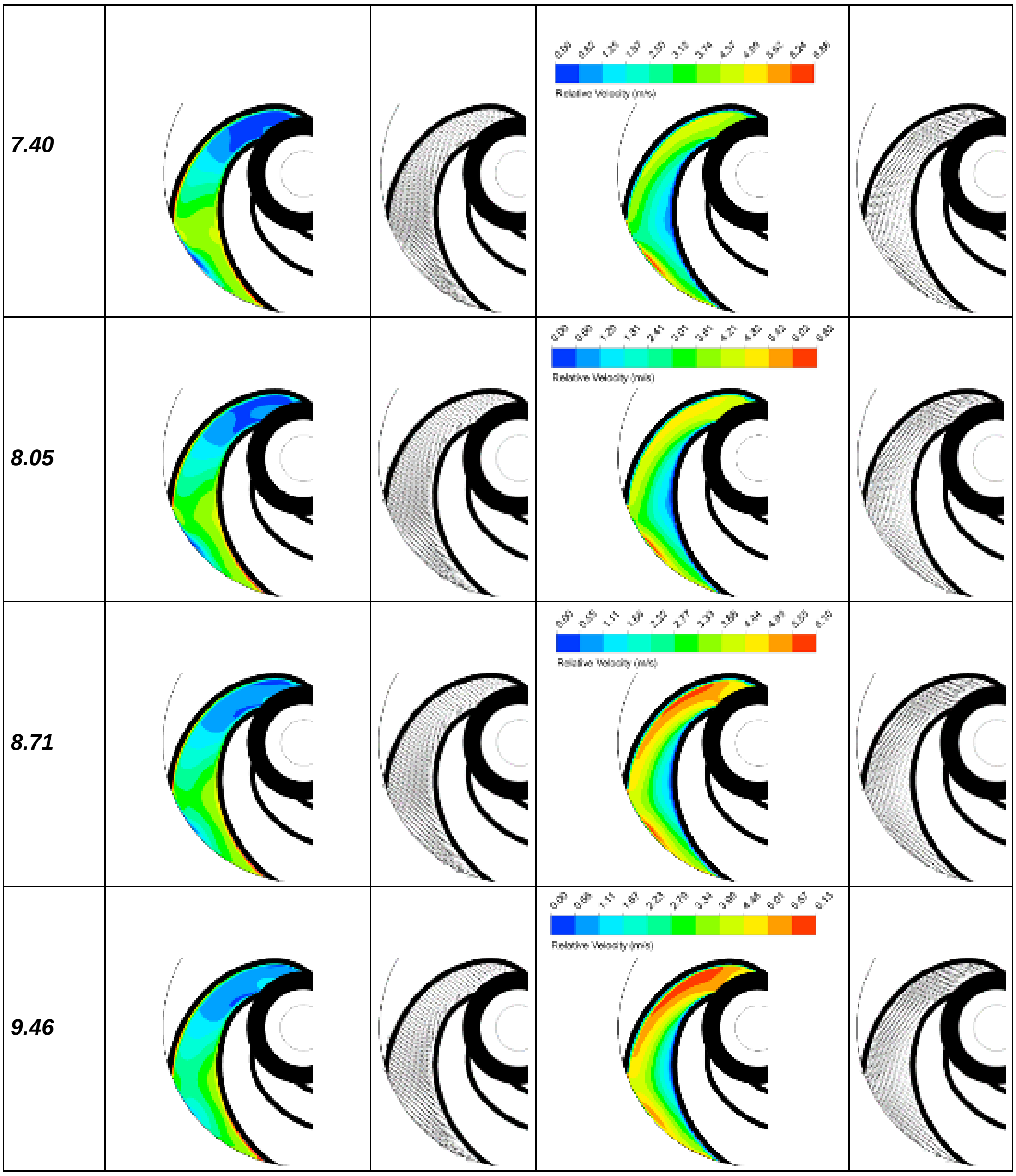
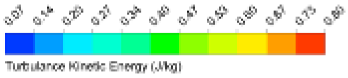
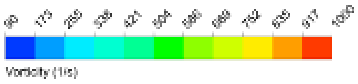
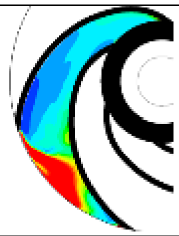
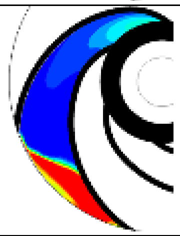
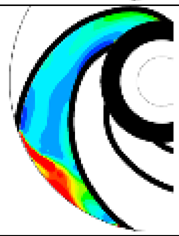
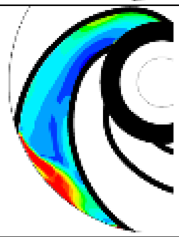
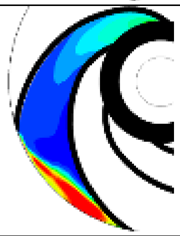
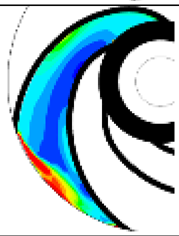
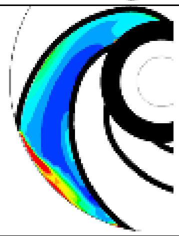
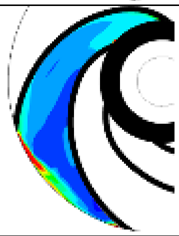
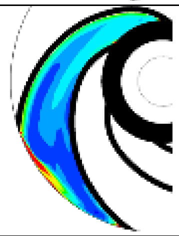
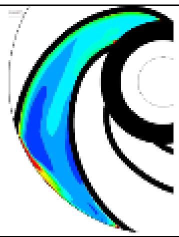


Fig 6 - The phase-averaged flow pattern of the impeller at midspan plane at 1425 rpm (I) absolute velocity contours, (II) absolute velocity vectors, (III) relative velocity contours, (IV)relative velocity vectors.

The vorticity and turbulence kinetic energy (TKE) contour fields on the pump impeller stage at different flow rates are given in Figure 7. The TKE values are in the range of 0.07-0.80 J/kg in the experiments. In low flow rates the maximum TKE values occurred at the impeller exit while it is lowered by the increasing flow rates. In addition a big TKE values are found at high flow rates which show that the pump inlet angle is not proper for that conditions. There is no big chance in TKE at the middle section of the impeller. As seen in the vorticity structure, the diffuser effect becomes lower by increasing the flow rate near the impeller exit. The size of the largest vorticity structure is also lowered at high flow rates. Due to the position of the impeller all vorticity takes the positive values inlet of the passage. The low vorticity region moved from the pressure side to the suction side at high flow rates.

Q̇(m³/h)	I	II
		
2.99		
4.12		
4.72		
5.45		
5.81		
6.75		
7.40		

8.05		
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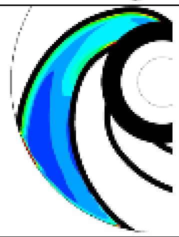
9.46		

Fig. 7 - The phase-averaged flow patterns of the impeller at midspan plane at 1425 rpm (I) Turbulence kinetic energy contours, (II) vorticity contours

CONCLUSIONS

In this study PIV investigation on a impeller passage of a multistage pump is presented. A code is developed to obtain relative flow characteristics from global velocity values. The phase-averaged relative velocity vector fields taken by 500 images as velocity contours, velocity vectors, turbulence kinetic energy contours and vorticity contours at half span plane of the pump impeller were obtained. The volume flow rate and manometric head at 1425 rpm on the experiments were varied between 2.99m3/h - 9.46m3/h and 13.3m - 6.0m -, respectively. It is seen that the fluid basically flows through the suction side near the impeller inlet under the same working condition. The phase-averaged velocity fields and turbulence quantities were obtained in a blade passage region of the centrifugal pump. The relative velocity values gradually increases from the impeller inlet to the impeller outlet. Contours of speed for both flow rates are included to help reveal structures within the flow field. The phase-averaged values as seen from velocity contours and the flow smoothed with the increase of flow rate. The turbulence production was seen to be mainly concentrated in the wake regions from the blade leading and trailing edges. Higher TKE values are observed at low flow rates at the impeller exit while those values are occurred in the impeller inlet at high flow rates. The effect of the diffuser position is seen not only in the velocity distribution but also a vorticity in the experiments.

In the future, more detailed studies can be performed such as some experiments at different shaft revolutions. Also, the results that have been obtained from the experimental studies can be compared with CFD studies, which will be completed in the near future. Some passive control methods like splitter blades will be applied on impeller geometry to obtain its affect on flow structures. These studies play an important role due to pump design and results can be used to validate the CFD codes.

ACKNOWLEDGEMENT

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EXPERIMENTAL RESEARCH ON THE WORKING PROCESS OF COMPLEX AGGREGATES FOR SOIL TILLAGE - REVIEW
/
CERCETĂRI EXPERIMENTALE PRIVIND PROCESUL DE LUCRU AL AGREGATELOR COMPLEXE DE LUCRAT SOLUL - REVIEW

PhD. Stud. Vlăduţ D. I.[1)], Prof. PhD. Eng. David L.[1)], Prof. PhD. Eng. Biriş S.Şt.[1)], Asist. Prof. Dr. Kabas Onder[2)], Asist.Prof. Dr. Selvi K. Cagatay[3)], PhD. Stud. Eng. Cujbescu D.[4)], Lect. PhD. Eng. Ungureanu N.[1)], PhD. Eng. Vlăduţ V.[4)], PhD. Eng. Marin E.[4)], Eng. Dumitru I.[5)], Eng. Oprescu M.R.[6)]

[1)]P.U. Bucharest / Romania; [2)]Akdeniz University, Antalya / Turkey; [3)]Ondokuz Mayıs University, Samsun / Turkey; [4)]INMA Bucharest / Romania; [5)]Power Group International S.R.L. / Romania; [6)]Condor Comimpex S.R.L. / Romania

E-mail: v_vladuta@yahoo.com

Keywords: *soil, combiner, working process, conservative*

ABSTRACT

The complex aggregates for soil processing and especially those with large working widths (> 6 m) are widely used in recent years because they provide a good soil processing, at high working speeds being obtained high productivity of this equipment. This paper presents an overview of experimental research conducted in the country and worldwide on the working process of such equipment, highlighting the qualitative indices of work, the advantages and productivity achieved by this equipment, and also modern constructive solutions that allow obtaining such productivity and high reliability.

REZUMAT

Agregatele complexe de prelucrat solul şi în special cele de lăţimi mari de lucru (> 6 m) sunt folosite pe scară largă în ultimii ani dorită faptului că realizează o bună prelucrare a solului, la viteze mari de lucru obţinându-se productivităţi ridicate ale acestor echipamente. Lucrarea prezintă o sinteză a cercetărilor experimentale realizate în ţară şi pe plan mondial privind procesul de lucru al acestor echipamente, scoţând în evidenţă indicii calitativi de lucru, avantajele şi productivităţile realizate cu aceste echipamente, dar şi soluţii constructive moderne ce permit realizarea acestor productivităţi şi o fiabilitate ridicată.

INTRODUCTION

Nowadays, humanity faces a major controversy in choosing the proper technology for soil processing. It is the time when an intelligent choice is necessary between conventional technologies (classical) for seedbed preparation, assuming an intense mechanical processing of soil, affecting soil structure and soil organic matter, and also the conservative tillage technologies for seedbed preparation, which eliminate the disadvantages in terms of an accepted production decrease.

In conservative technology, soil works are usually operations performed mechanically, by tools or machines, to change soil properties and thus to create conditions of life required by the crop plants.

The condition under which agriculture is carried out varies greatly from one area to another (type of soil, climate, etc.). But even the needs of different plant species are different. As a result, the concrete objectives of tillage will be multiple: the achievement of physical, chemical and biological characteristics (e.g. loosening or compaction), destroying weeds or some phytopathogens and pests, incorporation of fertilizers or pesticides, amendments, plant debris, creating the conditions for the incorporation of crop seed etc. (*Budoi and Penescu, 1996*).

Mankind developed tillage because they wanted to cultivate different species of plants. But, in many cases, this activity has become exaggerated in terms of number of works, intensity, time of execution and types of machines etc., which negatively affects soil characteristics (structure breakdown, decrease of humus content, compaction etc.).

Excessive works favoured the intensive oxidation processes and hence, reduced soil organic matter content, structure damage, increased risk of erosion, while heavy and repeated traffic often led to increased compaction and therefore triggered other negative phenomena. One worrying consequence of such excessive return to works of furrow overturning is the drastically decrease of a large number of representatives of mesofauna and foremost of earthworms etc., which, as we know, have a great role in formation of favourable soil characteristics (formation of stable aggregates, soil drainage etc.), (*Biriş et al, 2009; Vlăduţ et al, 2009*).

As a result, by the end of the first half of the century appeared the need to develop new technology with works to favour the establishment and growth of crop plants, but to avoid shortcomings of classic technology, to preserve and improve the productive potential of the soil. These technologies are known as "Tillage system for soil conservation, TSSC".

MATERIAL AND METHOD

Soil preparation for crop establishment (seeding) is one of the most important agricultural works, which is performed with high energy consumption and high costs. The quality of this work greatly affect the germination of crops and productivity of work that can be obtained per hectare. Therefore, at present, there are different equipment found in classic tillage technologies, which, with a single pass can be achieved with a minimal energy consumption, thus creating optimum conditions for sowing and to obtain a higher yield without soil degradation.

Following the extension of soil degradation due to conventional and technological mistakes, over the years, were studied and implemented in practice the so-called agricultural conservative technologies. These conservative technologies have contributed significantly to the reclamation and improvement of soil fertility and productivity and consequently of other environmental resources. The most important component of conservative technology systems, as in case of conventional one, is soil tillage – loosening type, processing and placing the seed in the soil. Passing from conventional tillage to the conservative was not easy and gave rise to a lot of questions that needed relevant answers, well-grounded scientifically, part of which was obtained through fundamental and applied research carried out under specific local conditions. Conservative systems rely on less intensive loosening of soil, carried out by different methods, without furrow overturning and only while preserving at soil surface a certain amount of plant debris, for this reason being considered ecological strategies of protection (*Biriş et al, 2015; Vlăduţ et al, 2008*).

Agricultural cultivators are equipment having an increasingly widespread for seedbed preparation in crop establishment, especially in the current conservative tillage technologies. Besides the fact that such equipment must achieve soil processing with superior qualitative and energy indices (*Vlăduţ et al, 2008*), their weight must be as small and reliability to be as good (*Vlăduţoiu et al, 2016*). At present it is possible to shorten spectacularly the cycle of conception-design-test-manufacture of this equipment by testing under simulated and accelerated regime (*Vlăduţ et al, 2007*) or by using the finite element method for analysing the distribution of stresses and strains in their elements of resistance (frames, racks for tools, working tools, etc.) (*Marin et al, 2002*).

RESULTS

In (*Petrescu et al, 2015*) was determined the proper frequency, using the finite element method (FEM) for three active structural elements that can be found in the composition of agricultural machinery used for seedbed preparation. Numerical analysis was conducted to know the frequencies of each active element, in order to determine the working program, and for what types of soil can be used these elements. Numerical analysis was performed on three types of active working elements, namely DELTA 1, DELTA 2 and GAMMA. For each element were determined the first three modes of vibration.

To achieve the geometric models, the CAD CATIA program was used and for numerical models the ANSYS software was used. Depending on the results obtained from modal analysis, the working parameters of the agricultural machine - vibro-combiner can be determined, namely: tractor power, forward speed, the depth of tillage. To validate the numerical models, experimental tests were conducted in order to determine the proper frequency.

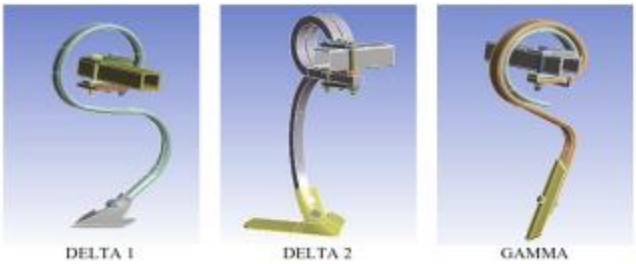


Fig. 1 – Geometric models of the three active elements [7]

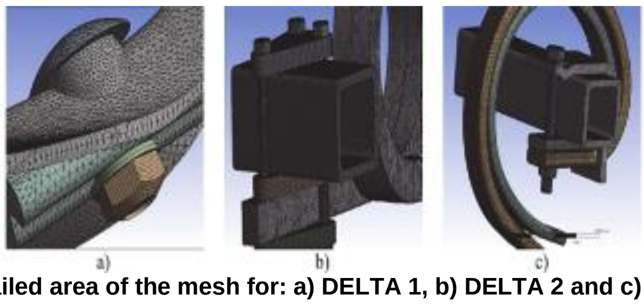


Fig. 2 - Detailed area of the mesh for: a) DELTA 1, b) DELTA 2 and c) GAMMA [7]

Boundary conditions imposed for the models are shown Figure 3. The constraints were placed on the support beam as in real life model.

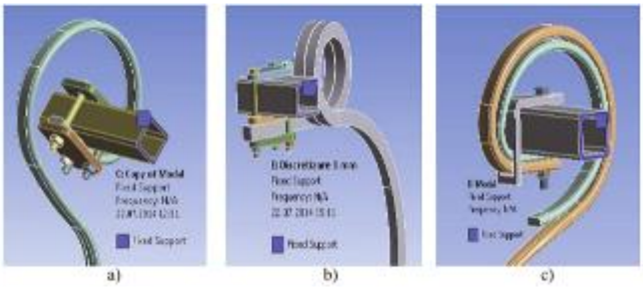


Fig. 3 - Detailed boundary conditions: a) DELTA 1, b) DELTA 2 and c) GAMMA [7]

Experimental tests were performed using Brüel & Kjaer PULSE system and a channel configured to meet the requirements (Fig. 4).

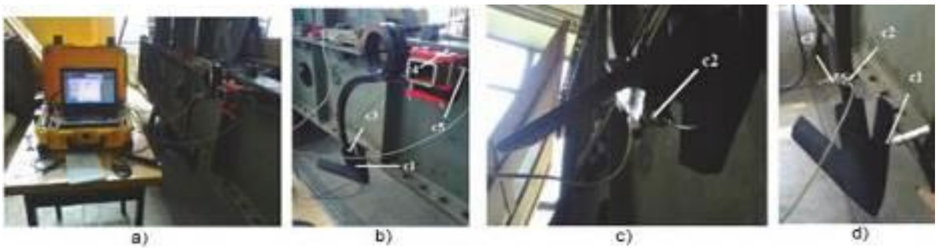


Fig. 4 - Experimental device (a), channel configuration for the first test (b), c) and channel configuration for the 9th test (d) [7]

The results obtained from FEM analysis provide frequency response and proper frequencies for all three models.

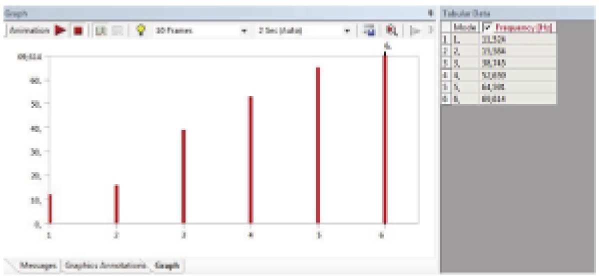


Fig. 5 - The first six proper frequencies for DELTA 1 [7]

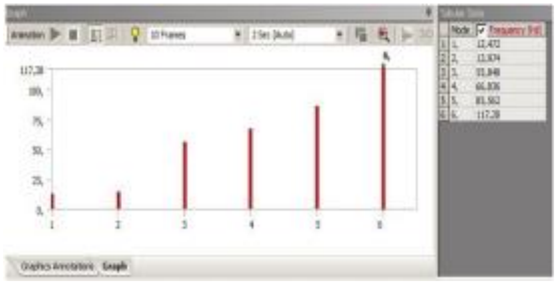


Fig. 6 - The first six proper frequencies for DELTA 2 [7]

The first proper frequency for DELTA 1 was obtained at a value of 11.52 Hz in longitudinal direction; the second frequency was obtained at 15.28 Hz in transverse direction, and the third in vertical direction, with a value of 38.75 Hz.

For DELTA 2 the first proper frequency was obtained at a value of 12.47 Hz in transverse direction, the second frequency was obtained at 13.97 Hz in longitudinal direction, and the third in vertical direction, with a value of 55.85 Hz.

Fig. 7 – The first six proper frequencies for GAMMA [7]

Table 1 [7]

Experimental results for DELTA 1

Channel Nº	Proper frequency Nº							
	1		2		3		4	
	Freq [Hz]	Mobility [m/Ns]	Freq [Hz]	Mobility [m/Ns]	Freq [Hz]	Mobility [m/Ns]	Freq [Hz]	Mobility [m/Ns]
2	11.25	91.7	15.25	3.85	20.75	4.46	40.75	1960
3	11.25	23.2	15.25	43.1	19.75	0.288	40.75	297
4	11.25	3.3	-	-	-	-	40.75	535
5	11.25	11.9	-	-	20.75	2.07	40.75	1460

Table 2 [7]

Experimental results for DELTA 2

Channel Nº	Proper frequency Nº			
	1		2	
	Freq [Hz]	Mobility [m/Ns]	Freq [Hz]	Mobility [m/Ns]
2	14	15.4	63	9.18
3	15	12.8	63.75	3.64

The first proper frequency for GAMMA was obtained at a value of 15.48 Hz in longitudinal direction; the second frequency was obtained at 18.06 Hz in transverse direction, and the third in vertical direction, with a value of 50.76 Hz.

Laboratory tests were performed only for elements of work DELTA 1 and DELTA 2 and they provided the same results as the finite element analysis. The data obtained are shown in Table 15 for numerical analysis type DELTA 1, respectively in Table 16 for DELTA 2 of the plowing.

Development of a competitive and sustainable agriculture that allows obtaining increased and healthy production cannot be achieved unless the works of crop establishment and maintenance are executed at a high quality level. Achieving of this involves assessing the quality of soil works according to certain quality and energetic indices, identified and measured by various methods.

To establish some criteria for assessing the quality of works carried out by machines for soil tillage, in (*Uceanu et al, 2008*) were performed experiments with different types of machinery, with different working bodies, at different speeds and depths on representative soil types, determining the admissible values of qualitative and energy indices of work, respectively the geometric and gravity elements of processed soil. Assessing the quality of work by the admissible limit values of qualitative and energy indices of work, determined using geometric and gravity elements, is an important step regarding the limit how far one should in the construction of machinery for soil tillage.

The main objective is to find the optimum constructive solutions and energy to obtain values considered admissible on the qualitative indices of work, with simple machines that have low energy consumption and as high economic efficiency, both in manufacturing and in agricultural exploitations.

Since soil works have an essential influence on the physico-chemical and biological characteristics of the soil, they are agro-technical measures of great importance, because they have complex effects on the physical, chemical and biological characteristics of soil.

By soil tillage should be ensured:

- accumulation and retention in the soil of the entire quantity of water from precipitation in summer and autumn;
- accumulation in the soil of a larger quantity of nitrate through the intensification of nitrification processes;
- obtaining of a layer of loose soil, but at the same time laid-down, to ensure good plant rooting and to avoid the unshod process;
- obtaining a seedbed without lumps, so that the seed can take as intimate contact with the soil in order to rise in the shortest possible time;
- control of weed, disease and pests, which bring great harm to agricultural production.

Soil works have influence on the water regime in the soil. Through various systems and methods of soil tillage are created favourable conditions for the accumulation in soil of higher quantities of water in dry regions, and in humid regions it provided a good drainage of water at greater depths, so as not to appear an excess of moisture in the arable layer of soil.

The influence of tillage on bulk density (weight by volume) is reflected by the fact that a loose soil creates good conditions for plant growth, because the roots develop better and penetrate more easily into the soil, especially in the early stages of vegetation.

Different degrees of soil compaction or soil loosening, achieved by agricultural works, are only maintained for a certain period of time. Hence, the influence of initial loosening on production is closely related to plant requirements towards a certain degree of soil loosening.

Soil porosity is a very important characteristic and decisively influenced by a good processing of the soil, because only within certain limits of aeration porosity and capillary porosity, plants and microorganisms can find better living conditions. The root system of plants can develop in good condition when the total porosity is between 48 and 60%, of which capillary porosity is 30-36% and aeration porosity is18-24%.

Also, the quality of soil tillage can have favourable repercussions, or not, on the hydric stability of soil aggregates. The size of soil aggregates is an important factor that determines the activity of microorganisms and biochemical processes, favourably influencing the regime of water, air and food in the soil.

By soil tillage it must also be achieved a distribution of soil aggregates, to create favourable conditions for plant growth and activity of microorganisms. Tillage methods can positively influence the formation of new structural aggregates. Hydrostatic diameter of aggregates is an indicative of soil aeration and intensity of biochemical processes in the soil.

Last but not least, the quality of soil tillage can impact the activity of soil microorganisms and biochemical processes.

Physical changes that occur in the soil by its methods of tillage, influences the ratio of soil content in the air, water and heat, creating favourable conditions for the activity of microorganisms. In fallow soil, microorganism activity is conducted with the highest intensity in the superficial layer, while on the tilled soil there is a more homogenous distribution of microorganisms into the depth.

Soil microorganisms use oxygen for the oxidation of organic matter from which they procure carbon dioxide and necessary food. Decomposition of organic matter to simple compounds and elements such as: CO_2, H_2O, NH_3, SH_2, P, Ca, Mg, Fe, etc., by heterotrophic bacteria, takes place with normal intensity only in the tilled and well-aerates soils.

Main agro technical works of soil for crop establishment are:
- basic soil processing with furrow overturning (plowing);
- basic soil processing without furrow overturning (chiselling);
- seedbed preparation by disk harrows, or by combiner, for sowing;
- soil processing to maintain the crops during the vegetation season.

Thus, the following were aimed:
- realization of production similar to those obtained in the conventional technology;
- reduction of production costs;
- increased stability of production;
- increased profits;
- increasing amounts of water from rainfall accumulated in the soil in winter;
- maintaining the physical, chemical and biological characteristics within the limits of normal activity of the root system of plants and microorganisms.

Indicators on operating parameters and energy consumption:
- qualitative indices of work;
- energy indices.

From the results obtained by testing under field-laboratory conditions were determined or calculated in accordance with the procedures in force, the following indices:

a) Qualitative indices:
- working depth, in cm;
- working width, in cm;
- degree of fineness (G_{ms}), in %;
- degree of covering by plant debris (G_v), in %;

b) Energy indices:
- effective working speed (V_e), in km/h;
- slipping (δ), in %
- fuel consumption per hectare (Q), in l/ha.

Table 3 [8]

Results obtained on the experimental plots

Name of basic work	Name of agricultural equipment in aggregate with U-650 tractor	Previous work	Experimental field	Qualitative indices of work						
				Working depth [cm]	Working width [cm]	Degree of fineness [%]				Degree of covering by plant debris [%]
						>100	50-100	20-50	10-20	
Seedbed preparation	GD-3,2	Harvesting	USAMV Timişoara	6.8	327.1	1.7	3.9	7.5	86.9	94.6
		Harvesting	SCDA Valul lui Traian	6.5	332.9	1.2	3.6	9.2	85.2	94.8
		Harvesting	MATHACHAND Amara	6.5	331.5	1.7	4.0	8.5	85.8	95.1
VIBROMIX	VIBROMIX	Harvesting	SCDA Şimnic	15.7	322.5	-				-
		Harvesting	INCDA Fundulea	16.0	323.0	-				-

Table 4 [8]

Name of basic work	Name of agricultural equipment in aggregate with U-650 tractor	Previous work	Experimental field	Energy indices					
				Speed [km/h]		Slippage [%]		Fuel consumption [l/ha]	
		-	-	II_R	III_R	II_R	III_R	II_R	III_R
Seedbed preparation	GD-3,2	Harvesting	USAMV Timişoara	5.57	8.49	13.60	12.29	6.73	6.11
		Harvesting	SCDA Valul lui Traian	5.10	8.33	13.00	10.83	7.10	6.27
		Harvesting	SCDA Şimnic	5.63	8.26	12.30	11.57	6.17	4.98
		Harvesting	Mathachand Amara	5.75	8.29	15.08	12.90	5.67	4.98

Field-laboratory testing of aggregates for soil processing, in different types of works, was carried out in September-October 2008 (the optimum time to work the soil in each area), on experimental fields located at INCDA Fundulea, SCDA Şimnic, USAMV Timişoara, SCDA Drăgăneşti-Vlaşca, SCDA Valul lui Traian and MATACHAND Amara.

Experiments were conducted on the six distinct areas of the country mentioned above, depending on the type of soil: black earth, reddish brown forest (luvisol), candic black earth, alkali black earth, and on tractor – machine aggregates, specific to soil tillage, existing in the mentioned units and comprised destination domains, composition and technical characteristics of the agricultural machinery used in the experiments, methodology, equipment and devices for measurement and control used during the tests, and also the formulas and calculation method of qualitative and energy indices of work.

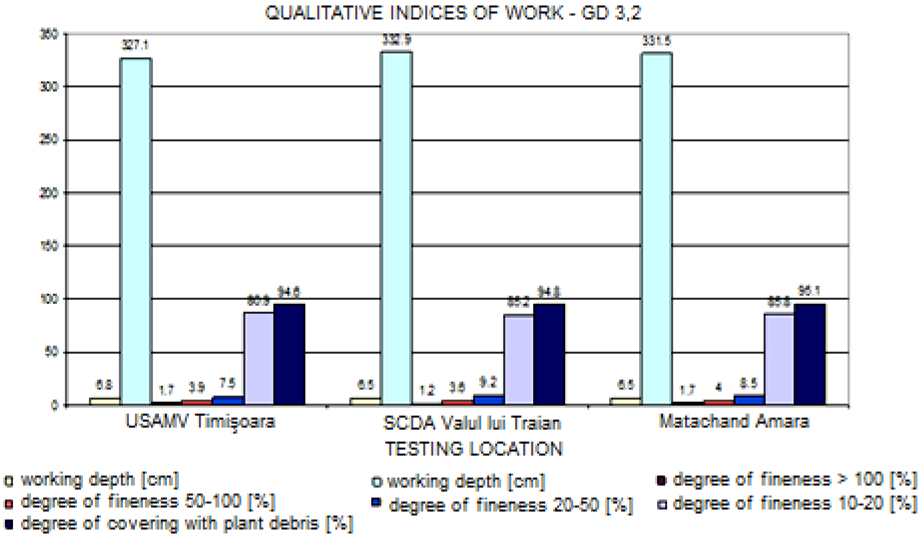


Fig. 8 – Qualitative indices of work for GD-3.2 harrow [8]

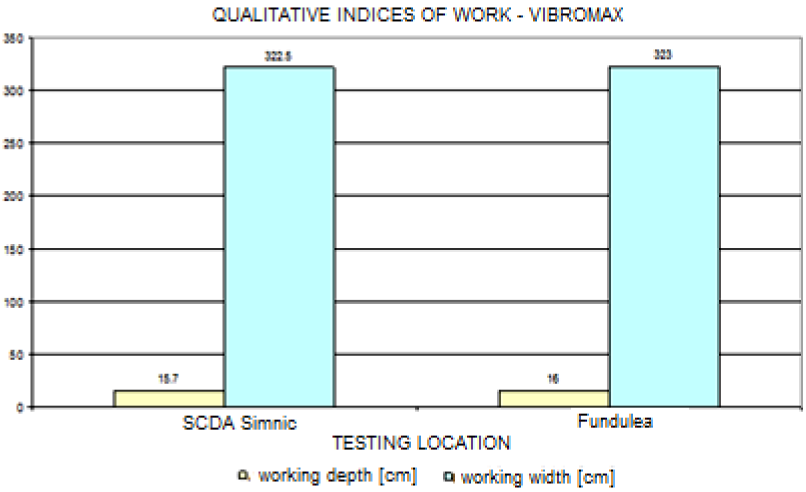


Fig. 9 – Qualitative indices of work for Vibromix [8]

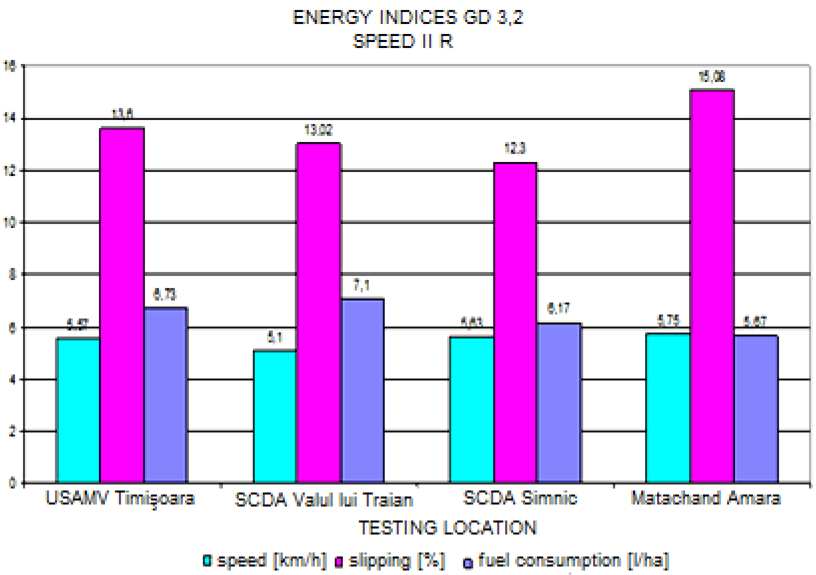


Fig. 10 – Energy indices for GD-3.2 harrow, speed II$_R$ [8]

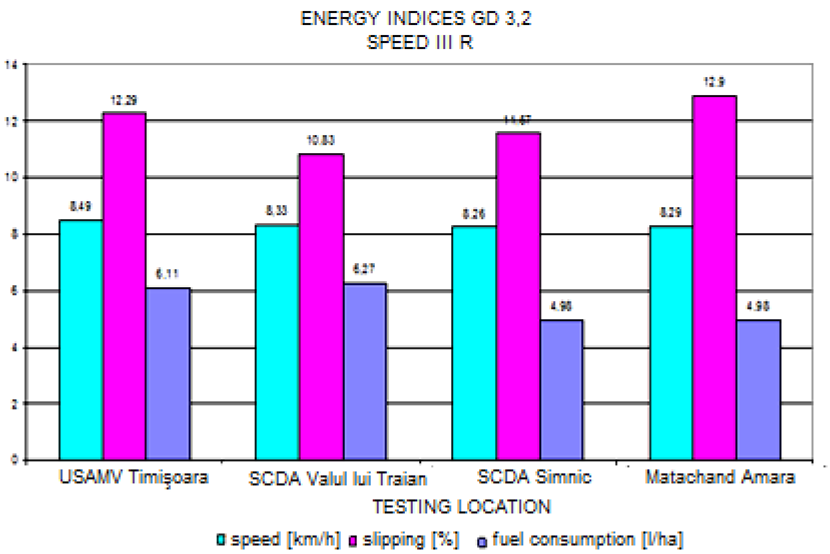


Fig. 11 – Energy indices for GD-3.2 harrow, speed III$_R$ [8]

- *GD-3,2 disk harrow,* accomplished the following indices:
  - working depth 6.5÷6.8 cm;
  - working width 327.1÷332.9 cm;
  - degree of covering by plant debris 94.6÷95.1%;
  - degree of fineness 1.2÷86.9 %;
  - working speed 3.30÷4.12 km/h, in step II$_R$ and 5.29÷6.43 km/h, in step III$_R$;
  - slipping 10.83÷14.40 %, in step II$_R$ and 11.48-14.40 %, in step III$_R$;
  - fuel consumption 26.51-36.06 l/ha, in step II$_R$ and 23.84÷32.28 l/ha, in step III$_R$;
- *modernized VBM VIBROMIX combiner (Fig. 6)*, accomplished the following indices:
  - working depth 15.7÷16.0 cm;
  - working width 322.5÷323.0 cm;
  - working speed 3.30÷4.12 km/h, in step I$_R$ and 5.29÷6.43 km/h, in step II$_R$;
  - slipping 10.83÷14.40%, in step I$_R$ and 11.48-14.40%, in step II$_R$;
  - fuel consumption 26.51÷36.06 l/ha, in step I$_R$ and 23.84÷32.28 l/ha, in step II$_R$.

In paper (*Constantin et al, 2008*) is presented a new mechanization technology comprising soil tillage by stubble plowing and / or seedbed preparation on freshly tilled soil or fallow soil on which are established summer-autumn crops, that can be applied to a level of quality suitable for the agro-pedological requirements, at a price as low and with low energy consumption, by promoting a new technical equipment for wheeled tractors of 120-220 HP. The new technical equipment, called GD-4, achieves working depths of 6-8 cm to soil stubble plowing and 10-14 cm to seedbed preparation on fresh tilled or fallow soil, with working width of approx. 4 m and the working capacity of approx. 3 ha/h.

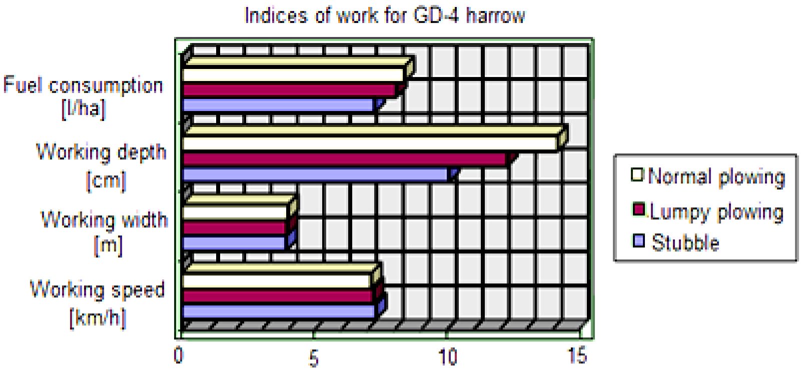
Plants sown or planted on a properly seedbed grow better than those when the seedbed is sitting on lumps that hampers (interrupt the capillarity) the infiltration of water towards plant roots. Currently, in our country, seedbed preparation on summer-autumn plowed soils is carried out with light disk harrows (in most cases) for 65 HP tractors, specialized combiners or imported heavy disk harrows, intended for high power tractors.

Seedbed preparation with a light disk harrow leads to higher fuel consumption, increased labour force, increased duration of work campaign and the execution of an inadequate seedbed under conditions with low soil moisture. In this context, it is aimed to promote a disk harrow with grinding bodies (additional), for high power tractors, in order to refine the technology of stubble plowing and seedbed preparation on fresh tilled soils on which are established the summer-autumn crops.

Soil works performed by heavy disk harrows are characterized by good results of soil grinding, mixing and mobilization, carried out under low moisture of the soil. In constructive and functional terms, disk harrows have the advantage of easily pass over any obstacles that arise during operation, and the active bodies, spherical disks type, have a low degree of wear due to the fact that stresses during operation are distributed over the entire length of the cutting edge.

Fig. 12 - Aspect during working with GD-4 harrow with independent disk [4]

GD-4 harrow with independent disk showed good stability in horizontal and vertical plane. Variations of the qualitative indices of work with the type of processed soil are shown in Figure 13.



	Working speed [km/h]	Working width [m]	Working depth [cm]	Fuel consumption [l/ha]
Normal plowing	7.17	4.02	14.2	8.4
Lumpy plowing	7.25	3.99	12.3	8.1
Stubble	7.35	3.96	10.1	7.3

Fig. 13 - Variation of work indices of GD-4 harrow by type of soil work [4]

The main indicator of the quality of work is the *degree of soil grinding (fineness)*. To determine it, a soil sample with size of 1m x 1m was delineated (using a metric frame with working depth of the harrow). From the sample were separately soil fractions of less than 50 mm of the lumps larger than 50 mm. The degree of fineness represents the ratio in weight of soil fractions with satisfactory fineness, respectively with lumps size of 50 mm, relative to the total weight of soil sample, calculated using the following equation:

$$G_m = \frac{\sum_{1}^{n} \frac{M_{ci}}{M_{ti}}}{n} \cdot 100$$

where: M_{ci} – measured weight of lumps with maximum conventional size smaller than 50 mm in the sample of soil, [kg]; M_{ti} – measured weight of the entire sample of soil, [kg].

Weighing has been performed with a portable scale, with a permissible relative error of 1%.

Main accomplished qualitative and energy indices are:

- average working depth a_{med} = 10.1÷14.2 cm;
- average working width B_{med} = 3.82÷3.96 cm;
- degree of soil grinding (fineness) G_m = 75.1÷80.2%;
- degree of incorporation into the soil of plant debris G_v = 95.2÷96.6%;
- loosening degree G_{as} = 20.1÷26.2%;
- working speed v_e= 4.97÷7.35 km/h;
- effective working capacity W_{ef} = 1.98÷2.95 ha/h;
- fuel consumption Q = 7.29÷8.37 l/ha.

In paper (*Constantin et al, 2012*) are presented the experimental research conducted with MATINA multifunctional aggregate for soil tillage in agricultural exploitations, promoting the conservative agriculture system, based on the basic work of soil, without furrow overturning, with plant debris superficially incorporated into the soil and maintaining at soil surface at least 30% of their total.

In quantitative and qualitative terms, this system ensures competitive production to those obtained in the classic system, but with low costs and high profits, under the condition of improving soil characteristics and environmental protection.

Testing in laboratory-field conditions of the aggregate were made within private farms in Dolj County and Teleorman County, at soil processing on fallow soil (spring) and on barley and wheat stubble (summer) in April-August 2011.

MATINA performed, in a single pass, the following agricultural works: deep loosening of soil with loosening bodies, in order to facilitate easier penetration of plant roots, in depth after the necessary nutrients and water; seedbed preparation with specific working bodies; grinding and additional levelling of soil by rollers with rods.

Fig. 14 – MATINA multifunctional aggregate for soil processing [5]

1 – battery with chisel bodies; 2 – battery with independent disks; 3 – roller with rods; 4 – mono-beam chassis with transportation train

Testing under laboratory-field conditions of MATINA multifunctional aggregate for soil tillage were made using the following wheeled tractors with dual traction and engine power of 180-240 HP, thus:

- on fallow soil (spring) it was used the ZIMBRU 2200 tractor with engine power of 220 HP, manufactured by SC MAT SA Craiova (Fig. 15);
- on barley stubble (summer) it was used the ORION 18 tractor with engine power of 180 HP, manufactured in Poland (Fig. 16);
- on wheat stubble (summer) it was used the STEYR-9270 tractor with engine power of 240 HP (Fig. 17).

It was tilled an area of 590 hectares, of which 60 hectares have been worked during spring, on fallow soil, and 530 hectares of barley and wheat stubble worked in summer 2011.

Fig. 15 – Aspect during experimental research under field-laboratory conditions with ZIMBRU tractor on fallow soil - spring [5]

Fig. 16 - Aspect during experimental research under field-laboratory laboratory conditions with ORION 18 tractor on barley stubble [5]

Fig. 17 - Aspect during experimental research under field-laboratory laboratory conditions with STEYER-9270 tractor in wheat stubble [5]

In laboratory-field testing of MATINA multifunctional aggregate for soil processing, the following qualitative indices of work were determined: working depth - a_m; working width - B_m; the destruction degree of plant debris - G_v; the degree of soil grinding (fineness) - G_m; the degree of soil loosening - G_{as}.

Based on data obtained and processed during experimental research in the field-laboratory conditions, it was compiled a summary of qualitative indices of work, which are presented in Table 4.

Table 4 [5]

Parameter name	Fallow soil – spring	Barley stubble	Wheat stubble
a_m [cm] – soil loosening (chisel)	24.71	23.62	22.8
a_m [cm] – seedbed preparation	13.25	12.32	11.15
B_m [cm]	299	298	297
G_v [%]	81.8	70.4	70.6
G_m [%] - lumps ≥ 100 mm	91.84	86.76	87.26
Gas [%]	20.56	20.41	20.08

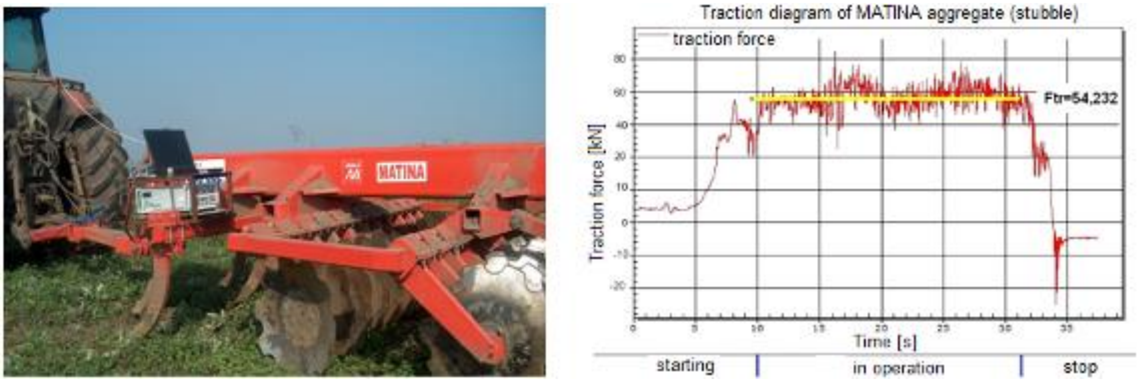


Fig. 18 – Aspect during the determination of traction force / Traction diagram of MATINA aggregate [5]

In laboratory-field testing of MATINA multifunctional aggregate for soil processing, the following energy indices in the field were determined: working speed - v_l; traction force - F_{tr}; slipping – δ; traction power - P_m; effective working capacity - W_{ef}; average fuel consumption. Traction force was measured with equipment composed of traction-compression bar and amplification system and data acquisition type MGCplu-HBM (Hottinger-Baldwin-Messtechnik).

Aspects during determining the traction force and traction diagram are shown in Figure 18. Table 5 presents the measured and determined values of energy indices in the field, achieved by the MATINA multifunctional aggregate for soil tillage during testing.

Table 5 [15]

Repetition	*Working speed,* [km/h] v_{lm}		*Traction force* [daN] R_i	*Traction force* [daN] F_{trm}	*Average slipping* [%] δ_m	*Average traction power, P_m* CP	*Average traction power, P_m* kW	*Effective working capacity* [ha/h] W_{ef}	*Average fuel consumption* effective [l/ha], Q_{ef}	*Average fuel consumption* hourly [kg/h], „c"
1	*9.2*	9.2	5270	5423.2	12.43	185.1	136.24	2.73	11.91	27.95
2	*8.5*		5950							
3	*8.7*		5750							
4	*10*		4805							
5	*9.6*		5108							

In spring 2011 was carried out, in adjacent rotation crops, soil processing in conservative system with MATINA multifunctional aggregate for soil tillage and in classical system with dedicated equipment. During the works were made measurements of fuel consumption on each system for soil processing, and the analysis showed that conservative system is achieved with fuel savings of approx. 40%.

Based on these considerations, (*Biriş et al, 2015*) presented an advanced methodology for the analysis of stress and strain distribution (static structural analysis using the finite element method) in the working bodies of agricultural cultivators for seedbed preparation.

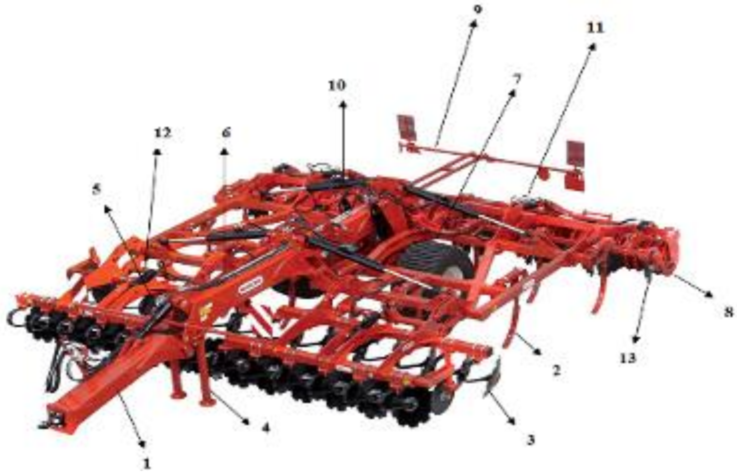


Fig. 19 - Technical equipment for conservative soil processing [1]
drawbar with towing ring (1); working bodies type knife chisel with extension (2); preceding disks (3); double bearing support (4); identification tablet (5); central frame (6); transport train (7); rear roller (8); lights kit (9); hydraulic installation for folding of lateral frames (10); hydraulic installation for working depth adjustment of the roller (11); hydraulic installation for working depth adjustment of the disks (12); disks levering bar (13)

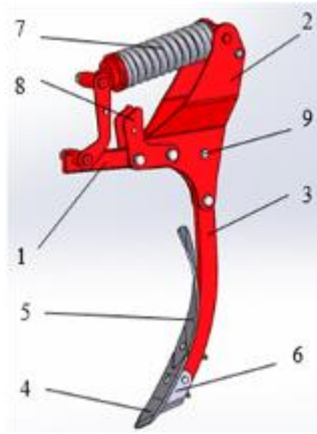


Fig. 20 – Active body of the equipment [1]

To optimize them, the geometric model of the working body for soil processing was developed in SolidWorks before being processed by an analysis program with finite elements (ANSYS), to carry out the necessary resistance calculations, which were performed in linear static domain (Fig. 21). The results obtained from the meshed model (Fig. 22) give very valuable information on proper geometric dimensioning of the working bodies of technical equipment for conservative tillage of soil is semi-mounted type and works in aggregate with 330-550 HP tractors.

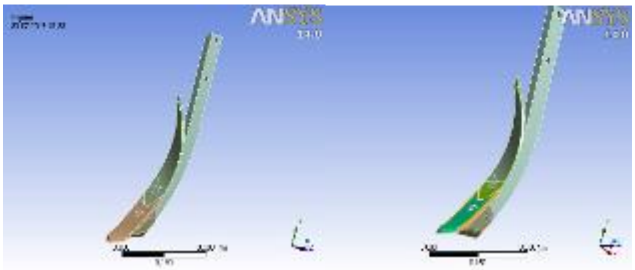


Fig. 21 – Geometric model of active body imported in ANSYS [1]

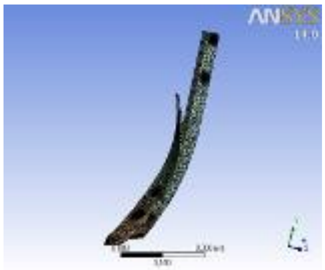


Fig. 22 – Meshed model of the active body [1]

The results of the static analysis of the working of the cultivator (Fig. 23, 24 and 25) consist of: distribution of total deformation, distribution of normal pressures on the coulter of the working body, distribution of equivalent stress by the Von Mises criterion in both the coulter and the wing of the working body, but also in support of the working body.

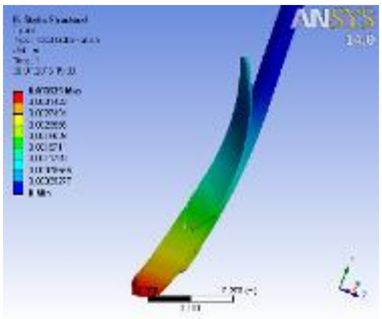


Fig. 23 – Distribution of total deformations [1]

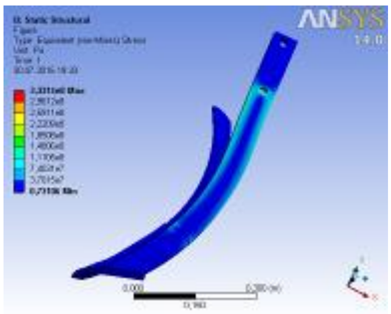


Fig. 24 – Distribution of equivalent stress [1]

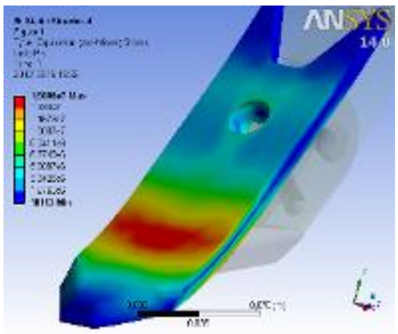


Fig. 25 – Distribution of stress on the coulter of active body [1]

CONCLUSIONS

So far, in Romania, the technology of soil tillage without furrow overturning has not been carried over very large areas, research conducted by specialists recommending that only on certain types of soil (eg salty, sandy subjected to erosion, etc.) tillage should be mandatory performed without furrow overturning in order to preserve soil structure and to maintain its fertility.

Recent research has highlighted the fact that in our country, more and more specialists and farmers recommend and begin to intensify the use of equipment for soil processing without furrow overturning, of which complex vibro-combiners and combiners are the most common.

Determination of bending resistance and shearing resistance of strength structures, respectively of tool-soil interaction may be determined by experimental research, and more recently by discrete element method (DEM) and finite element method (FEM) which enable the development of a high fidelity model to describe and can serve as a predictive tool for simulation in the design process.

ACKNOWLEDGEMENT

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CASE STUDY ON COST-EFFECTIVE AND ENVIRONMENTALLY SAFE MEASURES FOR CHICKEN MANURE TREATMENT FOR UKRAINIAN POULTRY SECTOR
/
ДОСЛІДЖЕННЯ ЕКОНОМІЧНО ЕФЕКТИВНИХ ТА ЕКОЛОГІЧНО БЕЗПЕЧНИХЗАХОДІВ ОБРОБКИ КУРЯЧОГО ПОСЛІДУ ДЛЯ УКРАЇНСЬКОГО ПТАХІВНИЦТВА

Ph.D. Stud. Onyshchenko O.M., Prof. Ph.D. KharytonovM.M.*
DnipropetrovskStateAgrarian-EconomicUniversity, Dnipropetrovsk, Ukraine;
Tel: 380973456227; E-mail: envteam@ukr.net

Keywords: *emission, composting facility, pelletizing of manure, farm revenue*

ABSTRACT

Composting is the most widely practiced waste management technology for poultry farms which allows obtaining valuable organic fertilizer. However, air emissions from composting, especially ammonia emission, reduce the nitrogen fertilizer value of the compost and greatly impact the environment. Thermal drying and pelletizing was proved to be an alternative to reduce odours, emission and provide higher rate of hygienic safety for operations.

The goal of this study was to evaluate emission from a poultry manure compost facility compared to same facility in case they hypothetically use thermal drying and pelletizing of manure and evaluate main economic indicators.

For poultry farm of average size with standard production cycle, the minimal required manure processing measure is putting manure into windrows, thus certain emissions are generated in fuel burning while putting compost into windrows, fermentation of manure and turning at rate of 3.2 kg of CO_2 per metric ton of final compost, and certain amount of NH_3per each metric ton of final product.

Although during thermal processing and pelletizing of manure emission that occurs is higher calculated per metric ton of final product (3.5 kg of CO_2 and 0.105 kg NH_3), considering much smaller amount of final product per same farm capacity due to very low wet content, bulk load that potentially might be created is significantly lower.

Considering that there is no significant revenue decrease due implementation of manure drying and pelletizing operation into farm infrastructure, this option could be claimed more sustainable in a long-term perspective.

ТЕЗИ

Компостування є найбільш поширеною технологією для переробки відходів птахофабрик, яка дозволяє отримати цінне органічне добриво. Однак, емісія азоту у процесі компостування, особливо у вигляді аміаку, зменшує цінність компосту, як азотного добрива, і створює значний вплив на навколишнє середовище, Термічна сушка та пелетування може бути альтернативою для зменшення запаху, викидів, та забезпечення вищого рівня гігієнічної безпеки виробництва.

Метою цього дослідження є еколого-економічна оцінка виробництва продукції птахівництва, що виробляє компост, та порівняння екологічних та економічних показників для стадії переробки якщо це ж підприємство гіпотетично впроваджує технологію термічної сушки та пелетування посліду.

Для птахоферми середнього розміру зі стандартним циклом виробництва мінімально необхідним заходом є переробка гною з подальшим зберіганням гною у буртах. Таким чином, певні викиди утворюються при укладанні посліду у бурти та його перевертанні, за рахунок витрати паливно-мастильних матеріалів та процесу стабілізації самого посліду у розмірі 3,2 кг CO_2 на тону готового компосту та певної кількості амміаку.

Хоча під час термічної обробки та пелетування викиди розраховані на тонну готового продукту є вищими (3.5 кг CO_2 і 0.105 кгNH_3на одну тонну готового продукту), для тієї самої потужності виробництва валова емісія нижча, адже за рахунок дуже низького вмісту вологи, кількість отриманого продукту значно нижча.

Враховуючи не значне зниження доходів через реалізацію сушіння та гранулювання посліду цей варіант може бути оцінений як більш сталий в довгостроковій перспективі.

INTRODUCTION

Ukraine was always known as “the breadbasket of Europe” because of the “chernozem”, very fertile and high-yielding black soil. Recently animal farming along with crop production has notably expanded and progressively became more vertically integrated – agricultural enterprises are controlling all elements of the value chain from grain and fodder production to retailing of processed meats.

Poultry production emerged as the most advanced segment of the sector and in fact it is “the most concentrated subsector of Ukraine's economy” where large farm agglomerations have 60 % of market share of the industrially-produced chicken in the country in 2014 (*Yarmaket all, 2014*).

Livestock production, especially poultry, has expanded rapidly during last 15 years and this expansion is expected to continue in the years to come. Questions arise about the number of animals that can be kept in a country or in a region without detrimental effects on food security, natural resources and environmental quality, and human and animal health. In this regard, several aspects have to be considered, especially the economic one (*Tarassevych, 2008*).

The standard procedure for manure management in big poultry complexes is to collect all manure in open-air storage sites where it remains for several months to stabilize – composting process that is recommended by all regulations in Ukraine as a multi-step, closely monitored process of combining of poultry manure with carbon rich organic materials. The decomposition process is aided by shredding the plant matter, adding water and ensuring proper aeration by regularly turning of the mixture to support thermophilic temperatures, the temperature of the pile or windrow ranges between 10 and 40 °C. Once microorganisms' activity is decreasing, usually this is reached, after 2 to 3 months, an additional 4 to 6 week curing stage is recommended to further stabilize the product and ensure no adverse reactions with the consumer. After that it is applied on the fields as fertilizer at the appropriate time (*Petersen and Andersen, 1996; DSTU 7527, 2014*).

In practice it happens that large heaps of manure piled in the fields, without a clear indication of how they are to be used. Manure had already been applied in the fields surrounding the heaps, so the leftover supplies were simply left there.

Important criteria for the development of sustainable livestock are management of nutrient pollution along with wastes re-use or utilization. In order to address nutrient pollution in the agricultural sector that has limited financial resources, the most efficient measures to tackle the pollution should be selected against the cost effectiveness criteria.

There are certain studies demonstrating the risks of manure direct application even after stabilization or composting because of trace contaminants such as drugs and antibiotics that birds get in farms.

Antibiotics used in poultry production system include bacitracin, bambermycin, chlortetracycline, dihydrostreptomycin, erythromycin, lincomycin, neomycin, oxytetracycline, penicillin, spectinomycin, streptomycin, tetracycline and tylosin (*Bhattacharya and Taylor, 1975*). There is certain class of chemicals used to control internal protozoan parasites that cause coccidiosis (*Erickson and Prior, 1990*).

The excretion of the coccidiostat sulphaquinoxaline and decoquinate has been studied in caged broilers fed diets containing these two drugs. Storage of broiler excreta at 23°C for 9 days showed contrasting effects; the sulphaquinoxaline content decreased about 40% with respect to initial content in the manure whereas the decoquinate concentration remained unchanged (*Hill and Pulkinen, 1988*).

In egg farms, chemicals are often included in diets to control parasites in the litter. Examples of some larvicides include rabon, zoalene, unistat, nicarbazin, furazolidone, and nitrofurazone and cyromazine (*Audsley et all, 2010*).

Some of these chemical residues have been found in compost, but the concentration of chemical residue, amount, frequency, retention and stability remain uncertain (*Nahm, 2005; Karci and Balcioglu, 2009*).

Poultry manure contains a large and diverse population of viruses, bacteria, fungi and 10 protozoa. Microbial concentrations in poultry litter can exceed 10 cells/g (Acosta- Martinez and Harmel, 2006; Cook et al., 2008; Rothrock et al., 2008a), and gram positive bacteria (i.e. *Actinomycetes, Clostridia/Eubacteria, Bacilli/Lactobacilli*) account for nearly 90% of the microbial diversity (*Asman, 1992*). Besides the consequences of land application of poultry manure containing few groups of chemical residues, decreases in the rate of decomposition of the poultry litter and the crop responses to manure-borne nutrients resulting from the land application of antibiotics- and coccidiostats-containing manures have been reported. The presence of antibiotics in manure poses the potential environmental risks of soil micro flora suppressing.

While microbes perform a variety of different enzymatic and metabolic processes within the litter environment, two microbial groups of special interest to the poultry industry are nitrogen mineralizing microbes and pathogens.

Ammonia volatilization results from the mineralisation of organic nitrogen in the poultry litter, namely uric acid and urea, and more than half of the nitrogen in poultry litter is lost as ammonia due to microbial activity (Kolhe and Mittra, 1989).

It has been estimated that field-applied manure Ammonia emission is the function of transfer of contributes about 10 % of the total emission of NH_3 in Europe, certain emission also connected with operating of agricultural machinery and fuel burning suppressing (*Ahmedet all, 2007*).

Pelletizing according to Eriksson and Prior (1990) also, nitrification inhibitors have been devised to reduce nitrogen losses and improve fertilizer use efficiency. The split application of N fertilizers is cheaper, but slow-release N fertilizers, when applied at the right time, minimize the risk of N losses by leaching suppressing. There are uncertainties about data on nutrient transformation and leaching from manure applied to soil. *Ahmed et al (2007)* had demonstrated slow release of nitrogen and decrease of wheat yields by 18.3-27.8% and rice yields by 27.5-50.4% as compared to common urea and also found that slow-release nitrogen fertilizer gave the highest yield of sorghum and wheat, respectively.

Approved by BAT, (best available techniques) pelletizing, also known as extrusion, converts fresh manure to a dry, pathogen-free, easy to handle, finished product that can be used as a fertilizer, soil amendment, feed additive, or energy fuel [15].

The purpose of a manure thermal treatment and pelletizing are listed in several comprehensive reviews and main of them are:

- Odour reduction
- More effective recovery of nutrients or energy from the manure
- Pathogenic bacteria and weed seeds removal
- Increase the fertilizer value
- Reduce the volume for transportation and storage logistic optimization
- Decrease the pollution potential of the manure (Hill and Pulkinen, 1988).

The pelleted broiler litter meets all qualifications as an organic fertilizer according to Ukrainian classification standards. Some components may be slightly denatured due to the heat and pressure from the pelleting process that occurred only for a short period (~5-10 second). Pelleted broiler litter has more appropriate characteristic in fertilizing values than fresh broiler litter due to higher content of nitrogen, and presence of phosphorous and potassium is necessary for plants proportions.

Although manure application increased significantly after the economic crisis as it is approved to be the cheapest option to fertilize croplands, recently, large producers started to consider environmental risk factors as growing so they have to respect sustainability principles (Kolhe and Mittra, 1989).

MATERIAL AND METHOD

The aim of the study is to evaluate cost-effectiveness of poultry litter utilization through the composting and alternative way – pelletizing and drying and application of those as a fertilizer by determination of the minimum cost of meeting a specified physical outcome.

Reduction of agricultural pressures was mainly evaluated as emission according to the methodology proposed in scope of Life Cycle Assessment methodology developed by Leiden University. As potential nitrate groundwater leaching can be only correctly projected for both cases as the rate of nitrogen leaching depend on the following factors: nitrogen mineralisation from the soil organic matter; nitrogen uptake by vegetation (if any) per month; nitrogen input from the spreading of fertilizer and soil depth, this value can be defined only through the field study for particular area (ISO, 2006a; 2006b).

Literature values were used to confirm the specific emissions to the atmosphere of different production lines and to define emission levels resulting from the two different poultry litter processing technologies the implementation of best available techniques (BAT). BAT emission levels were defined as reference values, counted according to the methods proposed by Leiden University using data from the ecoinvent database (*ISO, 2006b*).

The unit process row data were obtained from the commercial dry pelletized manure producer in Ukraine. Production process causes ammonia emission as well and average out from few sources comes to 105 mg of NH_3 per kg of dried poultry litter. No data were found on average transporting distance as it is assumed that fertilizer is applied locally on fields. It was assumed that existing poultry farm infrastructure is used for the manure processing.

Dorset dryers are frequently used for drying chicken manure with the help of warm air from stables. Most of these installations do not use pre-drying in the stable, which leads to substantial savings in electricity costs. The dried product is pelletized with a screw-pressing machine or extruder in particular cases.

Equipment cost was taken as average 2000 euros per 0.2 metric ton of manure per hour capacity which the producer reported.

For creation of manure pelletizing an industrial area of 1.38 m^3 per metric ton of pelletized manure produced is required, construction site at rate 0.053 m^2 per metric ton of produced pelletized manure, 0.56 m^2 of land for transportation (JRC-IES, 2010).

Data on investment costs and operating costs for the implementation of two technologies was calculated for two hypothetical production lines for manure processing that could be implemented on broiler and egg farms with total capacity of 50 000, 100 000 and 150 000 heads per year according to Concepts and Methods for Economic Evaluation of Alley Farming methodology developed by FAO (*Erickson and Prior, 1990*).

Investment cost according to average cost of equipment and industrial area occupied were calculated according to the equation:

$$a = \mathrm{Co} \times \frac{qn \times (q-1)}{qn-1} \tag{1}$$

With q = i+1; a – annual capital cost [euro]; C_0 – total investemnt cost [euro]; I – real discount rate [%]; n – number of years.

Farm offset revenues were evaluated according to the ready product for field application that hypothetically could be obtained by farmer (compost of pellet) which have their average fixed market price (prices for fuel, listed inventories, resources and products presented are actual for Ukrainian market and converted into euros). It is considered that there is no need to purchase fertilizers for farm so in this case certain savings are considered as revenue or in particular cases produced compost or dry pelletized manure can be sold. Cost analysis for one year, some costs of production varied with the level of production.

As two chosen manure processing technologies are particular combination of resources applied in the production process and need only some modifications and equipment in case of pelletizing, products have quite similar composition but percentage of particular elements varies mainly due to wet content of the product. Data of raw material (manure) qualitative characteristics and products characteristics (compost and pelletized manure) were collected from literature sources and some data (pelletized manure) were obtained from local Ukrainian producer.

Table 1

Fertilizing values of fresh chicken manure, composted and pelleted manure

Indicators	Values reported for fresh chicken manure in scientific studies by different authors	References	Values for composted manure reported in scientific studies by different authors	References	Pelleted broiler litter (commercial data from the producer of “Florex”).
Dry matter, %	29.5 – 35.6	Ekinci et al.(2000)	72 - 85		97
Organics (C), %	19.3 – 23.1	Wood, Hall (1991)	78.4	Candias et al. (1999)	80
pH	6.3 – 8.4	Gordillo and Cabrera (1997b)	-	-	6.9

Nitrogen, %	2.6 – 5.3	Beegle (1997)	0.7	Candias et al. (1999)	3,2
Ammonium N, %	0.3 - 1.0	Carballas (1996)	-	-	0.1
Phosphorous, %	0.6 – 3.9	Brown et al.(1993)	0.4	Candias et al. (1999)	2.4
K, %	0.7 – 5.2	Brown et al.(1994)	0.6	Candias et al. (1999)	2.4
Mg, %	0.2 – 0.9	Cummis et al.(1994)	-		0.7
Mn, mg/kg	125 - 667	Smith and Chambers (1993)	-	-	100
Fe, mg/kg	529 – 2.982	Stephenson et al.(1990)	-	-	300

As pelletized poultry litter under trade mark "Florax" is commercially available in Ukraine the income for poultry producer from implementing of manure pelletizing line to process manure that is created can be estimated. Besides economical effect, ecological effects according to the principles of sustainability should be evaluated. In case of manure management, emission to the air is the main factor that burdens environment and besides manure placement is taxation is based on that criteria according to existing Ukrainian regulations.

Available in the ecoinvent database data on NH_3 emissions from composting processes. *Matsusada et al. (2002)* varies from 15 mg/kg to 2740 mg/kg for poultry manure for aeration rates ranging from 0.2 to 1.4 L/(min kg) and C/N ratios from 19 to 56 for poultry, respectively. Composting proces itslef requires certain operations to put manure into windrows (5 L of fuel per dry metric ton of litter) which transforms into 18.3 kg CO_2 and turning - 14 kgCO_2 per dry metric ton of dry poultry litter (*JRC-IES, 2010; 2012*).

Spreading compost by a broadcaster, according to ecoinvent database data in average causes emission of (1.655 kg CO_2) per one metric of compost, 2.3 kg of nitrogen oxides, 0.21 kg of carbon monoxide, 0.053 kg of sulphur dioxide and 0.0068 kg of methane (*JRC-IES, 2010; 2012*).

Drying and pelletizing process for the poultry manure to obtain product with wet content around 3 % requires using of natural gas at rate of 0.0015 cubic meters per kg of dried manure. After drying feedstock undergoes a granulation process with electrically driven press requiring in approximately 0.12 KWh per kg of final product (*JRC-IES, 2012*).

Spreading of dry pelletized manure by the broadcaster creates additional emission of (1.33 kg CO_2) per one metric of compost from the 2.2 kg of nitrogen oxides, 0.25 kg of carbon monoxide, 0.061 kg of sulphur dioxide and 0.0043 kg of methane resulting from the fuel combustion (JRC-IES, 2012).

Application rate defined by fertilization value according to the concentration of nitrogen, phosphorous and potassium in the composition thus for dried and pelletized manure the amount of amendment applied is lower because of lower volume as it has very low water content compared to compost thus the use of fuel and working hours for broadcaster required to provide equal amount of nutrient per area in case of using of dried and pelletized manure is lower in this case (*JRC-IES, 2010; 2012*).

RESULTS

Air emission categorized by the type of air pollutants appeared to be equal for all stages of manure processing for both processing technologies according to available numerical data and even lower for composting in case of CO_2 potential emissions (fig. 1).

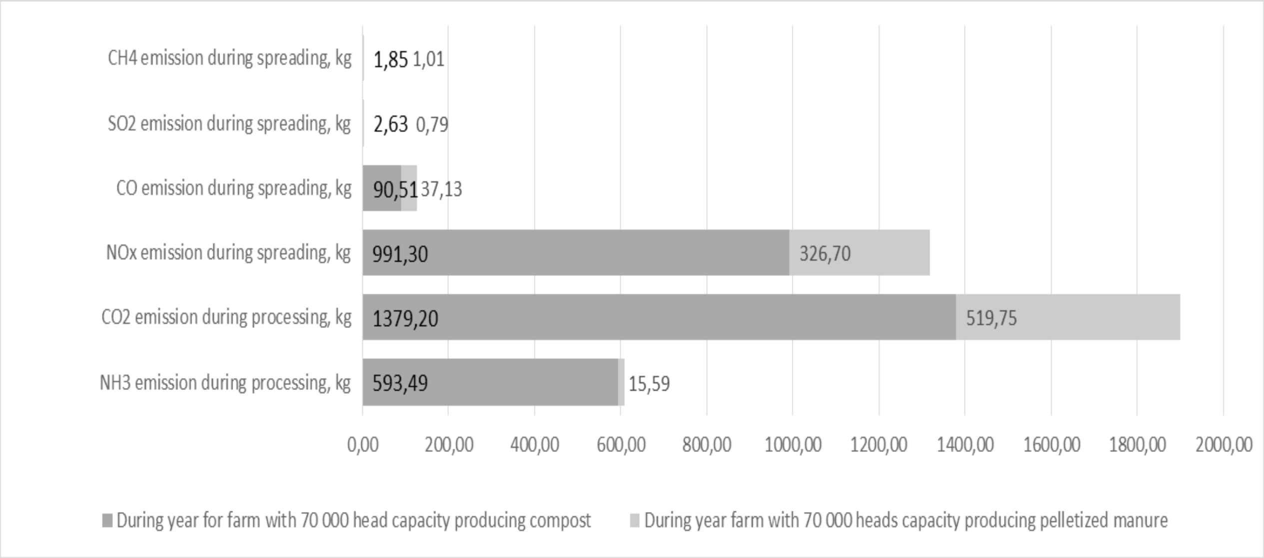

Fig.1 - Potential air emission categorized on pollutant type and process type.

Although due to significantly lower wet content of the product as in case of pelletizing, bulk outcome of product and emission created recounted on farm capacity, as amount of manure produced depend on amount of birds for any farming type, potential emission calculated per farm capacity is significantly lower in case when drying and pelletizing is chosen (fig. 2). Farm capacity of 70 000 heads per year was chosen as representative average farm for Ukraine.

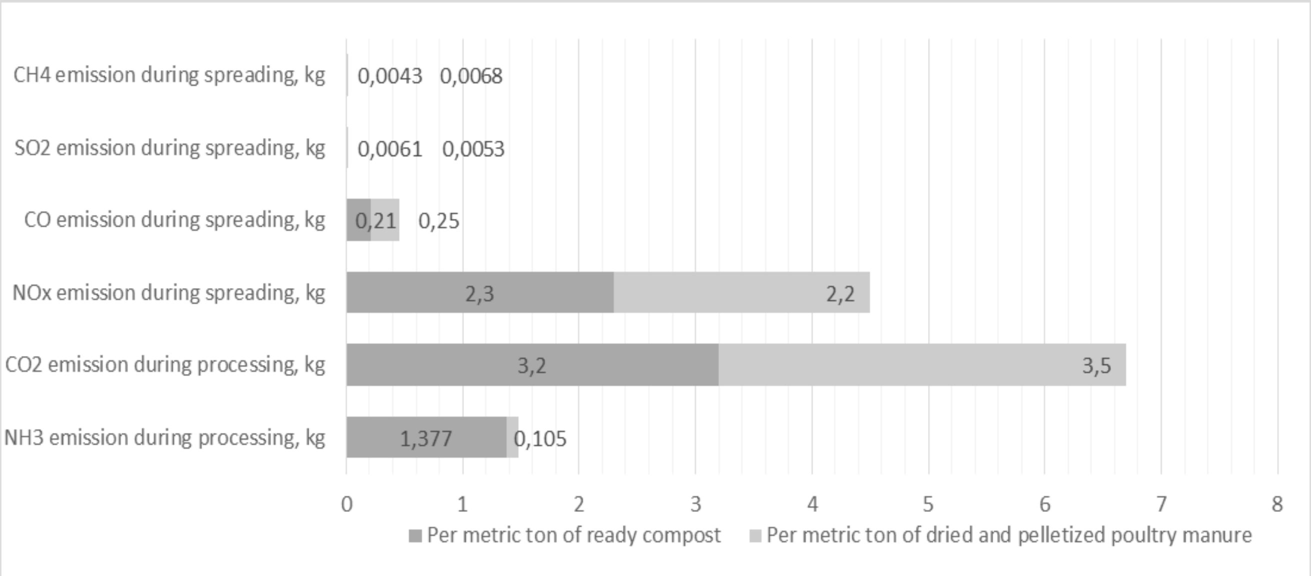

Fig. 2 - Potential air emission calculated as average for farms with 70 000 heads per year capacity categorized on pollutant type and process type

General farm revenue composting its manure to apply on the croplands for broiler and egg farms appeared to be higher with average cost of 60 euros for metric ton of ready compost (average actual market cost) but not significantly. Thus for broiler farm with year capacity of 50 000 birds can get up to 4680 euros revenue while pelletizing same amount of manure will bring only 1037 euros revenue.

For egg farm with 150 000 heads per year capacity composting can help to gain around 40300 euros revenue while manure thermal processing and pelletizing can create only product that has bulk market value up to 30000 euros (fig. 3).

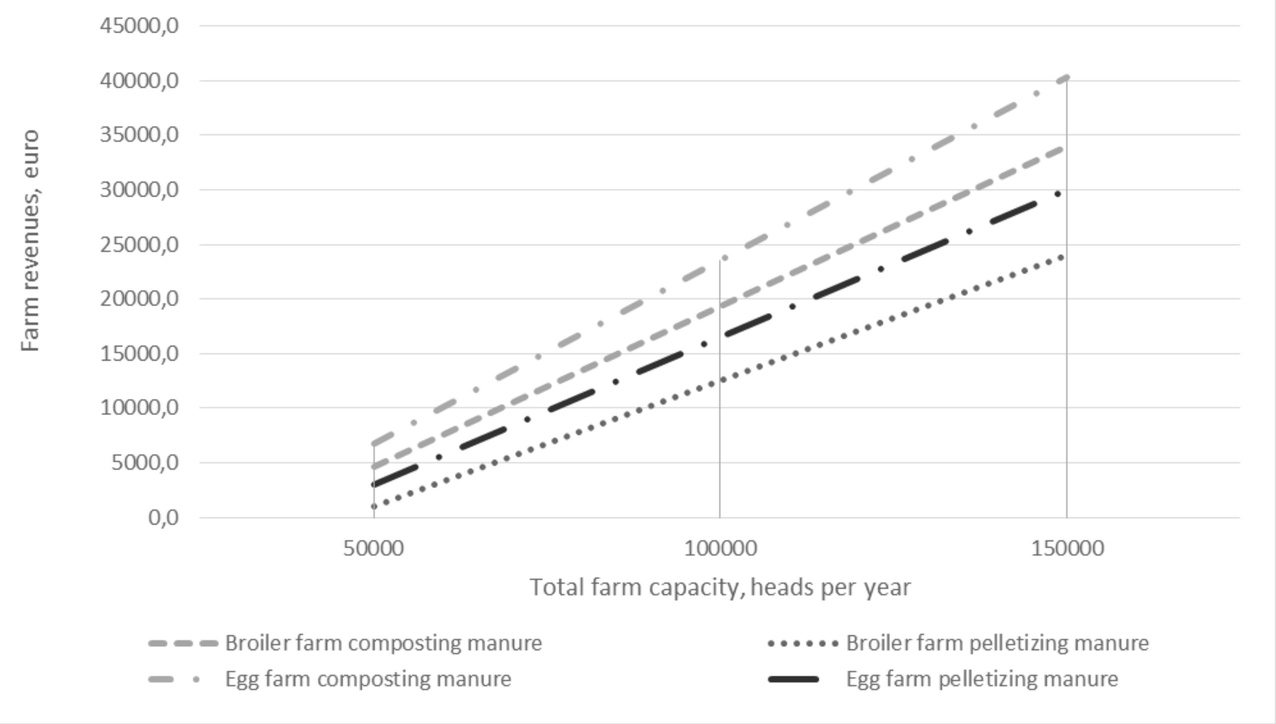

Fig.3. - Dependency of potential farm revenues for two main types of production (broiler meat and eggs) on type of manure processing and farm capacity

The trend remained the same for both studied farm types for all range of sizes and capacities which demonstrates its applicability for any type of enterprises in poultry sector. As composting is most widely used manure processing method, in terms of feasibility for farming, it is still priority option for farm, although considering storage and transportation logistics which can be calculated only for some particular facility, manure pelletizing can be more feasible in certain cases.

CONCLUSIONS

In current economic situation, composting is still most affordable and feasible solution for poultry farming sector and still one of the most available manure management options for producers.

Considering environmental risks which were demonstrated on example of air emission potential risks, especially for large farms, pelletizing could be recommended as more sustainable option for large farms, especially in case when they have the full cycle of forage production to cover needs of the broiler meet of egg production process.

As modern poultry farming sector is highly competitive and is becoming more and more regulated and ecological standards are rising, considering long term prospect of sustainable development, manure thermal processing and pelletizing can be best option to increase environmental safety and stability.

ACKNOWLEDGEMENT

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CONSIDERATIONS ON RECOVERING PHOSPHORUS FROM ANIMAL MANURE / *CONSIDERAŢII PRIVIND RECUPERAREA FOSFORULUI DIN DEJECŢII ANIMALIERE*

PhD. Eng. Danciu A.[*1)], Eng. Găgeanu G.[1)], Eng. Grigore I.[1)],
Eng. Cristea (Danciu) M.A.[2)], PhD. Eng. Sorică C.[1)], Eng. Dumitru I.[3)], Eng. Oprescu M.R.[4)]
[1)]INMA Bucharest / Romania; [2)]ROMWEST INTERNATIONAL S.R.L. / Romania;
[3)]Power Group International S.R.L. / Romania; [4)]Condor Comimpex S.R.L. / Romania
Tel: 0728.942.902; Fax: 021/269.32.73; E-mail: danciu_aurel1@yahoo.com

Keywords: *phosphorus recovery, fertilizers, treating animal waste*

ABSTRACT

The paper presents updated information on the importance of the technology for recovering phosphorus from animal waste for its sustainable use, leading to efficient resources and to ensuring available reserves for future generations. The use of results from the technologies presented in the paper on recovering phosphorus through a process of "quick washing" animal manure, as well as through "fractioned extraction procedures" and hydrothermal treatment, will lead to improving the use of recycled phosphorus in the EU and worldwide as well as to protecting phosphorus reserves in mine exploitations.

REZUMAT

În lucrare sunt prezentate informaţii actualizate despre importanţa tehnologiei de recuperare a fosforului din deşeuri animaliere în vederea utilizării durabile a acestuia, care să conducă la o eficientizare a resurselor şi la o asigurare a unor rezerve disponibile pentru generaţiile viitoare. Utilizarea rezultatelor tehnologiilor prezentate în lucrare, privind recuperarea fosforului printr-un proces de "spălare rapidă" a gunoiului de grajd, precum şi prin „procedurile de extracţie fracţionată"şi tratament hidrotermal, vor conduce la îmbunătăţirea utilizării fosforului reciclat în UE şi la nivel mondial precum şi la protejarea rezervelor de fosfor din exploatările miniere.

INTRODUCTION

There are considerable variations in the composition of manure from different animals, partially due to the quantity of water existing in the excrements. Thus, manure coming from cows and pigs contains a lot more water than manure from sheep and poultry and are therefore less concentrated, so they have in their composition smaller percentages of nitrogen, phosphorus and potassium [7].

Currently, important quantities of phosphorus are wasted in the food production cycle, often causing environmental problems, such as water pollution. Phosphorus is an irreplaceable part of modern agriculture. Without phosphoric acid, chlorophyll does not form, and plant growth, the process of maturing and ripening, is influenced by the presence of phosphorus in the soil. The continuous consumption by plants leads to the diminishing of this element, requiring soil amendments with products containing phosphorus [2].

Phosphorus (P) accumulation in high quantities in soils, caused by the intensive applying of animal manure on fields has infiltration potential and pollutes nearby groundwater [10]. This leads to eutrophication, which can subsequently cause an imbalance between production and consumption processes of plants/algae, with negative effects on the diversity of species and the durability of water for human use. It can also cause massive growth of algae, some of which are harmful species causing the death of fish and other marine animals and, once decomposed, they can poison humans and animals due to hydrogen sulphide emissions [3].

Diffused pollution appears when a single source of pollutant discharge in the aquatic system cannot be identified, the pollution of water bodies being realized through multiple ways. Agricultural activities can cause serious problems from the point of view of diffused pollution of water bodies as a result of nutrient losses (nitrogen and phosphorus) towards the surface and/or ground water bodies [8].

Modern phosphorus extraction takes place in mine exploitation, for a ton of phosphoric acid produced being necessary 9.5 tons of phosphate ore and are produced 21.8 tons of various waste and 6.5 tons of sterile, the technology consuming a lot of energy due to the consumption of large quantities of water [3].

The depletion of nutrients in the soil due to the increase of global population and of the industrial revolution in the 18th and 19th centuries led to supplementing the soil with P in order to enhance or maintain the yield of agricultural crops, a fact that required an increasing trend of phosphorus extracted from rocks, animal manure, human excretions and faeces of sea birds and bats (figure 1) [6].

Phosphorus is an essential element for life. It can be recycled indefinitely, but it cannot be replaced. It is present on a large scale on the face of the Earth, but exploitable reserves of phosphate rocks are concentrated in a few countries, which are found, with a single exception (Finland), outside the EU [4].

On a longer term, a series of factors indicate that the demand for phosphorus will most probably continue to grow [2]. Two thirds of current reserves of phosphate rocks identified by the International Fertilizer Development Centre– IFDC come from Morocco/ Occidental Sahara, China and USA (figure 2), [6]. Therefore, it is difficult to make an exact prognosis on the quantity of phosphate rocks reserves and their capacity to satisfy long term demand.

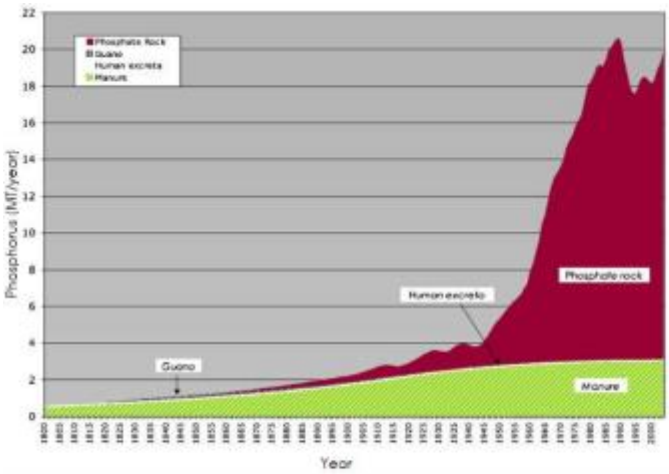


Fig. 1 - *Historical global sources of phosphorus [6]*
(Adopted from (Cordell, Drangert & White, 2009)

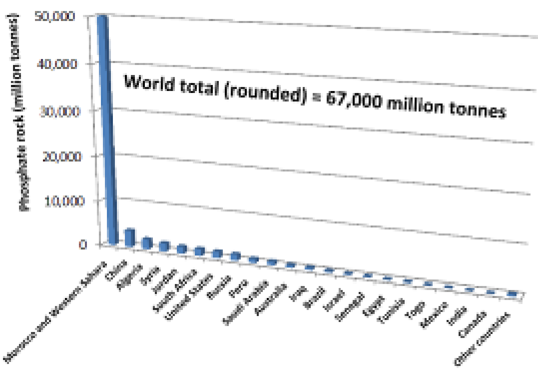


Fig. 2 - World phosphate rock reserves by country fertilizers (1800-2000) [6]
(Data: (Jasinki, 2013) - US Geological Survey, Mineral Commodity Summaries)

Phosphorus recovery from food waste and from other biodegradable waste represents a special characteristic of the directive that allows the flocculation of phosphorus with iron, producing a strongly bound compound from which it is not easy to recover phosphorus for commercial purposes and it cannot be fully available for plants [3].

Worldwide demand increase will be partially slowed down by the decrease of phosphorus usage in areas of intensive animal growth, where soils now contain more phosphorus than necessary for agricultural production; the excess phosphorus on saturated fields doesn't bring any benefit for crops and doesn't observe some environment regulation concerning combating water pollution.

Amid the continuous decrease/alteration of natural resources, as well as the necessity to preserve them (especially the ones of biological nature) it is necessary to reassess the options concerning the management of anthropogenic origin waste, in terms of increasing the degree of valorising them and of drastically reducing the quantities that require elimination. In this regard, it is necessary to classify waste in categories in order to prevent waste production, preparing for reuse, recycling and valorising, while waste storage should be interpreted as the last available option corresponding to the highest level of loss and alteration of resources [5].

To solve accumulation and distribution problems for this nutrient, a substantial quantity of animal manure needs to be moved at the extremities of farms, or even at larger distances, beyond county limits, or to proceed with the recovery of phosphorus from animal manure, an operation important for ensuring the use of the right quantity of fertilizer, in the right place at the right time. For the efficient use of resources, is suggested the possibility to limit global increase by using phosphate fertilizers from primary sources to 11% by the year 2050 compared to 40% nowadays, concentrating on the use of recycled phosphorus, which also has the advantage that is much more economically effective [3].

MATERIAL AND METHOD

State of the art technologies for managing animal manure and available programs for solving the problem of P from animal manure include operation such as [10]:

(1) improved methods for applying animal manure, such as immobilizing P with alum, to prevent leaks;
(2) generation of energy by burning, gasification or anaerobe digestion;
(3) waste or manure transportation to agricultural fields with low P content;
(4) as alternative, was invented a process of "quick washing" animal manure, consisting in a rapid extraction and the subsequent P recovery in solid state from manure, before applying it on the soil.

This last approach has three distinctive advantages compared to the current status of technique:
(1) compared to binding P with alum in a form that is not used by the plants, P recovered through quick washing is valuable because it can be reused as fertilizer;
(2) compared to co-burning and gasification processes, the residual organic matter is preserved, having additional benefits for the soil;
(3) compared to programs for transporting solid manure, it is not necessary to transport large volumes of animal manure, because only approximately 15% of the initial volume leaves the farm, containing a product rich in P.

The remaining solid waste (washed manure or common manure) has a more balanced nitrogen/phosphorus ratio (N:P), which is much safer for the environment, for land applications and for being used by crops.

The quick washing process is formed of three consecutive stages (steps) namely:
(1) P extraction, (2) P recovery, and (3) enhancing P recovery.

In the first stage, manure (from poultry) is washed with a water and acid mixture in a reaction vessel at a pH lower than 5.0 (figure 3) [10].

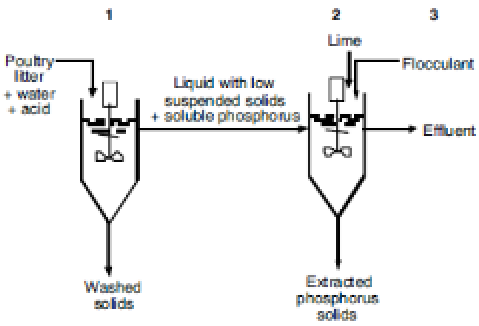


Fig. 3 - Quick wash process scheme [10]:
(1) P extraction, (2) P recovery, and (3) P recovery enhancement.

The washed animal manure is then stabilized and dehydrated to prevent useless carbon (C) and nitrogen (N) oxidation and digestion. This first step produces a liquid extract containing a reduced level of solid suspension (<3 g. L^{-1}) and P soluble extract. The liquid extracted is transfer in the second vessel where P is recovered (stages 2 and 3, figure 3).

In stage 1 of the process (figure 3), organically bound P is converted in soluble P by a rapid hydrolysis reaction with acid solution, and this rapid hydrolysis reaction has the capacity to extract large quantities of P from animal manure. This stage also releases P and insoluble complexes of inorganic phosphate. The hydrolysis and solubilising of P compounds are obtained by using organic acids (such as citric, oxalic, malic, etc.), mineral acids (for example hydrochloric or sulphuric) or a combination of the two categories of acids.

In stage 2, P from the liquid extract is precipitated by adding a base of alkaline soil in a pH interval of 9.0 – 11.0, to form P alkaline soil compounds containing metal.

Subsequently, in stage 3, an organic flocculant is added in the second vessel in order to enhance precipitation and the degree of phosphorus recovery from the precipitated product (figure 3).

After a new period of decantation, the solid precipitate rich in P is extracted from the base of the second vessel while the supernatant liquid is recycled in the washing system or applied on fields.
Stages 1 – 3 can be effectuated in a discontinuous system (in batches) using, for example, a single vessel for chemical mixing and decantation, or can be adapted for continuous operation, using two separated vessels to carry out the mixing in the first stage and then decantation, as shown in figure 3 [10].

a) Quick washing process

In this paper [3] are presented three tests on the quick wash process, in the first experiment being tested the potential of organic and inorganic acids to extract P form solids (stage 1). The second experiment was conducted to demonstrate the removal and recovery of P from the liquid extract (stages 2 and 3) generated by washing poultry manure in stage 1 (figure 3). Both experiments were conducted in the laboratory. The third experiment was conducted on a pilot prototype system in the fields [10], at a larger scale, in order to confirm the observations from the laboratory and the recommendation regarding the process.

Experiment 1

Organic and inorganic acids were tested to determine their potential of extracting phosphorus (step 1) from poultry manure, using the process of quick wash.

Water solutions of acetic, citric and hydrochloric acid were added to 2.00 g of poultry manure samples (1:25 weight/ volume ratio) in a graduated 50 ml glass cylinder, at seven levels of concentration (0; 2.5, 5, 10, 20, 40 and 80 mmol L^{-1}).

The solutions and the manure were mixed using an agitator (135 rot / min^{-1}), at room temperature (23^o C) for an hour. Subsequently, solids and liquids were separated by centrifugation (2000 rot / min^{-1}), for 5 minutes. The supernatant liquid was decanted and the following were analysed: pH, total P (TP) and total Kjeldahl N (TKN).

Solids were dried at 40^{o}C in a drier cu forced air circulation and were analysed in terms of TKN and TP. The extraction experiment was conducted in double exemplary, and the control test consisted in the extraction using distilled water. The efficiency of treating different acids was established by comparing the P extracted compared to the initial P content of untreated poultry manure.

Experiment 2

This experiment was conducted to demonstrate the removal and recovery of P from the liquid extract (stages 2 and 3), generated by the wash of garbage, in stage 1 (figure 3).

Poultry litter (64 g) was mixed (1:25 weight / volume ratio), with 1.6 l of citric acid solution 20 mmol in a 2 l beaker and agitated for an hour with a magnetic agitator. After the mix had been settled for 20 min, the liquid extract was separated from the washed manure and 35 ml aliquot parts were transferred in beakers (50 ml glass graduated tubes).

In half the beakers was applied the treatment with calcium hydroxide or hydrated lime [Ca $(OH)_2$], and to the other half was applied the treatment with $Ca(OH)_2$ and flocculant (stages 2 and 3).

A 2 % $Ca(OH)_2$ water solution was added in various quantities until the pH of the mixed liquid has reached the reference values 6, 7, 8, 9, 10 or 11 units (respectively samples from 1 to 6); also using a control sample, without any lime addition (sample 0).

P recovery was enhanced by adding an organic flocculant after reaching the reference value of pH (stage 3). The organic flocculant was represented by an anionic polyacrylamide (PAM), Magnafloc 120 L with 34% molar charge and 50% active substance. This flocculant was added at a rate of 7.0 mg active ingredient (a.i.) per litre and stirred for 30 s. for both tests, the one using only lime and the one using lime plus flocculant, the supernatant liquid was decanted and its pH, TP and TKP were analysed.

Solids were dried at 40^{o}C in a forced air dryer and were analysed to determine TKN and TP. The efficiency of different tests, with lime and with flocculation was expressed as percentage of the P extraction compared the initial P content. All tests were duplicated, at room temperature (23 °C) and ambient pressure.

Pilot installation for field experiments

The prototype system consisted of two connected reactor beakers (figure 4) [10]. The firsts beaker in the sequence was the P extraction reactor, consisting in a cone shaped 378 litre reservoir, a mixer and a pH controller. Once the liquid has reacted with the solids, the agitation was stopped in order to allow solids to settle. After the solids have settled, the supernatant in this reservoir was pumped to the second reservoir (378 litres), which was the P recovery reactor, being fitted with a mixer and a pH controller.

The system was completed with a smaller reservoir, of 57 litres, with a mixer and a pump, used for mixing and injecting the hydrated lime solution in the second reservoir.

Each quick wash sequence was called “cycle”. For each cycle, solid and liquid samples were collected in two exemplars. For all cycles, P extraction consisted in adding citric acid (10% weight / weight) to an agitated poultry litter mix (15.2 kg) and water (water litter ratio of 1:25 weight / volume) inside the extraction reactor.

Citric acid addition was stopped when the pH of the mixture reached a reference value of 4.5. The extraction mixture was sampled each 10 minutes during a 60 min period of agitation, to determine the minimum agitation time necessary to reach a stable TP concentration in the extraction solvent; TP was determined in the supernatant (after 24 h settling), from un filtered samples.

Solid litter was eliminated from the bottom of the P extraction reactor, after a 20 minutes settling period and was dehydrated through a filter. The filter was composed of a 0.84 x 0.84 x 0.13 m sieve box, with a wire base with 0.6 cm meshes and from a 200 µm material (commercial propylene), unwoven. The supernatant in the P extraction reactor was pumper in the P recovery reactor, Where the water hydrated lime (10 % $Ca(OH)_2$) was injected and stirred.

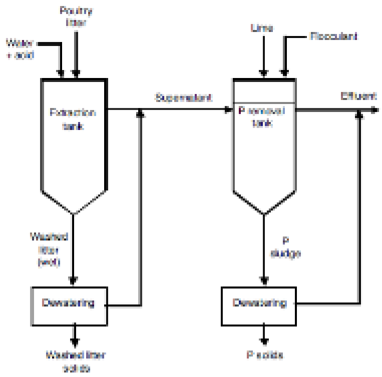


Fig. 4 - Schematic diagram of the field prototype system for manure quick wash. A mix, reaction, settling, and decantation sequence was used in each tank [10]

A pH controller stopped the lime injection when the pH value of the mixed liquid reached the value 9.0 (cycles 1 and 3) or 10.0 (cycles 2 and 4).

Once the desired pH was reached, the same flocculant used in Experiment 2 (anionic PAM, 34% charge, 50% active ingredient) was injected at a rate of 15 mg L^{-1} (active ingredient) and stirred for 60 s, to enhance P recovery. The precipitated solids were removed from the bottom part of the reservoir after a 30 min resting time and were dehydrated using a filter, as described before. Dried solids were analysed to determine the P, C, N, calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na).

b) Fractioned extraction procedures

Other experiments were conducted by Benjamin L, in [1], who used for the successive extraction of P, extraction procedures with:

1) deionised water;
2) sodium hydrogen carbonate ($NaHCO_3$) 0.5 M;
3) sodium hydroxide (NaOH) 0.1 M;
4) hydrochloric acid (HCl) 0.5 M.

Each extraction was conducted in a solution/litter ratio of 1:60 for an hour. Three types of poultry litter were used:, with a dry matter content of 25%, cow litter with a dry matter content of 14% and litter from broiler chickens raised on sawdust content with dry matter content of 84%. Samples were frozen to -80°C and were lyophilized.

In paper [1] were also experimented the fractioned extraction procedures with:

1) sodium hydrogen carbonate ($NaHCO_3$) 0.5 M, for 4 hours;
2) hydrochloric acid, HCl 1.0 M for 16 hours;
3) sodium hydroxide 0.5 M + *ethylenediaminetetraacetic acid* 50 mM EDTA (NaOH 0.5 M + EDTA 50 mM);
4) sodium hydrogen carbonate 0.5 M + hydrochloric acid 1.0 M ($NaHCO_3$ 0.5 M + HCl 1.0 M), for 4 hours;
5) sodium hydrogen carbonate 0.5 M + sodium hydroxide 0.5 M + *ethylenediaminetetraacetic acid* 50 mmol ($NaHCO_3$ 0.5 M + NaOH 0,5 M) + EDTA 50 Mm).

c) Hydrothermal treatment

The paper [11] presents pH influence on the hydrothermal treatment of pigs' litter that was pre dried in an oven at 60 °C for a few days and grinded. The hydrothermal treatment includes thermal hydrolysis (TH) conducted at 120 °C and at 170 °C as well as hydrothermal carbonizing (HTC) conducted at 200 °C and at 250°C, either in deionized water or in the presence of 0.1 M of NaOH, H_2SO_4, CH_3COOH or HCOOH, for each suspension the time being of an hour, and the heating and cooling speed being of approximately 10 °C min^{-1}.

RESULTS

Experiment 1

Phosphorus in the poultry litter was extracted by increasing the molar concentration (0 up to 80 mmol L^{-1}) both with mineral and with organic acids (figure 5) [10]. During extraction, a significant part of total P in the poultry litter was released from the solids in the litter. The total P extraction rate has increased along with increasing acid concentrations. At a 40 mmol L^{-1} acid concentration, approximately 81% of the initial phosphorus concentration (TP) from the poultry litter was extracted. In comparison, by washing the litter with distilled water, only 20% is extracted.

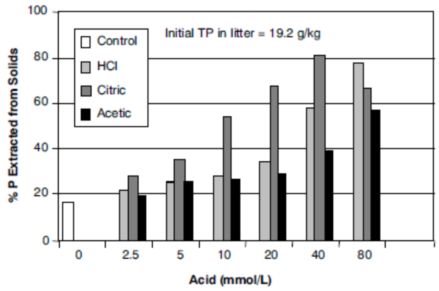


Fig. 5 - Extraction of phosphorus from poultry litter using acids at seven concentration levels ($LSD_{0.05}$ = 10) [10]

In addition to the acid concentration, the type of acid has caused a difference. Citric acid was more effective for extracting P than HCl or acetic acid at similar molar concentrations (2.5 at 40 mmol L^{-1}). High extraction efficiencies (>70%) were also possible with HCl and acetic acid (>50%), but the necessary molar rates have doubled (80 mmol L^{-1}). Even if P extraction has increased from 17% to 81% along with increasing the treatment with citric acid in the interval from 0 to 40 mmol L^{-1}, extraction was not greatly affected (table 1) [10].

Table 1 [10]

Effect of citric acid treatment on pH of the extraction solution-solids mixture, total P and N extracted, and N:P ratio in solid residue left after washing poultry litter

Treatment	pH Mixture [a]	Acid [mmol.L^{-1}]	Total N Extracted [b]		Total P Remaining in Washed Litter	Total P Extracted [c]		Total P Mass Recovery [d]	N:P Ratio Washed Litter [e]
			[g. kg^{-1} litter][a]	[%]	[g. kg^{-1}][a]	[g. kg^{-1} litter][a]	[%]	[%]	
0	8,2 (0,1)	0,0	10,2 (0,6)	29,1	18,0 (1,9)	3,3 (0,5	17	111	1,2
1	7,1 (0,1)	2,5	11,6 (0,6)	33,1	16,1 (0,1)	5,5 (0,1)	29	112	1,3
2	6,4 (0,1)	5	11,1 (0,5)	31,7	15,6 (0)	6,9 (0,1)	36	117	1,4
3	5,4 (0,1)	10	11,4 (0,1)	32,5	9,6 (1,2)	11,0 (0,1)	55	107	2,5
4	4,5 (0,1)	20	9,6 (0,3)	27,4	5,1 (0,1)	13 0 (0,7)	68	94	5,5
5	3,8 (0,0)	40	9,4 (0,1)	36,8	3,1 (0,4	16 ,0 (0,7	81	99	9,8
6	3,1 (0,1)	80	7,7 (1,2)	22,0	3,1 (0,1)	13,0 (2,8)	67	84	11,1

[a] Data are means of two replicates; values in parentheses are standard errors of the mean.
[b] Total N extracted = TN extraction relative to initial TN content in litter (35.1 g kg^{-1}); $LSD_{0.05}$= 2.0.
[c] Total P extracted = P extraction relative to initial P content in litter (19.2 g kg^{-1}); $LSD_{0.05}$ = 4.8.
[d] Total P mass recovery = ((TP Remaining in Washed Litter + TP extracted)/19.2) × 100..
[e] Ratio calculated using N and P concentration in digested samples.

Although other mineral and organic acids can be used for the quick wash process (such as sulphuric, malic, oxalic, phosphoric, nitric, ethylenediaminetetraacetic EDTA), except the ones presented in figure 5, for the quick wash process are preferred the acids that don't ad P or N during the quick wash process. However, the use of acids, such as nitric, ethylenediaminetetraacetic, sulphuric or phosphoric, can be useful for fortifying the final P extraction product with nitrate, sulphur or phosphorus.

The nitrate contained by poultry litter was extracted less efficiently than P. for example, approximately 81% of the total initial P in poultry litter is extracted through treatment 5, at 3.8 pH (40mM citric acid), but only 27% of N was extracted (table 1). Thus, residue from washed litter has a N:P ratio of 9.8. This is a ratio 5 times bigger than the one in untreated litter (N:P 2.1). The quantity of acid added during the process, to extract a specific quantity of P, can be controlled by establishing a specific limit point for the pH, using a pH controller.

The percentage of P extracted from solids has increased linearly along with decreasing pH (y = -11x + 107, R2 = 0.87, n = 19, P < 0.0001; figure 6) [10]. Although the quick wash process has constantly extracted more than 50% TP when the pH of the acid solution was lower than 5, similar P percentages in the poultry litter were extracted at different acid concentration (figure 6). Thus, the quantity of acid added during the process to extract a specific quantity of P, can be controlled by establishing a specific limit point for the pH, using a pH controller

From the results of *experiment 1*, the conclusion reached was that, following the quick wash process, the treated litter (washed solids) could be applied on crop fields, in doses that depend on the N demands of crops, without accumulation of excess phosphorus in the soil.

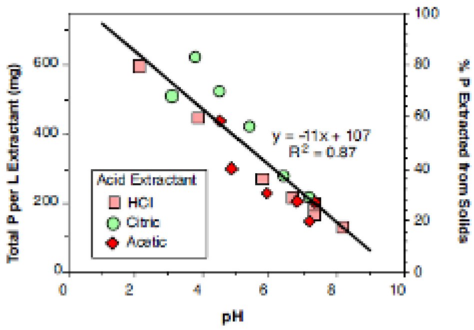


Fig. 6 - Effect of pH on TP extracted from broiler litter [10]

Total phosphorus concentration has increased along with decreasing the pH of extraction solutions of mineral and organic acids, more than 50% of the total phosphorus (TP) being extracted compared to the initial TP content in the poultry litter at pH values for the acid extraction solutions smaller than 5. The percentage % of P extracted from solids corresponds to the values in figure 6. The variable in the regression line v = -11x + 107 are x = pH and y = % P extracted from solids.

Experiment 2

An extraction solution of citric acid 20 mmol L^{-1} was selected for *step 1* for the subsequent recovery of P, with hydrated lime. This liquid extract contains a high concentration of TP of approximately 600 mg L^{-1} at a 4.7 pH (table 2, treatment 0) and a low concentration of TSS (2.1 g L^{-1}) after liquid-solid separation through decantation.

Table 2 [10]

Quick wash process (step 2), hydrated lime application for recovery of extracted soluble P from broiler litter.

Treatment [a]	pH	$Ca(OH)_2$ Applied [$g \cdot L^{-1}$ liquid]	Total P in Liquid Extract [b] [$mg \cdot L^{-1}$]	Total P Removed from Liquid Extract [c] [%]
0	4,7	0,0	613 (11)	0
1	6,0	1,4	381 (9)	39
2	7,0	2,0	299 (10)	51
3	8,0	2,6	215 (48)	65
4	9,0	3,1	251 (33)	59
5	10,0	3,7	303 (28)	51
6	11,0	4,1	237 (19)	62

[a] Liquid treatment was achieved by adding hydrated lime (2% $Ca(OH)_2$ in water) to obtain a specific pH.
[b] Data are means of two replicates (standard errors in parentheses).
[c] total P eliminated = P recovered from the liquid fraction compared to the initial P concentration in the liquid extract (613 mg L^{-1}).

The data show the total phosphorus (TP) concentration in the liquid extract and corresponding for each TP percentage removed by increasing pH with hydrated lime after the extraction of P (stage 1) with citric acid solution 20 mM (1:25 weight/volume ratio).

In step 2, TP was recovered from the solution by precipitating P soluble compounds, in alkaline conditions. The addition of hydrated lime decreased TP until a pH of 8.0 units was obtained (table 2).

The subsequent addition of a flocculant improves the percentage of TP recovered at a pH higher than 8.0 (table 3). A smaller quantity of organic flocculant agent was added at a ratio of 7 mg L^{-1} (active ingredient) for all tests (treatments) to intensify thickening and to enhance the TP content in the precipitated product (step 3).

Table 3 [10]

Quick wash process (steps 2 and 3), hydrated lime plus flocculant application for recovery of extracted soluble P from broiler litter.

Treatment [a]	pH	$Ca(OH)_2$ Applied (g kg^{-1} litter)	Total P Remaining in Liquid [b]	Total P in Precipitate[b] (g kg $^{-1}$ litter)	Total P Recovered in Precipitate [c] (%)	Total P Mass Recovery [d] (%)	P Grade in Precipitate [b] (% P_2O_5)
0	4.7	0.0	613 (11)	0.5 (0.1)	2.8	106	1.4 (0.3)
1	6.0	36	355 (4)	6.5 (0.2)	33.6	107	14.9 (7.0)
2	7.0	50	202 (16)	8.1 (0.5)	42.3	95	11.9 (3.3)
3	8.0	65	103 (4)	11.7 (0.1)	61.0	101	17.6 (4.4)
4	9.0	78	94 (17)	13.0 (0.2)	67.5	107	17.2 (0.6)
5	10.0	93	15 (2)	13.9 (0.1)	72.5	99	18.8 (1.2)
6	11.0	104	13 (4)	13.5 (0.0)	70.4	98)	14.4 (4.4

[a] Treatment of the liquid was done by addition of hydrated lime (2% $Ca(OH)_2$ in water) to obtain a specific pH. An anionic polymer (polyacrylamide, 34% charge) was added at a rate of 7 mg L^{-1} (active ingredient) to all treatments to enhance precipitation.
[b] Data are means of two replicates (standard errors in parentheses).
[c] Total P recovered in precipitate = TP in the precipitated solids relative to initial P content in litter (19.2 g kg^{-1}).
[d] Total P mass recovery = [(washed litter + precipitate + liquid effluent) / initial P content in litter] × 100; washed litter contained 5.0 g TP kg^{-1}.

Data in table 3 from paper [10] show the total phosphorus (TP) remaining in the liquid effluent, recovered on weight unit of poultry litter and the degree of phosphorus (P) in the precipitate produced by increasing pH with $Ca(OH)_2$ and adding organic flocculant after P extraction (stage 1) with citric acid solution 20 mM (1:25 weight/volume ratio).

Results in table 3 show an increase in the quantity of P extracted and a high TP content of the precipitate by adding $Ca(OH)_2$, followed by intensification with a flocculant. The highest rate of P extraction and content in the precipitate (18.8 % P_2O_5)was obtained when the pH reached the values of 10.0.

Table 4 [10]

Total P recovered in the precipitate has increased by adding organic flocculant (stage 3).

Lime treatment	pH[a]	Total P recovered in the precipitate (g kg^{-1} litter)[b]		Recovery increase with polymer (%)
		Without polymer	With polymer[c]	
1	8.0	10.0 (1.2)	11.7 (0.1)	14.0
2	9.0	9.1 (0.8)	13.0 (0.2)	30.0
3	10.0	7.7 (0.7)	13.9 (0.1)	45.0

[a] Specific pH values obtained using hydrated lime (2% $Ca(OH)_2$ in water).
[b] Total P recovered= P removed from the liquid fraction compared to the initial P content in the litter (19,2 g kg^{-1}). Data are means of two replicates (standard errors in parentheses).
[c] Anionic polyacrylamide, 34% charge, applied at a constant rate (7 mg L^{-1} active ingredient).

The enhancing effect of adding the organic flocculant on the TP content of the precipitate is summarized in table 4, at three levels of hydrated lime (pH 8, 9 and 10), with or without using a polymer (anionic polyacrylamide) after extracting citric acid (20 mM).

From this data, the conclusion was reached that, after acid extraction, > 60% of the total P from poultry litter can be recovered by adding hydrated lime and small quantities of organic flocculant (stages 2 and 3).

Pilot experiment installation

Experiments on prototype [10] were based on the final alkaline values of pH, which were determined in laboratory experiments 1 and 2 to extract and recover > 60% TP from poultry litter. The first component tested was the effect of stirring time on the total P extracted from the suspension formed by mixing poultry litter with the extraction liquid (stage 1). P was extracted from poultry litter at a 4.5 pH with citric acid, at a stirring time of 20 minutes, the concentration of total phosphorus (TP) extracted remaining stable (300 – 330 mg L^{-1}).

In average, N:P ratio in broiler poultry litter has increased from 2.0 before washing, to 4.6 after washing. This higher N:P ratio in for being used on crops.

The complete process has recovered more than 60% of the total initial P in broiler litter; these high P recovery rates were obtained both for extraction at a pH of 9.0 and 10.0 units.

Before dehydration, the average moisture content of the P mud recovered was approximately 95.5%. after filtering, P mud had an average moisture content of 89.9%. the drying process was accelerated by placing the recovered P mud in a greenhouse, to dry out. The average moisture content has decreased to more than 10% in the following 13 days after filtering according to [10].

An additional characteristic of P recovered product was the reduced bulk volume, a fact that makes P recovered product to be able to be transported more economically outside the farm in order for it to be used as fertilizer.

Fractioned extraction procedures

Research conducted by Bejamin L, in [1], concluded the following: phosphorus recovery through fractioned recovery procedure was of 94% for litter from broiler grown on straw bedding, of 79% for cow manure and of 92% for pig litter, results obtained with significant differences between the three types of litter, from the total phosphorus recovered in different sequential extract, table 5.

Table 5 [1]

Concentrations of Phosphorus Compounds in Sequential Extracts of Animal Manures from the Hedley Fractionation Procedure Determined by Solution 31 P NMR Spectroscopy and ICP—OES Spectrometry
mg P kg^{-1} dry wt

	total phosphorus[a]	phosphate[b]	phosphate monoesters [b]	phospholipids[b]	DNA[b]	pyrophosphate[b]
0	**1**	**2**	**3**	**4**	**5**	**6**
Broiler Litter						
water	4547 ± 103 (29)	4036 (89)	291 (6)	138 (3)	82 (2)	ND[C]
$NaHCO_3$	826 ± 13(5)	679 (82)	147 (18)	ND[C]	ND[C]	ND[C]
NaOH	1854 ± 27(12)	266 (14)	266 (14)	1588 (86)[d]	ND[C]	Tr[e]
HCl	7734 ± 198 (48	1114 (14)	6620 (86) [d]	ND[C]	ND[C]	ND[C]
sum of fractions	14961 ± 225 (94)	6095 (41)	8647 (58)	138(<1)	82 (<1)	Tr[e]
Cattle Manure						
water	537± 18(11)	228 (42)	200 (37)	ND[C]	109 (20)	ND[C]
$NaHCO_3$	2116 ± 17 (43)	2077 (98)	Tr[e]	ND[C]	ND[C] 39 (2)	39 (2)
NaOH	952 ± 33 (19)	492 (52)	350 (37)	ND[C]	ND[C]	110 (12)
HCl	311 ± 4 (6)	311 (100)	ND[C]	ND[C]	ND[C]	ND[C]
sum of fractions	3916 ± 41 (79)	3107 (79)	550 (14)	ND[C]	109(3)	150(4)
0	**1**	**2**	**3**	**4**	**5**	**6**
Swine Manure						
water	7992 ± 139 (55)	7644 (96)	278 (3)	70(<1)	Tr[e]	Tr[e]
$NaHCO_3$	3419 ± 110 (23)	3308 (97)	111 (3)	ND[C]	ND[C]	ND[C]
NaOH	846 ± 36 (6)	498 (59)	325 (38) [f]	ND[C]	ND[C]	24 (3)
HCl	1252 ± 87 (9)	830 (66)	422 (34)[g]	ND[C]	ND[C]	ND[C]
sum of fractions	13508 ± 200 (92)	12279 (91)	1136 (8)	70 (<1)	Tr[e]	24 (<1)

[a] Data were determined by ICP—OES and are mean ± standard deviation of three replicate extracts. Values in parentheses are the recovery (%) of the total manure phosphorus in each extract.
[b] Determined by solution ^{31}P NMR spectroscopy. Values in parentheses are the proportion (%) of the total phosphorus in each extract.
[c] ND, not detected.
[d] All phosphate monoesters were phytic acid (calculated by sum of signals).
[e] Tr, trace.
[f] Phytic acid concentration (C2*6) was 118 mg P kg^{-1} dry wt (14% of the extracted phosphorus).
[g] Phytic acid concentration (sum of signals) was 401 mg P kg^{-1} dry wt (32% of the extracted phosphorus).

For litter from broiler chickens, the biggest part of recovered P was in water (29%) and in HCl extracts (48%). In contrast, only 11% of the phosphorus from cow litter was found in the water extract, and the most P was recovered in the sodium hydrogen carbonate $NaHCO_3$ (43%). A higher proportion of P was recovered in NaOH from cow litter (19%) compared to the other two types of litter. The highest percentages of P recovered from pig litter were extracted in water (55%) and sodium hydrogen carbonate $NaHCO_3$ (23%), and very small percentages in NaOH extracts (6%) and HCl (9%).

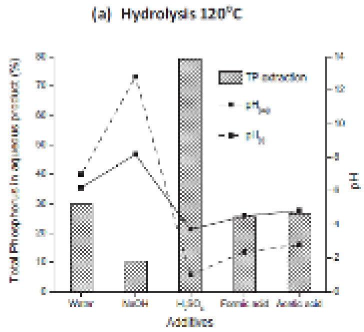
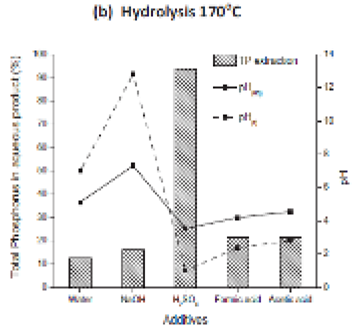
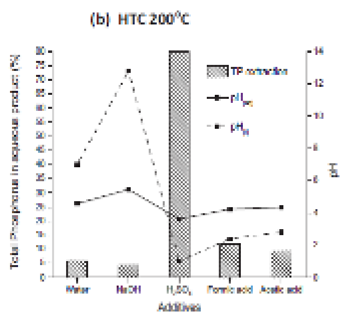
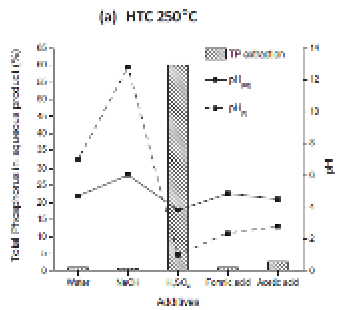
The recovery percentage of total phosphorus using $NaHCO_3$ (23%) / NaOH-EDTA was of 99% for broiler litter grown of straw bedding, of 83% for cow litter and of 94% for pig litter, according to [1], these being higher than in the case of procedure using $NaHCO_3$ / HCl for all types of litter.

Hydrothermal treatment

In the case of *hydrothermal treatment*, when processing litter in water at each temperature, has as result the reduction of pH, along with increasing temperature from 120°C to 250°C. In exchange, the processing of litter using acid reagents leads to the opposed effect, pH decreases, and the quantity of total phosphorus increases, (table 6) [11].

Table 6 [11]

pH, total organic carbon (TOC), nitrogen and phosphorus in the aqueous products

Hydrothermal process	**pH**	**Concentration (mg/L)**					**Effect of pH on the extraction of total phosphorus into the aqueous product**
		TOC	**NH_4^+-N**	**TKN**	**PO_4^{3-}**	**TP**	
120 °C							
Water	6.2	8900	410	1230	560	650	
0.1 M NaOH	8.2	13,270	290	1540	200	290	
0.1 M H_2SO_4	3.7	10,410	430	1240	1690	1800	
0.1 M formic acid	4.5	9200	380	1030	380	510	
0.1 M acetic acid	4.8	10,370	360	1030	400	550	
170 °C							
Water	5.1	17,760	620	1770	220	240	
0.1 M NaOH	7.3	18,520	720	1920	270	320	
0.1 M H_2SO_4	3.5	17,810	850	2140	2020	2200	
0.1 M formic acid	4.2	16,750	500	1620	370	390	
0.1 M acetic acid	4.5	18,680	490	1620	390	400	
200 °C							
Water	4.6	14,520	430	1680	100	110	
0.1 M NaOH	5.5	16,820	390	1810	80	90	
0.1 M H_2SO_4	3.6	12,850	760	1830	1,470	1490	
0.1 M formic acid	4.2	15,110	570	1750	210	210	
0.1 M acetic acid	4.3	16,970	500	1750	170	170	
250 °C							
Water	4.7	14,260	530	1470	10	10	
0.1 M NaOH	6.0	16,230	570	1450	10	10	
0.1 M H_2SO_4	3.8	12,090	710	1660	1050	1050	
0.1 M formic acid	4.9	14,680	540	1550	20	20	
0.1 M acetic acid	4.5	16,880	540	1510	40	40	

TOC – total organic carbon; TP – total phosphorus; PO_4^{3-} – phosphate; TKN – total Kjeldahl nitrogen; NH_4^+-N – ammoniac nitrogen.

Maximum phosphorus extraction (79%) from pig litter in 0.1 M H_2SO_4 solution was achieved at the 120°C temperature (table 6) and was of 1800 mg / l.

The lowest phosphorus concentration (290mg / l) was observed after processing in NaOH and represents only 11% of the total phosphorus (TP). By using water, 30% TP is extracted, and organic acids behave similar to water, extracting between 26% and 27% TP. After conducting the thermal hydrolysis treatment at 170°C, phosphorus extraction using only water is reduced to 13%, while phosphorus extraction with formic acid and with acetic acid is reduced to 21%, respectively 22%. Phosphorus extraction was the highest with H_2SO_4 reaching 94% of TP and representing the highest phosphorus concentration (2200 mg / l) in the water phase. A similar phosphorus concentration was observed with the help of organic acids, resulting o concentration of 390 mg / l with formic acid and of 400 mg / l with acetic acid, while with sodium hydroxide and with deionised water, extraction percentages were slightly lower, resulting concentrations of 320 mg / l with sodium hydroxide, respectively 240 mg / l with deionised water. Phosphorus extraction after hydrothermal carbonization treatment was generally lower compared to thermal hydrolysis. At 200°C, only 6% of phosphorus was extracted in water, thus resulting a concentration of 110 mg / l. The highest extraction was again with H_2SO_4 and represents 80% of TP, however the concentration begins to decrease compared to the treatment at 170°C. Phosphorus extraction through hydrothermal carbonisation treatment (HCT), conducted at 200°C lead to a concentration of 1490 mh / l in H_2SO_4, compared to thermal hydrolysis (TH) conducted at 170°C also in H_2SO_4, which lead to a concentration of 2200 mg / l.

At 250°C, very little phosphorus was extracted in softened water, in organic acids or in alkaline solutions (1-3%) and varied between 10 and 40 ml / l. Phosphorus extraction with H_2SO_4 was reduced at 60%, approximately 1050 mg / l.

Generally, phosphorus extraction in water decreases along with increasing temperature, the highest extraction being at lower temperatures. This is, in accordance to the results described by Szogi et al. in paper [10], who reported that 49% of the total phosphorus can be extracted from animal litter at room temperature in water (Szogi and al., 2014). The "quick wash" process described by Szogi et al. is operated at room temperature and extracts phosphorus from raw animal litter, followed by a recovery in solid state (calcium phosphate) by adding lime and an organic polymer

Phosphorus extraction at 170°C in H_2SO_4 reaches 94% of the total and is, therefore, higher than the quick wash approach, however, the use of H_2SO_4 could be a more corrosive oxidation.

In general, TOC in process waters remains relatively constant at each temperature, no matter the reagents used.

CONCLUSIONS

It was found that 60% of the total initial P can be extracted and recovered from solid poultry litter by using the ***quick wash process*** for treatment, according to methods in paper [10]. Findings have indicated that by washing poultry litter with a solution of organic or mineral acids, insoluble P is transformed into soluble P through rapid hydrolysis reactions.

Over 60% of TP compared to initial TP from solid litter was extracted when the acid extraction suspension had a pH <5.0. Solid washed residual waste was separated from the liquid extract to prevent useless oxidation and digestion of C and of organic N. in practices, acid is added in the minimum necessary proportion to balance the N:P ratio of the washed ratio and to produce a residue that gives a higher safety for the environment, by applying it on the field and using it for agricultural crops.

Once the liquid extract is separated from the solid residue, P is precipitated by adding lime to the liquid extract to form a complex of alkaline earth P compounds containing metal. Subsequently, an organic polyelectrolyte was added to enhance precipitation and P extraction degree in the product.

This quick wash extracts and recovers P from poultry litter, producing and concentrated P product that can be easily transported outside farm and reused as fertilizer.

Two main groups of phosphorus compounds have been extracted through the ***process of fractioning*** [1], a fraction easily soluble extracted with water and sodium hydrogen carbonate ($NaHCO_3$), and a stable fraction extracted with NaOH and HCl. Organic phosphorus from easily soluble fractions contains deoxyribonucleic acid (DNA), phospholipids and simple phosphate monoesters. These compounds are poorly absorbed in the soil, being mobile in the environment, even if they are present in relatively small concentrations.

Organic phosphorus extracted with NaOH and HCl is considered low soluble. Phytic acid (in litter from pigs and from poultry grown on straw bedding) is immobile in soils, because it is strongly absorbed by clays and reacts with metals to form insoluble precipitates.

The fractioned extraction procedure with $NaHCO_3$ / NaOH-EDTA allows recovering soluble and poorly soluble phosphorus in two extracts by separating animal litter. In procedures, an initial $NaHCO_3$ extract was used to approximate the easily soluble phosphorus fraction. Also, phosphorus recovery is much lower for cow litter extracted in water, compared to the one extracted with $NaHCO_3$.

Based on the elementary concentrations in the extracts of various animal litter, phosphorus seems to be associated with calcium and magnesium.

The two stage extraction procedure by fractioning: initial extraction in $NaHCO_3$, recovers easily soluble phosphorus, while the second extraction achieved in NaOH-EDTA recovers poorly soluble phosphorus. The soluble fraction includes phosphate concentrations and small quantities of phospholipids, nucleic acids and simple monoester phosphates that are relevant to the environment due to their mobility in the soil and to the biological availability of water ecosystems. Low soluble fraction includes poorly soluble phosphate, plus phytic acid in the litter from animals fed with seeds. The fraction of poorly soluble organic phosphorus recovered from litter coming from cattle fed on pastures includes a range of phosphate monoesters and diesters.

Phosphorus extraction, in the case of **hydrothermal treatment** [11], is influenced by the pH of the solution and by temperature, the extraction being higher at acid pH and at temperatures lower than 200 °C, reaching a percentage of 94% of the total phosphorus at 170°C in H_2SO_4.

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CALCULATING METHODOLOGY OF FUEL CONSUMPTION FOR DIFFERENT VEGETABLE CROPS IN PLAINS, HILLS AND MOUNTAINS
/
METODOLOGIE DE CALCUL A CONSUMULUI COMBUSTIBIL PENTRU DIFERITE CULTURI VEGETALE IN ZONA DE CÂMPIE, DEAL ŞI MUNTE

Ph.D. Stud. Eng. Cujbescu D.*[1)], Ph.D. Eng. Matache M.[1)], Ph.D. Eng. Vlăduţ V.[1)], Eng. Bolintineanu Gh.[1)], Ph.D. Eng. Danciu A.[1)], Ph.D. Eng. Voicea I.[1)], Ph.D. Stud. Eng.Mircea C.[1)], Eng. Vlad C.[2)], Eng. Dumitru I.[3)]
[1)]National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, INMA, Bucharest, Romania; [2)]ICEADR Bucharest / Romania; [3)]Power Group International S.R.L. / Romania
E-mail: dcujbescu@yahoo.com

Keywords: *agricultural works, fuel consumption, energy source, farmers*

Abstract

The paper presents the research results performed to substantiate a framework methodology for estimating fuel consumption at country level, according to the power classes of the existing energy sources correlated with farms areas and main agricultural works to be carried out in the plains, hills and the mountains of Romania. The substantiation methodology was done taking into account the established general conditions on agricultural machinery and tractors, work to be carried out, taking into account both the methodology used in Romania before 1990 and two of the most important methodologies used globally to establish consumption fuel: DLG and Nebraska.

Rezumat

Lucrarea prezintă rezultatele cercetărilor efectuate pentru stabilirea condiţiilor generale de lucru ce stau la baza fundamentării unei metodologii cadru de estimare a consumului de combustibil, la nivelul ţării, funcţie de sursele energetice existente, clasele de puteri ale acestora corelate cu suprafeţele existente la fermieri şi lucrările agricole ce trebuie efectuate în zonele de câmpie, deal şi munte din România, pentru principalele lucrări agricole.

INTRODUCTION

Traditional or family farming is spread in many parts of the world and in Romania is practiced again in all ecological zones. This agricultural system uses widely manual labour and animal power on small areas, natural or chemical fertilization and simply crop rotation. In time, has been introduced small mechanization, pesticides and even increased its land area and energy inputs.

The system, although is capable of high yields, is unviable economically and vulnerable to external pressures. In fact is underdeveloped and poor countries agriculture and we could fit it into the category of eco-biological peasant farming.

Intensive or industrial agriculture represents large land areas system, with high commercial energy inputs, equipped with a diverse and highly technical mechanization. It is present in developed countries and has a high yield. This system provides raw and fresh materials, large products quantities throughout the year, as production activity is conducted in open field, in orchards, vineyards and greenhouses for vegetables and flowers. The crops structure is very diverse, the crop rotations are modern and technological process is led by highly qualified specialists. The system is a high consumer of energy, fertilizers and pesticides.

Chemical agriculture, of high yield, allows choosing a wide variety of food, according nutritious needs and consumers tastes- possibility that cannot be found in the traditional system.

However, the agricultural environment, both in the air and on plants is contaminated in different ways and with different intensities. Sustainable agriculture supposes the practice of alternative productive activities in a wider sense, the gradual shift from the purely biological one biologically sustainable and integrated.

Sustainable agriculture implies the practice of an alternative productive activity in a wider sense, by gradual shift from the purely biological to that one biologically sustainable and integrated. This should fully use, but judiciously, the achievements of chemistry, engineering and biology to raise the crop yields.

The contribution of chemical fertilizers and pesticides to increase crops should not exceed 40-45%, and the idea of sustainable agriculture lies in raising productivity by achieving safe and consistent profits, with minimum negative effects on the environment and ensuring population food security and is based on the diversification of specific climatic technologies of the different areas.

This involves a laborious concept which provides the complexity of the system regarding the biological stability of plants, conservation and protection of natural resources and introduction and then generalizing the viable economically technologies economically for a long period of time, capable of high yields and low costs.

Knowing how existing natural conditions satisfies the biological requirements of agricultural plants is of great significance for the national economy, because only beginning from this scientific base, can be performed a rational layout of the crops.

Growth and development of cultivated plants and their biological productivity and finally the crop, are the result of the exchanges and energy transformation that takes place within agricultural ecosystems.

The carrying out of these dynamic and very complex processes take place in different forms for each cultivated plant species and type of ecosystem and is subject to the requirements and mode of action of biological factors, territorial vegetation and ecological factors (climate and soil).

In all farming systems, agricultural works, through their effects on physical, chemical and biological soil properties represented one of the most important links to increase the production.

By soil tillage must achieve a loose layer in which plants and penetrate the soil, especially in the early stages of vegetation. For this purpose it has to achieve a balance between the solid phase and porosity of the soil, which must be of 1/1. The most pronounced effect on porosity has the ploughing which can increase the pore volume of the loose layer by 20-30%. [5]

Once with porosity increasing, takes place the change of bulk density. Most cultivated plants find favourable conditions to the development of the root system when the bulk density is from 1.07 to 1.45 g / cm^3 [3].

The soil works performed at the optimum moment has a favourable influence in its structural state, while repeating and making inappropriate moisture content causes deterioration of the structure.

By soil works, it creates favourable conditions for the accumulation and retention of large amounts of water in the soil in dry areas and wet areas in both the accumulation and deep drainage, thus avoid moisture excess in the arable layer.

MATERIAL AND METHOD

Establishing the fuel consumption of energetic source

The ability to estimate the fuel consumption of a tractor is very useful for sizing the budget for the work to be performed. In this methodology are proposed the calculation relations of fuel consumption based on measurements made to estimate fuel tractor consumption.

Using these equations, one can estimate and compare fuel consumption for different operating conditions and loading of the tractor. Depending on the time of use of a tractor fuel and lubricant costs will fit between 15% and at least 40% of total operating costs.

Therefore, fuel consumption is a major criterion of selection and management of tractors and machinery used in agriculture. The effectiveness of a tractor is evaluated based on the following criteria:

- results of the works achievement;
- their related costs.

Traction power is defined as a product between thrust and speed.

Because of the transmission and engine efficiency not all the energy from the fuel is converted into useful work. Optimizing the operations performed by agricultural tractors can be done by:

- optimization of the fuel consumption;
- optimization of the traction devices;
- selection of an optimal working speed.

RESULTS

A. Methodology for obtaining fuel consumption in Romania, before 1990

The last documents in Romania which standardized the diesel fuel consumption and remuneration rates have considered [9]:

- group the works on five categories of complexity;
- unified production standards;
- unified rules to carry works in t/km;
- unified rules of fuel consumption;
- unified rates of mechanizers' remuneration;

- farming transformation coefficients in ha/year;
- coefficients of correction of production standards in function of slopes and lengths of plots;
- coefficients of correction of production standards for works performed in vegetable growing;
- coefficients of correction of production standards for works performed in IInd exchange and for work performed during winter; on sandy soils located in Sadova-Corabia.

The rules were developed and were applied with the following terms of organization:

- working machinery grouped into bands;
- parking the tractors and execution of technical maintenance only to field camp;
- diesel tractor supply is done in field camp, only before the start or after work;
- troubleshooting in the field, is performed only by qualified personnel equipped with mobile workshop;
- follow up work by distributing aggregates corresponding to a number of trailers to harvesting and fertilizer spreaders, trailers tank in combat, means of transport for seeds, etc. .;
- usage of the aggregates that perform at a shift more agricultural works, with outstanding fuel economy and workmanship;
- usage of the aggregates that perform a shift more agricultural works, with outstanding fuel economy and workmanship;
- during timed observations for establishing the norms, workplaces were organized using graphs to conduct detailed charts and graphs combined circulation activities.

Due to different working conditions in which runs the same work, production standards were differentiated by:

- aggregate type;
- work speed and width;
- soil category (in ploughings case):

a) light (soil with specific resistance up to 35 kgf/dm^2);
b) medium (with specific resistance of 35.1 – 60 kgf/dm^2);
c) heavy (with specific resistance over 60 kgf/dm^2);

- working depth;
- average production per hectare;
- distance between rows (within works of sowing, planting, weeding, spraying, etc.).

The rules are set for land slope below 6 ° and length of plots between 501-800 m, in daylight, in normal conditions (humidity, temperature, etc.), resulting in the production standards apply only to those work conditions.

For different working conditions the following correction factors it applies:

a) Correction coefficient of production standards during the winter period (0.8) and the weighting workmanship value of 1.25.

These were applied during period from November 1 to April 1, only with the approval of Trust for the Mechanization of Agriculture (at the time), when work under low temperature and rainfall or agricultural works executed only in field (on the fly).

b) correction coefficient of the production standards for works performed in second organized exchange (0.9) and the workmanship value of 1.11. It was applied in that time only with the approval of Trust for the Mechanization of Agriculture in that time.

c) Correction coefficients for the production norms and correction coefficients of workmanship value depending on slope and length of plots.

For their application, each unit (CAP or UAS) to be framed - by-case in one or more factors (high culture, viticulture, horticulture), with the approval of the trust for mechanization, using for this purpose a methodology (approved and published in the Bulletin no. 3/1974).

Coefficients for correction of production norms and labour value are function of the slope and length of plots. For their application, each unit (CAP or UAS) to be framed – by case- in one or more coefficients (high culture, viticulture, horticulture), with the approval of the Trust for Mechanization, using for this purpose a methodology (approved and published in the Bulletin no. 3/1974).

When agricultural works where executed, on the fly, large parcels for culture, viticulture, horticulture and fodder harvesting, with average lengths on collective farms and smaller or higher U.A.S. than 501-800 m, and over 6 ° slope, production standards were corrected using correction coefficients that correspond the groups that fit each C.A.P and U.A.S., so :

Table 1

Slope	Coefficients name	Lengths of parcels in m				
		under 100	101-250	251-500	501-800	over 800
Under 6°	- Correction coefficients of the production norms	0.74	0.83	0.91	1.00	1.05
	- Correction coefficients of workmanship value	1.35	1.20	1.10	1.00	0.95
6 – 9°	- Correction coefficients of the production norms	0.69	0.77	0.83	0.91	0.95
	- Correction coefficients of workmanship value	1.45	1.30	1.20	1.10	1.05
Over 9°	- Correction coefficients of the production norms	0.63	0.69	0.74	0.80	0.83
	- Correction coefficients of workmanship value	1.60	1.45	1.35	1.25	1.20

Correction coefficients applied both in facilities in hilly areas and in the lowland areas, with the exception of unified labour standards which in collection are differentiated for all categories of slopes.

In these situations, agricultural mechanic remuneration for works executed in the field, was calculated by applying the correction coefficient value of the norms or by applying labour value.

Correction coefficients of the labour value did not apply to stationary works, transport or other works for which the daily achievements are not influenced by the length and slope of the land parcels.

Changing the collective or U.A.S. resorts served by the mechanization of agriculture in correction coefficients, it was done only with the Trust for the Mechanization of Agriculture approval, based on a new methodology using land inventory indicated framing.

d) Correction coefficients of the production norms and correction coefficients of the labour value, for the works executed in vegetable field.

In vegetable sector, agricultural mechanic achieves differentiated remuneration according to the average length of parcels in each CAP or UAS.

As a consequence, the parcels distributed in vegetable sector from each farm, were framed in the appropriate correction coefficients corresponding their average length.

Correction coefficients of the production norms and the labour value of are presented in the following table:

Table 2

Average length of the parcel from CAP and UAS	Correction coefficients of norms	Correction coefficients of labour value
until 80 m	0.70	1.40
between 80.1 – 140 m	0.80	1.25
between 141 m – 500 m	0.85	1.15

For vegetable work performed on larger plots over 500m, the production norms and tariffs were not corrected.

a) Correction coefficients of norms and labour value for the works executed in large cultures, on sandy soils within Sadova – Corabia zone, or other zones with such soils, are presented in the following table:

Table 3

Crt. no.	Agricultural works for which are used the coefficients	Norms correction coefficients		Labour correction coefficients
		production	consumption	
1	Ploughing + harrowing (all depths)	1.20 x norm from heavy soil normative	0.45 x diesel norm from heavy soil	0.83 x rate corresponding united norm on heavy soil
2	Prepared germinating bed (disking, harrowing), seeding, crop maintenance	0.85 x production norm from normative	1.20 x diesel norm from normative	1.18 x rate corresponding united norm
3	Spreading chemical fertilizers, pest control in large cultures, grain harvesting and baling	0.90 x production norm from normative	1.45 x diesel norm from normative	1.12 x rate corresponding united norm

b) In harvesting the grain cereals, in the same time with straw gathering in carried collectors, time production was reduced by 5% and the standard of diesel consumption was raise by 5%, and in case of trailed collector the norm production was reduced by 10% the consumption norm increased with 10% diesel fuel.

c) When baling straw bale in the same time with straw gathering, production norms in collection were reduced by 10% and the rate of diesel consumption increased by 10%.

In case in which the production norm of was influenced by several factors in calculating the salary of agricultural mechanic, it takes into account all correction coefficients of the labour value.

The rules were set by timer in normal working conditions.

Local standards are developed by the production units trained staff for this purpose, with due respect to the Labour Code, Law no. 5/1978 and HCM no. 201/1958, taking into account:

- the use of improved technology for working with machines suppliers;
- works executed with new machines, until establishing united norms;
- improvement the working machines characteristics or in applying several machines;
- using some aggregates which realize diesel and labour savings, comparing with existing norms in the present collection;
- better organisation of working places;
- exchange of working environment (changing working conditions) (drought or excessive moisture, high weeds, low culture, outstanding productions per hectare, etc.).

For works which were executed with small series tractors were used the same rules as for works executed for occasionally works.

The works executed in the field were differentiated on categories of complexity, as follows:

Table 4

Work category	**1**	**2**	**3**	**4**	**5**
RON/daily norm	109	124	141	160	190

B. Methodology of determination fuel consumption according DLG organisation

In Germany the competence of achievement the fuel consumption for farm tractors is attributed to DLG Competence Centre [10]. Within testing proceedings, the DLG Competence Centre reports fuel consumption for farm tractors in three situations: consumption on the dynamometric stand at the PTO, consumption achieved with the tractor in aggregate with various agricultural machinery and consumption during transportation. The testing procedure on stand reports consumption in the following situations:

1. Full load:

- absolute fuel consumption and specific fuel consumption at rated speed;
- absolute fuel consumption and specific fuel consumption at maximum power of the tractor engine;
- absolute fuel consumption and specific fuel consumption at maximum engine torque tractor;
- absolute fuel consumption and specific fuel consumption at 1000 rpm la power socket.

2. Partially load:

- absolute fuel consumption and specific fuel consumption at maximum rotation and loading at 80% of rated speed;
- absolute fuel consumption and specific fuel consumption at loading by 80% of rated output of the tractor engine and 90% of rated speed;
- absolute fuel consumption and specific fuel consumption at loading by 40% of rated output of the tractor engine and 90% of rated speed;
- absolute fuel consumption and specific fuel consumption at loading by 40% of rated output of the tractor engine and 60% of rated speed;
- absolute fuel consumption and specific fuel consumption at loading by 60% of rated output of the tractor engine and 60% of rated speed.

In figure 1 is presented a diagram with variation curves of the determined parameters according to those presented above.

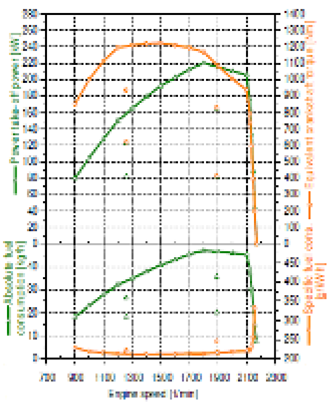

Fig.1 – Reporting absolute and specific consumption of fuel in function power outlet and time for an agricultural tractor (determinations on the dynamometric stand) [9]

The tractor test procedure in aggregate with various agricultural machinery report the consumption in the following situations:

1. Loading with traction force:

- Absolute fuel consumption and specific fuel consumption for the tractor in aggregate with plough, 100% load (code z1P);
- Absolute fuel consumption and specific fuel consumption for the tractor in aggregate with plough, charging 60% (code z2P);
- Absolute fuel consumption and specific fuel consumption for the tractor in aggregate with plough, 100% load (code z1G);
- absolute fuel consumption and specific fuel consumption for tractor in aggregate with cultivator, 60% load (code z2G).

2. Loading with tensile force and power plug:

- absolute fuel consumption and specific fuel consumption for tractor in aggregate with rotary, 100% loading (code z3K), 70% loading (cod z4K), and 0% loading (cod z5K);
- absolute fuel consumption and specific fuel for tractor in aggregate with windrover,100% loading (cod z3M), 70% loading (cod z4M) and 40% loading (cod z5M);

3. Loading with tensile force, work to power plug and hydraulic installation:

- absolute fuel consumption and specific fuel consumption for tractor in aggregate with amendments spreaders, (cod z7MS);
- absolute fuel consumption and specific fuel consumption for tractor in aggregate with tractor in aggregate with cu straw bale machines, (cod z7PR);

In figure 2 is presented an example of results obtained in field experiments for specific fuel consumption in above cases.

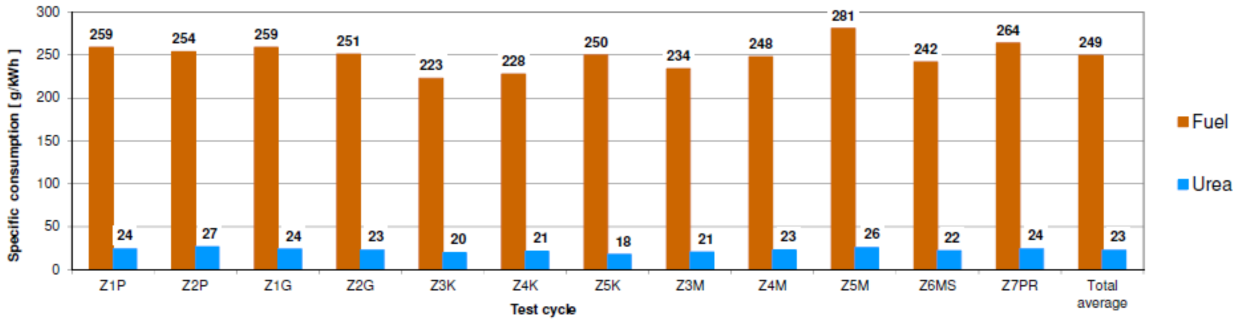

Fig.2 – Reporting the absolute fuel consumption and specific fuel consumption in function of aggregate, for a tractor [10]

In transport the consumption is reported by the idling mixture, with flat profile and only on roads, the maximum design speed of the tractor.

C. Methodology of determining the fuel consumption according tractor testing laboratory in Nebraska

Method of determining the fuel consumption, specific at “Nebraska Tractor Test Laboratory”, within “University of Nebraska, Lincoln”, Nebraska 68583-0832 is performed in accord with:

- OECD Standard Codes for the Official Testing of Agricultural and Forestry Tractors – 2015;
- SAE J1526 – 2015 International Standard (Society of Automotive Engineers);
- Nebraska test procedures.

According the three specific procedures of determining the fuel consumption is performing on dynamometric stand on power socket [11].

The procedure of determining fuel consumption on dynamometric stand comprises the following situations:

1. Absolute fuel consumption and specific fuel consumption at rated engine speed with load (maximum power at rated speed);

2. Absolute fuel consumption and specific fuel consumption at 80% from power obtained at point1, with engine speed set at maximum power at rated speed;

3. Absolute fuel consumption and specific fuel consumption at 80% from power obtained at point1, with engine speed set at 90% of rated speed;

4. Absolute fuel consumption and specific fuel consumption at 40% from power obtained at point1, engine speed set at 90% of rated speed;

5. Absolute fuel consumption and specific fuel consumption at 60% from power obtained at point1, engine speed set at 90% of rated speed;

6. Absolute fuel consumption and specific fuel consumption at 40% from power obtained at point1, engine speed set at 60% of rated speed;

During these tests are recorded the torque, engine speed and fuel consumption per hour.

D. Methodology of determination fuel consumption according testing laboratory of tractors proposed by INMA Bucharest

For each range of farm tractors corresponding to each farm category established by Law 37/2015 sets out key agricultural activities taking place since the establishment culture to harvest and release of vegetal waste. The main agricultural works for different vegetable crops in plains, hills and mountains are: ploughing, harrowing, working the soil with combiner, spraying, chemical fertilizer management, organic fertilizer management, amendments administration, seeding and harvesting.

Accordingly these works are selected 3 tractors representative for each range (≤45 HP, 46-80 HP; 81-120 HP, 121-360 HP;> 360 HP) and is determined the fuel consumption for a 100% charge; 75%; 50% of rated engine tractor in aggregate with various farm machinery that lends itself above the main building works.

The procedural steps for measuring fuel consumption, with various farm machinery aggregated are:

- tractor identification which agricultural works will be achieved;
- agricultural machinery identification which are going to work in aggregate with the chosen tractor;
- establishing the test program (worked area, working conditions, work indices, soil type);
- choosing the measuring equipment;
- performing the tests;
- processing and reporting data.

There will be measured the following parameters required in determination the consumption norms for different vegetable crops in the plains, hills and mountains:

- tensile force;
- moment at power socket;
- power at pulling power;
- total power;
- determining the use of tractor engine power;
- driving wheels slipping;
- fuel consumption; determination of fuel quantity is done at the end of every team exchange, with the help of a fuel volume by measuring box, or by existing measuring system on fuel supply equipment;
- consumption coefficient, q is determined with the help of the following relation:

$$q = \frac{Q}{U} \tag{1}$$

where: Q represents the amount of fuel consumed for the execution of U works, in litres.

The consumption coefficient of fuel is expressed in litres per hectare or gallons per ton.

To estimate fuel consumption is used the following formula:

a) The simplified calculation formula

$$Q_{med} = k_1 \cdot P_n \tag{2}$$

where:

Q_{med} – represents diesel average consumption (l/h);

P_n – represents rated power (CP);

k_1 – represents a constant (specific fuel consumption ((0.1716 + Dx) l / CPh);

Δx – have to be experimentally determined, based on results from tests in the field.

Bowers (2001) substantiated that equation (3) was developed on the basis of power test results as follows: for various tests of power (approximately 100%, 85%, 65%, 45%, 20% and 0% of rated power) the results were averaged, then the average was divided to rated power of the tractor.

For this reason, annual estimates of the fuel consumption using this method give fuel consumption based on the assumption that the tractor is operated under the same model of charging for equal time. In this case, this method underestimates fuel consumption [2, 7, 8].

b) generalized formula for calculating

Depending on operating conditions of the fuel consumption is estimated at reduced engine load and maximum acceleration. In ASABE standards (2011) general equations of fuel for compression-ignition engines have been developed as follows:

$$Q_{a\,max} = (0.1692 \cdot Z + 0.0741) \cdot P_n \qquad (3)$$

where:

Q_{amax} – represents diesel consumption, partial load and maximum acceleration, (l/h);

Z – represents the report between used power and rated power,

$$Z = \frac{P_u}{P_n} \text{ (CP);}$$

P_u – represents the used power (CP).

$$Q_{ared} = Q_{a\,max} \cdot [1 - (N - 1) \cdot (0.45 \cdot Z - 0{,}877)] \qquad (4)$$

From relations (3) and (4) results:

$$Q_{ared} = k \cdot (0.1692 \cdot Z + 0.0741) \cdot [1 - (N - 1) \cdot (0.45 \cdot Z - 0{,}877)] \cdot P_n \qquad (5)$$

where:

Q_{apar} – represents diesel consumption, with partial load and reduced acceleration (l/h);

N – represents the ratio between low engine speed and maximum acceleration;

k – correction factor determined experimentally, based on tests carried out in the field. It takes into account the working conditions (slope, soil type, previous work, soil moisture, degree of compaction) and the indices of previously established working (type work, working depth, working width, the operating speed).

CONCLUSIONS

Establishing a framework methodology for estimating the rules of production and consumption of fuel in the country, according to the sources existing energy classes powers of their related areas of existing farmers and agricultural work to be carried out in the plains, hills and mountains in Romania, for the main agricultural work is a necessity for our country at this time.

The substantiated methodology allow the fuel consumption for the main agricultural activities in our country, for different vegetable crops in the plains, hills and mountains: ploughing, harrowing, soil tillage with combiner, sprayers, fertilizers management, organic and amendments management, sowing and harvesting, for 3 representative tractors for each range (≤45 HP, 46-80 HP; 81-120 HP, 121-360 HP;> 360 HP) for 100%, 75%, 50% of rated engine tractor in aggregate with various farm machinery that lends itself the above the main building works.

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GENERAL CONDITIONS OF WORK FOR SUBSTANTIATING A CALCULUS METHODOLOGY OF FUEL CONSUMPTION
/
CONDITII GENERALE DE LUCRU PENTRU FUNDAMENTAREA UNEI METODOLOGII DE CALCUL A CONSUMULUI DE COMBUSTIBIL

PhD. Stud. Eng. Cujbescu D.[1], PhD. Eng. Matache M.[1], PhD. Eng. Vlăduţ V.[1], Eng. Bolintineanu Gh.[1], PhD. Eng. Danciu A.[1], PhD. Stud. Eng.Persu C.[1], Eng. Vlad C.[2], PhD. Eng. Ungureanu N.[3], Eng. Oprescu M.R.[4]
[1]National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, INMA, Bucharest, Romania; [2]ICEADR Bucharest / Romania; [3]PU Bucharest / Romania; [4]Condor Comimpex S.R.L. / Romania
E-mail: dcujbescu@yahoo.com

ABSTRACT
The paper presents results of research conducted to establish overall working conditions underlying the substantiation frame methodology for estimating fuel consumption, in the country, depending on existing energy sources, their power classes correlated with existing areas and farmers and agricultural work to be carried out in the plains, hills and mountains of Romania, for the main agricultural works.

REZUMAT
Lucrarea prezintă rezultatele cercetărilor efectuate pentru stabilirea condiţiilor generale de lucru ce stau la baza fundamentării unei metodologii cadru de estimare a consumului de combustibil, la nivelul ţării, funcţie de sursele energetice existente, clasele de puteri ale acestora corelate cu suprafeţele existente la fermieri şi lucrările agricole ce trebuie efectuate în zonele de câmpie, deal şi munte din România, pentru principalele lucrări agricole

Keywords: *energy source, farm, energy indices, working speed*

INTRODUCERE
Agriculture is of ancient times and remains today a vital area of human activity. It remains the only source of food, a major supplier of raw materials for industry and also an important market for its production.

Agriculture is a branch of material production, which, with help of green plants and under the guiding of human action is generated by transforming kinetic energy of the sun, into energy potential organic matter, the only form of energy available for human and animal body.

The relative importance of agriculture varies from country to country, but it remains the main branch of the national economy in all states including the highly developed ones. The experience of recent decades has shown that global economic problems cannot be solved leaving aside the agriculture.

Agricultural development is influenced by natural factors, techniques and social economic ones.

Among natural factors, the climate plays an essential role; it conditions spreading and agricultural crops structure by the regime of temperature, moisture and light. The relief influences the distribution of crops by altitude, versants exposure, tilting slopes. Genetic type of soil contributes by acquiring its main fertility, plus the ability drainage and water retention.

Technical factors play an important role in increasing production, through mechanization, chemicalization, irrigation etc. the social- economic through capability and readiness of the entire workforce and economic context in which development of this branch of the economy. Like any economic activity, agricultural activity ends with the satisfaction of human needs and the overall progress of the country.

The main functions of agriculture in the national economy are [8]:
- food function;
- socio-economic function, to participate in the growth and development process;
- environment protection and sustainable socio-economic development function.

Knowing how existing natural conditions satisfy the biological requirements of agricultural plants is of great significance for the national economy, because only from this scientific basis can make a rational layout of crops. Growth and development of cultivated plants, their biological productivity and finally their harvest are the result of exchanges of substance and energy transformation that takes place within agricultural ecosystems. The carrying out of these dynamic and very complex processes take place in different forms for each cultivated plant species and type of ecosystem and is conditioned of biological requirements and mode of action of vegetation factors and ecological territorial factors (climate and soil).

Action of vegetation and ecological factors on growth, development and fruiting of plants in relation to their biological requirements, determine a reference level of greatest importance, namely: ecological optimum. It is very important to know the concept of ecological optimal ,because, based on its level, restrictive action factors of the physical environment masking ecogeographic areas, the most favourable to unfavourable, where cultures meet their difficult biological requirements or who are those improper for plant growth and development.

Setting up a modern and competitive agriculture on Romanian territory, to ensure high and stable yields, is not possible without ecological zoning of agricultural crops. This can be considered as ecological zonality support of agricultural production.

In our country, in relation to ecological factors and optimum ecological, was proposed grouping by grade favourable natural areas. Is considered very favourable area where natural conditions meet all the requirements of plants. As intervene and intensifies some elements unfavourable, areas were rated as favourable, least favourable and even improper for agricultural or horticultural crops.

By areas means more administrative territories, which is characterized by the unity of the environment factors and presents conditions which have more or less similar for agricultural crops. For example: West Plain includes the territory between the border of western and western foothills, from Satu-Mare to Oravita; is very favourable for maize, fodder plants, winter wheat, autumn barley, sunflower, soybean, sugar beet, potatoes, hemp and favourable for peas, beans, flax for oil, rice.

Within areas differentiates:

- *basins,* restricted areas, covering several localities, with almost identical pedoclimatic conditions and a range of specialty crops;
- vegetable, fruit, vineyards *centres* are identical pedoclimatic conditions specific territories, specializing in one-two cultures.

MATERIAL AND METHOD

In all agricultural systems work through their effects on physical, chemical and biological soil properties was one of the most important links to boost production.

By soil tillage must achieve a loose layer in which plants to find optimal conditions for growth and development. In a loose soil roots develops and penetrates the soil more easily, especially in the early stages of vegetation. For this purpose the work must be achieve a balance between the solid phase of the soil and porosity, report must be to 1/1. The most pronounced effect on porosity has plowing that can determine the increase pore volume of loose layer with 20-30%.

With increasing porosity, takes place modification of apparent density. Most major crop plants have favourable conditions for the development of the root system apparent density is between 1.07 to 1.45 g / cm3. [5].

The soil work performed at the optimum moment has a favourable influence its structural state, while repeating and performing inappropriate moisture content generates structure deterioration.

By soil works creates favourable conditions for the accumulation and retention of large amounts of water in the soil in dry areas, and wet areas in accumulation and deep drainage, so it must be avoided excess moisture in the arable layer.

By soil tillage (plowing, sloppy, harrowing, roller etc.) arable layer is subjected to a series of operations that have the effect of modifying its characteristics. Depending on the agricultural machine that carried out the work, the soil is subject to the following technological processes [9]:

- turning or overturning soil is performed using the plow and usually performed once a year. By overthrowing arable layer are incorporated into the soil the stubble, fertilizers, amendments etc. and it is brought to the surface layer of soil from the depth, structured with superior qualities;
- *chopping and loosening* the soil is achieved with the overthrowing the furrow. Arable layer can be loosened using subsoil parts. Chopping and loosening the soil surface layer can be achieved with harrows, cultivators etc. .;
- *mixing soil layer.* This process aims to create a uniform layer of soil, with physical, chemical and biological similar properties. By mixing are distributed evenly in the soil fertilizers, organic waste, amendments;

- *soil compaction* is achieved by work with the roller, which increases capillary porosity to the detriment of non-capillary one favouring water climb to the surface of the soil in the area seed germination. Compaction is used more frequently in dry areas;
- *levelling* is done in order to reduce water loss from soil by evaporation to lighten the work of sowing, maintenance and harvesting, for uniform distribution of the irrigation water, etc. Levelling is achieved with the help of levellers, harrows and sometimes with the roller, in this case in which the compaction of the soil is achieved.

By special soil works, depending on crop needs and pedoclimatic conditions, may take place other technological processes such as: creating irrigation furrows or to remove excess water, forming ridges, vegetable land modelling, etc. Soil works are classified according to several criteria [3]:

After the running tools: plow works, cultivator works, shaping works, harrow work, roller works, etc.

After running the depth: depth works, surface works.

After performing season: summer works, autumn works, winter works and spring works.

After plants for that are running: works for winter wheat, works for maize, works for potato, etc.

❖ **Ploughing**: is the most important work of the soil, is considered the basic work. In our country conditions usually on the same field plowing is executed only once a year and in some cases twice a year. By plowing a thinner or thicker layer of soil, called furrow, comminute, mix and loosen. Among the most important effects of plowing we mention:

- burying the pulverized soil layer and bringing to the soil surface;
- structured;
- incorporation of plant residues, weeds and fertilizers;
- loosening by which in achieved soil aerating and heating in depth;
- storing large amounts of water in the soil, etc.

Following the positive influence of plowing on physical, chemical and biological properties in plow soils increases the content of chemical substances available to plants are reduce the content of substances not fully oxidised, increase the number of useful microorganisms etc.

In order to carry out plowing of the field must be delimited in plots or strips, the width must be a multiple even with the working width of aggregate and at the same time to minimize empty movements at the ends. Plowing can be performed in several ways, namely:

a) *plowing sideways*. The aggregate enters in to work at right edge of the plot overthrowing the furrow to right on uncultivated field, thus forming a ridge, and at the end of the plot the aggregate is moving in load and start again in reverse on the other side of the plot, where the furrow is thrown on the right again, on uncultivated field and is formed a second ridge. The tractor moves in idle at the end of the first edge and enters in work next to the first furrow where executes the third furrow. The work also continues on both sides of the plot until it reaches the middle where at the end of work will remain a ditch. At plowing sideways, the plot area is formed three humps: two ridges on sideways of the plot and a ditch at the middle of the plot.

b) *moldboard plowing.* The aggregate performs the first furrow in the middle of the plot, so that the second resulting furrow falls over the first furrow. In this way it will form a ridge in the middle. Next, will perform the third furrow first, the fourth next the second and so on, until it reaches the side edges of the plot. In this case the plot edges remain open two ditches, because the resulted soil of the last furrow falls inside the plot. So the plowing on moldboard results also three humps as in plowing sideways but, in this case the middle of the plot it forms a ridge on the edges remain two ditches.

c) *smooth or in one side plowing.* To accomplish this plowing is used a reversible plow with two bodies, one overthrows furrow on the right and the other one overthrows on the left, exchange between the two bodies being made at the end of the plot. Thus the plow overthrows the furrows only in one part of the plot, creating a uniform plowing, without ditches and moldboard. Working in this way the aggregate does not have to go and do idle races and in the end will result in one ditch at the edge of the plot.

This method of execution of plowing is used in particular on slopes fields, subject to erosion, where plowing runs along the level curves. For a good quality plowing result it is necessary primarily as the aggregate we work with to be well tuned and the active parts to be sharpened. An important role that can have the shape of moldboard crown which can be: helical, cylindrical and cultural.

On the quality of plowing has an overwhelming importance the soil humidity. Thus, the clay soils have high adhesion and cohesion, are worked well to a humidity content of 50-65% of the soil capacity for water. On these soils, the optimum moment of work is of short duration. If the ground is working on a too high humidity content resulting furrows in the form of strips (belts), which is comminuted very hard, with much expenditure of energy and time. If soil humidity is too low resulting boulders that need to be comminuted and requires repeated work with a disc harrow and roller.

Sandy soils with low adhesion and cohesion, work well both on dry and in the wet state. The limits of working regarding humidity, at these soils are between 30-85% of soil capacity for water. Silty soils occupy, from this point of view, an intermediate place.

The presence of harrow of plowing in aggregate is another condition that determines the quality of plowing. Harrow has the role to comminute the lumps by plowing and levelling worked land.

The quality of plowing is influenced by the depth at which runs every year on the same plot. If plowing is executed several years in a row on the same plot, at the same depth, forming hard pan or plow footprint (the layer of compacted soil) interposed between arable and the sub-arable layer, which prevents the roots to penetrate into the deeper layers and is impermeable for water and air. Therefore plowing depth should vary from year to year.

Land strongly wedded, stubble, land which was cultivated corn and sunflower, etc., before executing plowing will work with the disc harrow in order to fragment organic waste ensuring thus their incorporation into the soil by plowing.

The quality of plowing depends on the relief. The best conditions for achieving a quality plowing are offered by the flat land. Choosing an appropriate speed for forwarding with the aggregate for plowing, also conditions the plowing quality. Plowing executing depth classified into five groups, namely:

- superficial;
- normal;
- deep;
- for unblocking.

- *Superficial plowing*, is performed at a depth of 14-17 cm, in the following cases: prepare the field for successive crops, for autumn grain late autumn after preceding late cultures in the situation when soil humidity does not allow the execution of normal plowing; when in a year is executed on the same field two plowing, one will be superficial, early spring on land that for various reasons remained un-tilted for autumn; the works system to combat couch grass, it is recommended to start with a superficial plowing; in wetlands if executed autumn plowing was tapped until spring because of rain and snow; sometimes when taking into natural and artificial grassland culture (debarking plowing) or for incorporation of organic fertilizers and amendments.
- *Normal plowing* is executed at a depth of 18-20 cm both in the summer, after early preceding cultures, and in autumn, after late previous cultures, crops that not require deeper plowing (straw cereals, grain legumes).
- *Deep plowing* is executed summer or autumn of 22-30 cm depth for crops requiring deeper loosening the soil such as potatoes, beets, corn, alfalfa etc. Among the advantages of deep plowing are: favouring the accumulation of larger quantities of water in the soil, contributing to the destruction of weeds difficult to refute (couch grass, pelamid etc.), are better incorporated into soil organic the fertilizers and amendments, etc. It is recommended that the same plot the deep plowing to alternate from year to year with normal plowing, which can be achieved only if rotations are rational.
- *Very deep plowing* is executed at a depth of 31-40 km; they are required on clay soils, compacted that require deep loosening to improve their physical properties. Such lands very deep plowing will be executed at 3-5 years.
- *Unblocking plowing* is executed with special plows to a depth of 40-80 cm for the establishment of nurseries, growing vineyards and fruit, etc. Because the unblocking the humus layer is buried at great depth and remove the surface soil horizon B and C, infertile, it is necessary to administer large quantities of organic and chemical fertilizers, and on acid soils and amendments. Unblocking plowing increases soil permeability to water and air enhances biological activity and degradation of incompletely oxidized compounds, incorporating weeds and pests, etc.

After plowing execution times can be: of summer / of autumn and in some cases: of winter / of spring.

- *Summer plowing* runs is executed after harvesting of early crops (summer peas and potatoes, autumn grain etc.). These plowing are executed along winter and spring crops according to the rotation determined in the crop rotation.
  - Summer plowing has many advantages:
  - contributes to storage and preservation of water from precipitation;
  - favours the growth of nitrate content;

- contributes to combating weeds, pests and phytopathogenic agents, etc.

In order for summer plowing, to be at the required quality is execute immediately after harvesting in aggregate with star harrow, for shredding lumps, levelling and soil settlement.

Regarding the depth execution of plowing it depends on:

- soil humidity;
- plants that will be cultivated;
- other factors.

In general, for successive crops is executed superficial plowing, for autumn crops normal plowing and for spring crops are required normal or deep according to their requirements.

- *Autumn plowing* is executed after late preceding crops (corn, sunflower, potato, beet etc.) for autumn or spring crops. For autumn crops (autumn grain) is executed, immediately after harvesting of the preceding plant, are done normal or superficial plowing according to soil humidity, in aggregate with the star harrow. For spring crops, plowing depth varies from 20-30 cm, depending on the plant that will be sown, the soil condition, the degree of weeds etc.

  Autumn plowing has many advantages over spring plowing:
  - accumulate water from rainfall in the cold season;
  - weeds seeds and pests are incorporated in depth and are destroyed;
  - weed seeds brought to the surface are destroyed by frost during winter;
  - accumulates 2-3 times more nitrate than the fields plow in the spring;
  - facilitates the smooth execution of soil works and sowing in spring etc.
- *Winter plowing* is executed in extreme situations when conditions are unfavourable in autumn (drought or excessive rainfall). This plowing can be done during winter good weather when the ground is not covered in snow and it is not frozen at all or only on the surface. In terms of quality this is an inferior against autumn plowing, but superior against spring plowing.
- *Spring plowing*, is contraindicated for conditions of our country. In case when we have not done for some reason the autumn plowing. Spring plowing will be executed early in aggregate with star harrow at a depth of 16-18 cm, to reduce water loss from the soil.

❖ **Harrowing:** soil levelling performed on the surface, loosening and shredding it to a depth of 3.12 cm. To perform this work using different types of harrows: with discs, tooth rigid or adjustable, simple rotating or star etc. Harrow work is performed mainly in the following situations:

- for shredding simultaneously plowing, harrows star being a mandatory part of the aggregate; for maintenance of summer plowing, when are used adjustable toothed harrows or disc ones (sometimes both in the aggregate) according to the degree of weed and thickness of the crust formed after rains;
- caring for spring crops (rotary hoe or harrow with adjustable teeth) before or after emergence, to destroy crust and weeds that just emerge;
- caring for lawns, lucerne and clover field, in early spring or after mowing, with adjustable toothed harrows, in order to collect organic waste and loosen the soil favouring emerging plants; for regenerate old lucerne is used to disc harrow.

Disc harrow can be used in the following situations: for clearing stubble when you cannot execute right away summer plowing after harvesting the early plants, prepare the field for successive crops, prior to plowing autumn if on the soil remains plant debris, preparation soil for sowing autumn crops after proceedings cultures they leave the soil loose (beet, potato) or when soil humidity does not allow plowing.

Harrows working speed varies, generally between 4-10 km / h, relative to the tensile force, the harrow type, the soil humidity, working depth, etc.

❖ **Soil tillage with cultivator:** characterized by an intermediate effect between plowing and harrowing because they realize cutting weeds, shredding and loosening the soil without overthrowing layers. Cultivators can be equipped with various active bodies according to work that need to be done; there are used mainly in the following situations:

- from preparing the soil for plowing in order to sow, when the cultivator is equipped with parts for total cultivators;
- to prepare the seedbed when besides cultivator is attached rotary harrow or harrow with rigid toothed and helical harrow (aggregate carrying the name combiner);
- as the case hoeing, second digging, simultaneously with additional fertilization;
- opening the culverts to irrigation furrows;

- on heavy soils (ex. luvisol albic) where necessary to work the soil deeper (20-22 cm), without turning furrow, when using chisel cultivator equipped with strong and active pieces shaped like chisel.

Cultivators working full speed is 6-8 km / hour. When working on crop care, the first hoeing is speed of 4-5 km / h and the next hoeing is 6-8 km / hour. Sugar beet speed is reduced by 20%.

❖ **The soil tillage with the roller:** it is used for compaction and levelling the soil and for shredding lumps. Soil compaction can be achieved through 5-10 and even 12 cm depending on the rollers' weight. Rollers action on soil is determined and shows how their surface is. Thus, smooth rollers executes soil compaction without break boulders that push them into the soil, while ring rollers attached to soil compaction contributes to the shredding boulders and destruction of crust. The roller is used mainly in the following situations:

- the compaction of plowing too loose when you should sow immediately;
- from shredding rocky plowing to ease the work soil with disc harrows, to prepare a seedbed properly for autumn cereals;
- before sowing small seeds (lucerne, clover, poppy, mustard etc.) and after sowing large seeds if the soil does not contain adequate humidity;
- caring for autumn cereals when they have emerge uprooted out the winter ("barefooted");
- plants grown for green fertilizer, work with the smooth roller before executing the plowing, plants are lie down in direction of the plow movement, easing their incorporation under furrow.

Movement speed of the roller depends on the purpose, as follows: when seeking soil compaction loosely with the ring roller, movement speed is 3-4 km / h, and when the aim is to shred more boulders, moving speed can be 5.7 km / h.

❖ **Preparing the seedbed:** this work should pursue the establishment of a soil layer well shredded on sowing depth, seated in depth and loose on the surface, to be incorporated into the seed in intimate contact with the soil to germinate in a short time and uniform manner throughout the plot. Seedbed preparation should be done the day before or the day of sowing and, the last work of preparation will be executed perpendicular to the direction of sowing with disc harrows, cultivators and weeders and, when using the combiner can work in the same direction with the sowing. Simultaneously with seedbed preparation is incorporated into the soil nitrogen chemical fertilizers, herbicides and insecticides and also are destroyed emerged or under-emergence weeds. By loosening soil only on sowing depth creates conditions that sowing equipment distribute evenly the seeds the more seated soil with sufficient humidity. In such conditions the seeds remain covered with loose soil, aerated and heated creating a favourable environment triggering the sprouting.

Soil tillage systems

By soil tillage system it is understood application mode in more complex works, specifying their number, sequence and time when is executed.

The main soil tillage systems are:

- works system for winter crops;
- works system for spring crops;
- works system for succeeding crops;
- minimum works systems.

▪ *Works system for winter crops:* autumn cultures (wheat, rye, barley, autumn rape, can be sown after early preceding crops (peas, beans, early potato, flax, etc.) or after the plants that are harvested later (corn, sunflower, beet, soybean, etc.). In the first case (after early preceding crops) immediately after harvesting the preceding plant is executed summer plowing in aggregate with the star harrow, at a depth of 20-22 cm. By autumn plowing will be maintained free of weeds and works without the crust by working with disc harrow or cultivator, in aggregate with adjustable toothed harrow. The last work will be done at seed depth, perpendicular on the sowing direction.

▪ *Works system for spring crops:* spring crops can be sown after the plants harvested early or after crops harvested late. After early preceding crops, soil works are generally the same as for autumn cultures following the plants that are harvested in the summer.

Regarding the depth of plowing it ranges between 20-30 cm depending on the plant that will be cultivated, the climatic conditions of the year (dry or rainy) humus layer thickness, degree of soil work and other factors, so for example, according to the requirements for deep plowing, spring crops are classified into two groups, namely:

a) plants that require soil loosening at depth of 20-25 cm (ex. grain legumes);

b) plants that require deeper loosening of 25-30 cm (beet, potato, corn, sunflower).

- *Works system for succeeding crops:* after crops that are harvested early (vetch, autumn rape, autumn barley, early potato etc.) can sow the second crop (corn for grain, silage or green mass, Sudan grass, fodder rye, soybeans, sunflower beet, flax fibre, etc.). These successive cultures or double certainly make it in areas of heavy precipitation during the summer or under irrigation. Another condition for these cultures to succeed is the work of soil preparation and sowing to be done as soon as possible, in order not to lose ground water and to allow time and required temperatures needed for the crop second. For this purpose immediately after harvesting the early crops soil should be fertilized and then make a superficial work. On lighter soils, loose and clean of weeds is sufficient a work with the disc harrow. In other cases will be executed superficial plowing in aggregate with star harrow then seeded.
- *Minimum works systems:* starting from the fact that due to the numerous works that are practiced under the current technologies, soil settles, deteriorating structure, decreases the humus content, and in the case of slope lands the erosion is accentuated, has outlined the idea of applying a smaller number of works the same surface.

Using this system is conditioned by the existence of some aggregated of complex machines that executes combination of several operations, the use of greater quantities of fertilizer, insecticide and fungicides, herbicides, knowledge of crop plants particularities and pedoclimatic local conditions.

Depending on pedoclimatic conditions, the crop plant, the system of fertilization and weed control were developed several variants of minimum tillage systems of which the most common are:

- Plowing- sowing system;
- Cultivating- sowing system;
- Agriculture without plowing system.

Agricultural tractors in recent years have become increasingly more sophisticated and complex in terms of construction and functionality. The reasons for this development are, inter alia, the requirements of agriculture for their use, to achieve high work capacities, to achieve high index of quality of work performed, desire of users to have greater comfort in the management, adjustment and servicing of agriculture tractors and need to obtain by the operator of an increased volume of information on the process of work executed and the technical status of components. The ultimate goal of improvement measures is, of course, improve their operational economy. [1]

Any reference to agricultural mechanization must start from the tractor, as the main energy source for most of agricultural equipment. It should be understood that the tractor separated from other farm machinery or means of transport does not presents interest, its importance is manifested within technical systems of extreme diversity, in composition of which is included. In traditional farm tractor took over with great success obligations of a large number of people and animals, which made the global labour force employed in agriculture to reduce permanent and agricultural production to grow continually.

Classification of agricultural tractors

Extensive use of tractors, in agriculture and in other economic sectors has led to a wide variety of types of tractors. Actual tractors can be grouped by different criteria, like: [6]

- destination;
- engine type;
- type of rolling system;
- some construction features:
  - ✓ tractor type;
  - ✓ transmission type;
  - ✓ number of powered wheels;
  - ✓ steering scheme;
- value of engine power;
- number of plow bodies that tractor works in aggregate;
- value of tensile forces, etc.

According to the purpose, the tractors are classified into the following groups:

- agricultural tractors;
- industrial tractors;
- transport tractors (road).

Agricultural tractors after their area of use can be:

- general purpose;

- universal;
- specialized;
- self-propelled chassis.

General purpose tractors are wheeled or tracked tractors, which are used in the execution of the main agricultural works: plowing, total cultivation (total processing of the cultivator), harrowing, sowing, harvesting etc. Light (ground clearance) of these tractors is 270-350 mm. Tractors in this category are called "for plowing", after the name of basic work that performs.

Universal tractors form a group of wheeled tractors, outside work done with tractors intended for general, use in maintenance work of hoeing cultures (works between rows with cultivators for hoeing), as the transport works, especially in agriculture. These tractors are different from those of general purpose; they have greater light (40-750 mm), most often variable, it has the possibility of changing the gauge and have a wider range of speeds. In some specialized works, these tractors are known as "universal hoeing tractors".

Specialized tractors comprise the group of tractors that by their special construction are suitable for carrying out various works. This group includes the tractors for work in gardens, orchards, vineyards, rice fields, tea plantations, cotton etc. (with light of 750 ... 1000 mm and more), for hilly and mountainous regions for the work in plant crops with high port (portal tractors) for marshy lands (for irrigation, drainage, damming corrections of river courses) [1].

Classification of tractors according to economic dimension of farms and agricultural holdings and Total Standard Production (SO).

Law 37/2015 classifies farms and agricultural holdings according to the economic dimension as follows:

a) under 1.999 euro: subsistence farms that produce entirely for their own consumption;

b) 2.000 – 7.999 euro: semi-subsistence farms which ensure their own consumption and a small part of agricultural production is sold;

c) 8.000 – 49.999 euro: small commercial farms that sell more than 50% of agricultural production that it conducts;

d) 50.000 – 999.999 euro: commercial / medium agricultural holdings farms sells its entire agricultural production that it conducts;

e) over 1.000.000 euro: commercial / large agricultural holdings that its sells entire agricultural production that it conducts.

Considering the classification of farms and agricultural holdings according to Value Production Standard "SO" which replaces the measuring unit preceding or Economic Size Unit (ESU), tractors can be classified into the following categories by groups of power (medium value of SO It was estimated at approx. 500 E / ha):

Table 1

Tractors classification by groups of power

Farm type	Farm theoretical area [ha]	Tractor theoretical power [CP]
subsistence farms	≤ 4	≤ 45
semi-subsistence farms	4.01 - 16	46 - 80
small commercial farms	16.01 - 100	81 - 120
commercial farms / agricultural holdings medium	100.01 - 2000	121 - 360
commercial farms / large agricultural holdings	> 2000	> 360

Agricultural machinery and equipment

For preparing a seedbed as perfect as possible, we must perform care and harvesting of the crop work in time, agricultural production has a wide range of machinery, equipment and tools.

Modernization of agricultural production requires the expansion and diversification of farming mechanization, it ensures increase of labour productivity, works were carried out good quality and optimal terms, leading to increased yields and lower costs over time. With the help of tractors and agricultural machinery is made of the technological flow of culture agricultural work.

Machinery and equipment for agricultural production must meet certain requirements. First they are matched with technology and specific work of each group of plants. They are running on large tracts of land needing the energy to execute the work and the necessary energy for idel movement. The machines and equipment must be as universal as possible, easy to handle, with low weight, the active parts to be demountable, which allows for the specific investment reduction, the consumption of metal an of fuel. However, exploitation will be more economical and more efficient, and lower fuel consumption, by type of work. Machinery and equipment in their work should compact as little as possible the soil, particularly the soil with heavy texture.

Tractors, energy source in execution of works, must have a low fuel consumption, to have hydraulic lifters and other mechanisms to act as more machinery and tools and be used in a wide range of works. For an efficient use of machinery equipment and tools, they are grouped in a specific machines systems sector of activity, for a crop group, or even a single culture.

By machine system means the assembly of production equipment for each sector and even crop to full mechanization of field work. Machine system can be specified for each production process (for harvesting straw cereals, harvesting corn, seed conditioning, etc.) and common (soil works, seeding and planting, land maintenance, etc.).[4]

Currently agriculture features machine systems for all crops that work is carried out from land preparation to harvesting and storage. Machines system in vegetal production obviously leads to increased work productivity and reduced costs per tonne of product.

An essential condition in work mechanization and within coupling systems is their energy source, forming various aggregate. After the energy source used, the aggregates can be tractors, with carriage, horse drawn and electric motors. Depending on the kinds of machines and equipment that make up the aggregate, it can be simple (tractor +plow, tractor + drill) and complex (tractor + plow + harrow). [2, 9, 10]

Aggregate productivity is the amount of work performed by the aggregate per unit time, determined by the working width, average speed of movement and working time. Most important means to increase aggregate productivity it constitute the best use of work time in exchange by:

- reducing shutdowns;
- removing idel movements on the plot or to a plot to another;
- avoiding technological process interruption, malfunctions, etc.

Components of machine systems can be grouped by:

- after the way are actuated:
  - ✓ manual,
  - ✓ mechanic;
- after the manner of execution of work:
  - ✓ mobile (tractor, harvesting machine);
  - ✓ stationary (machines for selecting seeds);
- by the way the works are executed:
  - ✓ sowing machine;
  - ✓ planting machine;
  - ✓ harvesting machine;
  - ✓ conditioning machines;
- after the working sector:
  - ✓ machines for cereal crops;
  - ✓ machines for technical crops;
  - ✓ machines for fodder crops.

In Table 2 are presented the main machinery and equipment used in agricultural crops. [7]

Table 2

Main machinery and equipment used in the work done for agricultural crops

Agricultural work	Machinery and equipment
Preparing the soil	- leveller; - carried plow; - plow with variable working width; - reversible plow; - toothed harrow; - star harrow; - disc harrow; - carried cultivator; - ring roller; - smooth roller; - rotary hoes; - cutting machine; - combinator; - verticutter;

	- sprayer machine.
Applying fertilizers	- machine for administered organic fertilizers; - machine for administered mineral fertilizers and amendments; - portable tanks; - plane; - helicopter.
Sowing and planting	- precision universal sowing machine fine; - sowing machine of pneumatic precision; - sowing machine in stubble; - planting machine of potato tubers.
Crop maintenance	- spraying and dusting machine - sprayer equipment; - plane; - helicopter - sprinkler installation.
Harvesting products	- combine, universal, self- propelled; - cobs gatherer; - potato harvesting machine; - beet harvesting machine; - pea harvesting machine; - combine for harvesting flax fibre.

CONCLUSIONS

Establishing overall working conditions that lie at the basis of a methodology framework for estimating fuel consumption, in the country, according to the sources existing energy, classes powers of their related areas of existing farmers and agricultural work to be carried out in the plains, hills and mountains of Romania, for the main agricultural work is a necessity for our country this moment.

General working conditions are given by: the main types of agricultural work carried out in Romania, classification of agricultural tractors, the main machinery and equipment used in the work done for agricultural crops.

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WATER REQUIREMENTS FOR MAJOR CROP PRODUCTION UNDER CLIMATE CHANGE IN EGYPT
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الاحتياجاتالمائيةلإنتاجالمحاصيلشعبيةفيظلتغير المناخفيمصر

Hesham, A. Farag[1)], Tarek H. Mohamed[1)], M.A. EL-ATAR[1)],
Hazem Sayed Mehawed[1)], Hanafi A.Radwan[1)], Samir M. Saleh[2)]
[1)]Agricultural Engineering Research Institute, Agricultural Research Center (ARC), Cairo-Egypt;
[2)]Central Laboratory for Agricultural Climate, Egypt
E-mail: hesham@aenri.org

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ABSTRACT

Global climate change has serious impact on water resources and agriculture in the future. The aim of this research was to calculate water requirements for maize, wheat and sugarcane grown in 5 governorates in Egypt under current climate and under ongoing climate change scenario up to 2100. The results indicated that water requirements for maize, wheat and sugarcane will increase by 12%–18% compared to the current water use depending on governorate location, while the applied irrigation amount is expected to increase in all governorates under climate change water requirements. This study investigates the projected changes in evapotranspiration and irrigation water demand for maize, wheat, sugar cane crops in Middle and Upper Egypt. The average air temperature, as statistically downscaled and compared with the current climate, was defined in the period 1971–2000. FAO-56 Penman-Monteith equation was used to estimate ETo by using the climate data. Evapotranspiration is estimated based on the predicted maximum and minimum using the RCPs scenarios (RCP3.0 – RCP4.5 – RCP6.0 and RCP8.5) during three time series (2011-2040, 2041-2070 and 2071-2100). The obtained results revealed that the maximum and minimum air temperatures were increased under all RCPs scenarios compared to current data. Moreover, the RCP8.5 had the highest maximum and minimum air temperature compared to the other RCPs scenarios. It was found that for all future periods the annual evapotranspiration will increase for the all agro-meteorological zones by uneven values. The main results in this study revealed that ETo significantly increased in different tested time series compared to current ETo values. The values of ETo in long term (2071-2100) were higher than in short (2011-2040) or mid-term (2041-2070) with respect to the current situation. The highest ETo values were predicted in this study by RCP8.5 during the 2071 – 2100 time series in the Upper Egypt region. The estimation of water requirements of the major crops in different agro-climatic zone show that winter season had the highest cultivated area with wheat followed by summer season. Upper Egypt region has the largest cultivated area of maize and sugar cane during different cultivation season. Total water requirements (WR) for maize, wheat and sugar cane during the different cultivating seasons revealed that WR will increase under all scenarios in comparison with the current conditions. The highest water use efficiency was recorded in the Upper Egypt climatic zone during the winter season in 2015. Winter season gave the highest water use efficiency (WUE) under current and future conditions. Moreover, all RCPs scenarios had lower WUE than the current conditions during different time series. Regardless of the seasons, the RCP8.5 gave the lowest WUE in comparison with the other RCPs scenarios. This paper suggested an adaptation options for better water management for maize, wheat and sugar cane crop in Middle and Upper Egypt region, such as Gated pipe system consuming total water budget in Middle and Upper Egypt.

الاحتياجات المائية للمحاصيل الرئيسية تحت ظروف التغير المناخى فى مصر

يشكل تغير المناخ العالمي آثار خطيرة على الموارد المائية والزراعة في المستقبل. و يهدف هذا البحث إلى حساب الاحتياجات المائية لمحاصيل الذرة والقمح وقصب السكر في 6 محافظات في مصر في ظل المناخ الحالي وتحت سيناريو تغير المناخ حتى عام 2100. وأشارت النتائج إلى أن الاحتياجات المائية للذرة والقمح وقصب السكر ارتفع بنسبة 12٪ -18٪ مقارنة مع استخدام المياه الحالية اعتمادا على موقع المحافظة، حيث من المتوقع أن يزداد الاحتياجات المائية في جميع المحافظات تحت ظروف تغير المناخ. يؤدى الى التغيرات المتوقعة في البخر والطلب على مياه الري لمحصول الذرة ، محصول قصب السكرو القمح فى مصر الوسطى والعليا.وتغير درجة حرارة الهواء ومقارنها مع المناخ الحالي، الذي يعرف بأنه الفترة 1971-2000. واستخدمت منظمة الأغذية والزراعة معادلة 56 بنمان-مونتيث لتقدير البخر نتح باستخدام البيانات المناخية. ويقدر البخر على أساس الحد الأقصى المتوقع والحد الأدنى باستخدام سيناريوهات التغير المناخى (RCP3.0 - RCP4.5 - RCP6.0 وRCP8.5)خلال ثلاثة السلاسل الزمنية (2011-2040، 2041-2070 و 2071-2100). وكشفت النتائج أن درجات حرارة الهواء القصوى والدنيا وزادت في جميع سيناريوهات التغير المناخى مقارنة بالبيانات الحالية. وعلاوة على ذلك، كان RCP8.5 أعلى الحد الأقصى والحد الأدنى من درجة حرارة الهواء بالمقارنة مع السيناريوهات التغير المناخى ألاخرى. فقد وجد أن لجميع الفترات المقبلة سوف الى زيادة البخر السنوي لجميع المناطق الزراعية بقيم متفاوتة. وكشفت الدراسة أن هناك زيادة كبيرة للبخرفي مختلف السلاسل الزمنية مقارنة بقيم البخر الحالية. وكانت قيم البخر في المدى الطويل (2071-2100) أعلى من القصير (2011-2040) أو منتصف المدة (2041-2070) فيما يتعلق بالوضع الحالي. وكان من المتوقع الحصول على أعلى قيم البخر في هذه الدراسة من

قبلسيناريو التغير المناخى RCP8.5خلال السلاسل الزمنية 2071 - 2100 في منطقة مصر العليا. تقدير الاحتياجات المائية للمحاصيل الرئيسية في مختلف المناطق الزراعية المناخية تظهر زيارتها فى فصل الشتاء في منطقة مصر العليا المزروعة بالقمح وكذا موسم الصيف. مجموع الاحتياجات المائية (WR) لمحصول الذرة والقمح وقصب السكر ارتفع في جميع سيناريوهات التغير المناخى مقارنة مع الظروف الحالية. وسجلت أعلى كفاءة استخدام المياه في منطقة مصر العلياخلال فصل الشتاء في عام 2015. موسم الشتاء أعطى أعلى كفاءة استخدام المياه تحت (WUE) الظروف الحالية والمستقبلية. وعلاوة على ذلك، اعطت كل سيناريوهات التغير المناخى WUE أقل من الظروف الحالية خلال سلسلة زمنية مختلفة. بغض النظر عن فصول السنة، أعطى RCP8.5 أدنى WUE بالمقارنة مع السيناريوهات عمليات التغير المناخى الاخرى. وتشير هذه الورقة خيارات التكيف لتحسين ادارة المياه على الذرة والقمح وقصب السكر الأوسط المحاصيل ومنطقة مصر العليا، مثل نظام الأنابيب المبوبة في مصر الوسطى والعليا

INTRODUCTION

Egypt is characterized by limited water and soil resources parallel with high population rate. Irrigation water management has become very important task to be implemented in Egypt due to the prevailing conditions of water scarcity. This situation creates challenges for agricultural scientists to manage water efficiently under Egyptian conditions. Egypt currently faces a tight water future (*Sanchez and Swaminathan, 2005*). The water gap in Egypt will reach 21.0 billion m^3 by the year 2025 even in the absence of climate change with water competition increasing (*El-Raey, 1999*). In Egypt the production of wheat is 7.97 million tons from 1.23 million ha (*FAOSTAT, 2009*). Wheat production is affected by different factors such as climatic condition, irrigation and soil fertility. The expansions of the cultivated areas are continuously increasing and water irrigation is being the limiting factor. Irrigation and fertilization interactions are considered one of the most important factors for increasing production (*Shaaban, 2006*). The average seasonal evapotranspiration of the winter wheat measured by the lysimeter was 452 mm. During the initial stage of the winter wheat, evapotranspiration was quite low due to low temperature, short sunshine hours, and weak radiation. The average observed value of evapotranspiration was 0.53 mm d^{-1}. During the development stage, the average value rose to 2.07 mm d^{-1} because of high evaporative demand and growing crops. During the middle development stage, the average evapotranspiration was 4.92 mm d^{-1} because of the fully developed crop canopies and high evaporative demand. The recorded highest daily water consumption was 9.0 mm. The late development stage lasted usually 10–20 days with an averaged evapotranspiration of 4.18 mm d^{-1} (Liu and Luo, 2010). Climate change will alter agricultural water use and potentially increasing demand. Effects on crop water use have been studied, under Egyptian conditions, in scattered and limited studies (*El Afandi, 2015; El-Marsafawy, 2001and Me-dany, 2001*) IPCC (2013) investigates the projected changes in water used for one of a major Egyptian crop (sugar cane) using the latest climate change projections. Sugarcane is grown mainly in Upper Egypt in the governorates El-Minia, Sohag, Qena, Luxor and Aswan. The total area cultivated with sugarcane in these main producing governorates was 311000 feddan in 2011. The total production was 15398006 ton with an average productivity of 49.5 ton per feddan in the same year. Traditional irrigation systems were not adapted for sugarcane cultivation with limited water. Against the background of the rapid decline in irrigation water potential, it appeared low water-use efficiency in the flood (conventional) method of irrigation (*Hanafy et al. 2008*). Also, sugar cane is one of the major strategic agricultural products in Egypt. It occupies the second place in terms of importance after wheat. Sugarcane is grown between 28°N and 24°N of the equator in Egypt. Optimum temperature for sprouting (germination) of stem cuttings is 32 to 38°C. Optimum growth is achieved with average daily temperatures between 22 and 30°C. Minimum temperature for active growth is approximately 20°C. (APRP, 1998).

Maize is one of the most important crops for the Egyptian national economy; it is main source of human food in some governorates. Maize production in Egypt significantly increased over the past three decades. The total cultivated area in 2012 was 679,508 hectares with average productivity of 6.87 ton/ha (*MLAR., 2013*).

The efficient use of water by modern irrigation systems is becoming increasingly important in arid and semi-arid regions with limited water resources. On the other hand, water supply is considered a limiting factor for crop production and food security in Egypt. The crop yield is affected by the magnitude of water supply shortage (*El-Hendawy, 2008*). Shortage of the available water supply caused decreasing the available soil water and then inhibits plant growth and productivity (*Porro et al, 1986*). Accordance of plant demands with the given climate, availability of water and environment conditions for agricultural crops are the most important preconditions for high yield if climate changes, as expected by atmospheric scientists, adversely impact crop production *(IPCC, 2001*). Egypt has to increase its reliance on food imports. The expected climate changes in Egypt according to the climate change scenarios will cause an increase in evapotranspiration depending on the climate region. The increase of ETo in the Delta region was between 2.4% to 16.2 %, in the Middle Egypt region between 5.9% to 21.1% and in the Upper Egypt region between

5.8% and 22.5% until 2100 as compared to current situation (*EEAA, 2002*). (*Farag et al, 2014*) Studied the RCP scenarios in different time series, they found that RCP 8.5 had the highest increased of air temperature compared to the other RCPs scenarios. Evapotranspiration increased significantly compared to current ET_o values. The highest ET_o values were projected in this study by RCP 8.5 during the 2071 – 2100 in the Upper Egypt region in comparison with Middle Egypt (*Abdrabbo et al, 2015*). It is recommended usage of FAO-Penman - Monteith Equation to calculate the crop-water requirements under Egyptian conditions. Four evapotranspiration equations were tested under current condition and for 2040 according to different RCP scenarios.

The study concluded that Penman - Monteith equation is considered the best equation for predicting evapotranspiration under different climate regions in Egypt. In 2002, the Egyptian Environmental Affairs Agency EEAA, reported that "Egypt is highly vulnerable to climate change impacts, maybe due to the large and tightly packed population and if climate changes makes Egypt climate drier, the pressures on agriculture would intensify". Water is one of the major sectors that face a lot of pressures under the current and future conditions because of Egypt's limited water resources. The main objective of this study was to estimate the water requirement for sugar cane, maize and wheat under RCP scenarios in different climate regions in Egypt.

MATERIAL AND METHOD

2.1 Representative Concentration Pathway (RCPs) scenarios:

ClimaScope is a data visualization engine providing data on the projected climate changes for a range of global greenhouse gas emission scenarios. Outputs are stamped with metadata on which GCM which carbon cycle was used, which emission scenario was used and the source of the data in order to provide traceability. The data come from peer-reviewed models linked together within the Community Integrated Assessment System (CIAS) developed at the Tyndall Centre for Climate Change Research within the School of Environmental Sciences at the University of East Anglia *(Warren et al., 2008; Mitchell et al., 2005and Osborn, 2009*).

2.2 Agro-climatic regions:

Egypt has been divided into several agro-climatic regions according to the average temperature values. The most important agro-climatic regions are: the Middle Egypt region represented by Menya governorate and the Upper Egypt region Represented by (Asyut, Sohag, Qena, Luxor and Aswan Governorate). These governorates were selected according to the highest cultivated area of sugar cane, wheat and maize during the last five years.

2.3 Climatic data:

The average agro-meteorological data were collected for the concerned governorates to calculate the average data for each agro-climatic zone. The maximum and minimum temperature in the current (1971 to 2000) and different time series [(2011-2040), (2041-2070) and (2071 - 2100)] for different RCPs scenarios (RCP2.6, RCP4.5, RCP6.0and RCP8.5) were downscaled from ClimaScope internet website http://climascope.tyndall.ac.uk/. The projected data was according to HadCM3, Bern model. Whereas, the daily historical data of relative humidity, wind speed, precipitation and solar radiation were collected from automated weather stations of the Central Laboratory for Agriculture Climate (CLAC) to calculate the evapotranspiration of each agro-climatic zone. The data from 1998 to 2013 for different governorates were collected by automated agro-meteorological stations of the all concerned governorates.

2.4 Evapotranspiration calculation:

Evapotranspiration was calculated, for both, current and future conditions for different agro-climatic regions using Food and Agricultural Organization (FAO) Penman-Monteith (PM) procedure, FAO 56 method, presented by Allen 1998. In this method, ETo is expressed as follows:

$$ET_o = \frac{0.408\Delta\,(R_n - G) + \gamma \frac{900}{T + 273} u_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34\,u_2)} \tag{1}$$

where:

ETo is the daily reference evapotranspiration (mm day-1), Rn is the net radiation at the crop surface (MJ m^{-2} day^{-1}), G is the soil heat flux density (MJ m^{-2} day^{-1}), T is the mean daily air temperature at 2 m height (°C), U 2 is the wind speed at 2 m height (m s^{-1}), es is the saturation vapour pressure (kPa), ea is the actual vapour pressure (kPa), is the slope of vapour pressure curve (kPa °C $^{-1}$) and γ is the psychometric constant (kPa °C $^{-1}$). Irrigation requirement for maize was estimated according to Allen 1998:

$$WR = [(ETo \times Kc \times IE) + LR] \times 4.2 \quad \ldots\ldots\ldots \ (m^3 / fed / day) \qquad (2)$$

where:

WR = irrigation requirement for crop m^3/ Feddan/ day Kc = Crop coefficient [dimensionless].
ETo = Reference crop evapotranspiration [mm/day].
LR = Leaching requirement LR (%) (Assumed 20% of the total applied water).
IE = irrigation efficiency for the irrigation system.
4.2 is a conversion factor transforming the estimate from millimetres per day to cubic meters per Fadden (4200 m^2) per day.
2.5 Water use efficiency (WUE):
The WUE was calculated according to F.A.O., 1982 as follows:
The ratio of crop yield (y) to the total amount of irrigation water use in the field for the growth season (WR),

$$WUE\ (Kg/m^3) = Y(kg)/WR\ (m^3) \qquad (3)$$

RESULTS

Trend of seasonal average air temperature:

Data presented in Fig. (1) illustrate the average seasonally trend of the average air temperature for Middle and upper Egypt region under current (1971- 2000) and future (2011-2040, 2041-2070 and 2071 - 2100) conditions for the concerned Menya governorate (Middle Egypt). Data show that the seasonal average temperature in the Middle Egypt increased for all tested RCPs scenarios under all-time series (2011-2040, 2041-2070 and 2071 - 2100) compared to current seasonal average temperature (25.6°C). The highest seasonal air temperature values were projected under RCP8.5 scenario during the all-time series (2011-2040, 2041-2070 and 2071 - 2100), while the lowest seasonal average air temperature values were found under the RCP2.6 scenario during the different time series. The results also indicated that the range of seasonal average air temperature values was 26.9 (under RCP2.6 at 2011-2040) to 31.3°C (under RCP8.5 at 2071-2100). The same trend was found in the Upper Egypt agro-climatic regions Fig. (2). Regarding the upper Egypt region (Represented by Asuyt, Sohag, Qena, Luxor and Aswan Governorate) the range of seasonal average air temperature values was ranged by 28.3 (under RCP2.6 at 2011-2040) to 35.6°C (under RCP8.5 at 2071-2100). The highest seasonal average air temperature under current and future RCPs scenarios was found in the Qena Governorate (representing Upper Egypt region). The range of seasonal average air temperature °C values was ranged by 30.9 (under RCP2.6 at 2011-2040) to 35.6°C (under RCP8.5 at 2071-2100). The difference between the highest average air temperature (35.6°C) and the current seasonal average air temperature (29.8) was about 5.8 °C. In addition, recent climatologically studies found that surface air temperature increased from 1850 to 2005 by 0.76ºC and the linear warming trend over the last 50 years is determined by 0.13ºC per decade (*IPCC, 2007, Moratiel et al 2011 and Abdrabbo 2013)*.

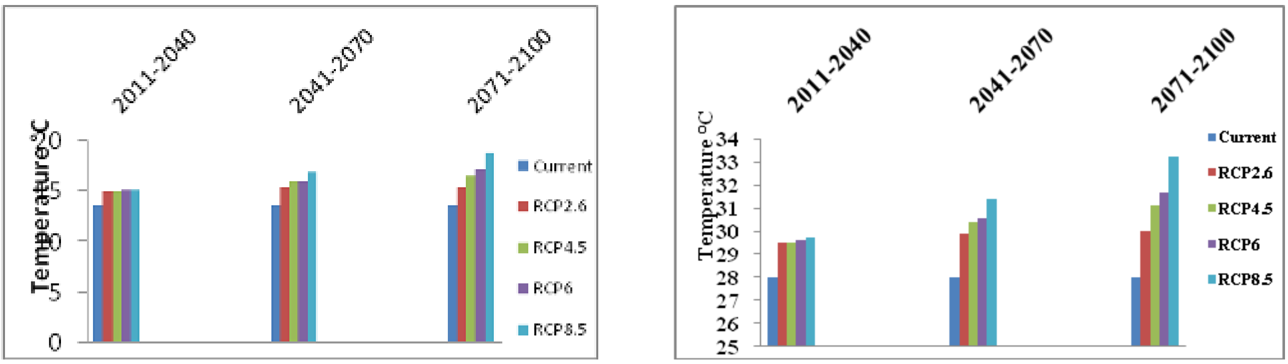

Fig. 1 - The average seasonal average air temperature in Middle Egypt region under current and future conditions for different RCPS scenarios and time series.

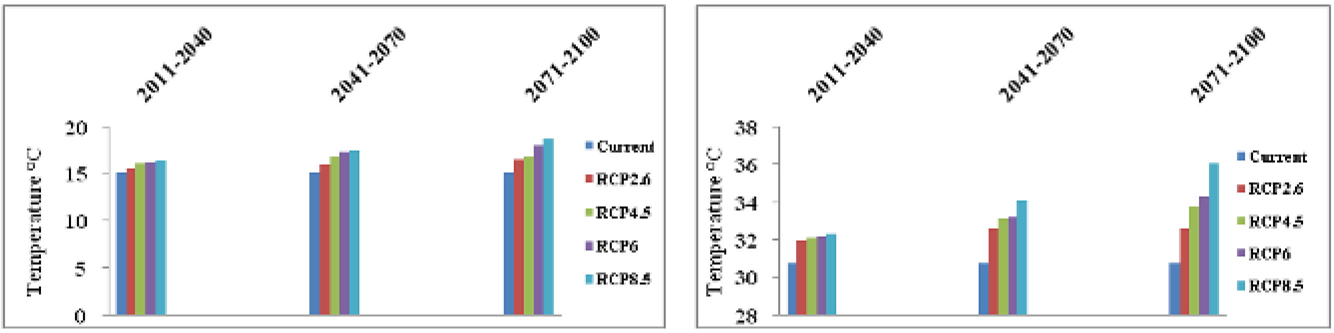

Fig. 2 - The average seasonal average air temperature in Upper Egypt region under current and future conditions for different RCPS scenarios and time series.

Evapotranspiration (ETo): ETo data values were estimated for the Middle and Upper Egypt region during the maize and sugar cane summer season under current and future conditions (2011-2040, 2041-2070 and 2071 - 2100). Regarding the monthly ETo values, the highest ETo of the Middle and upper Egypt region in the current situation was estimated during the June month (6.06 mm/day). The ETo values during under all RCPs scenarios (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) were higher than the current values.

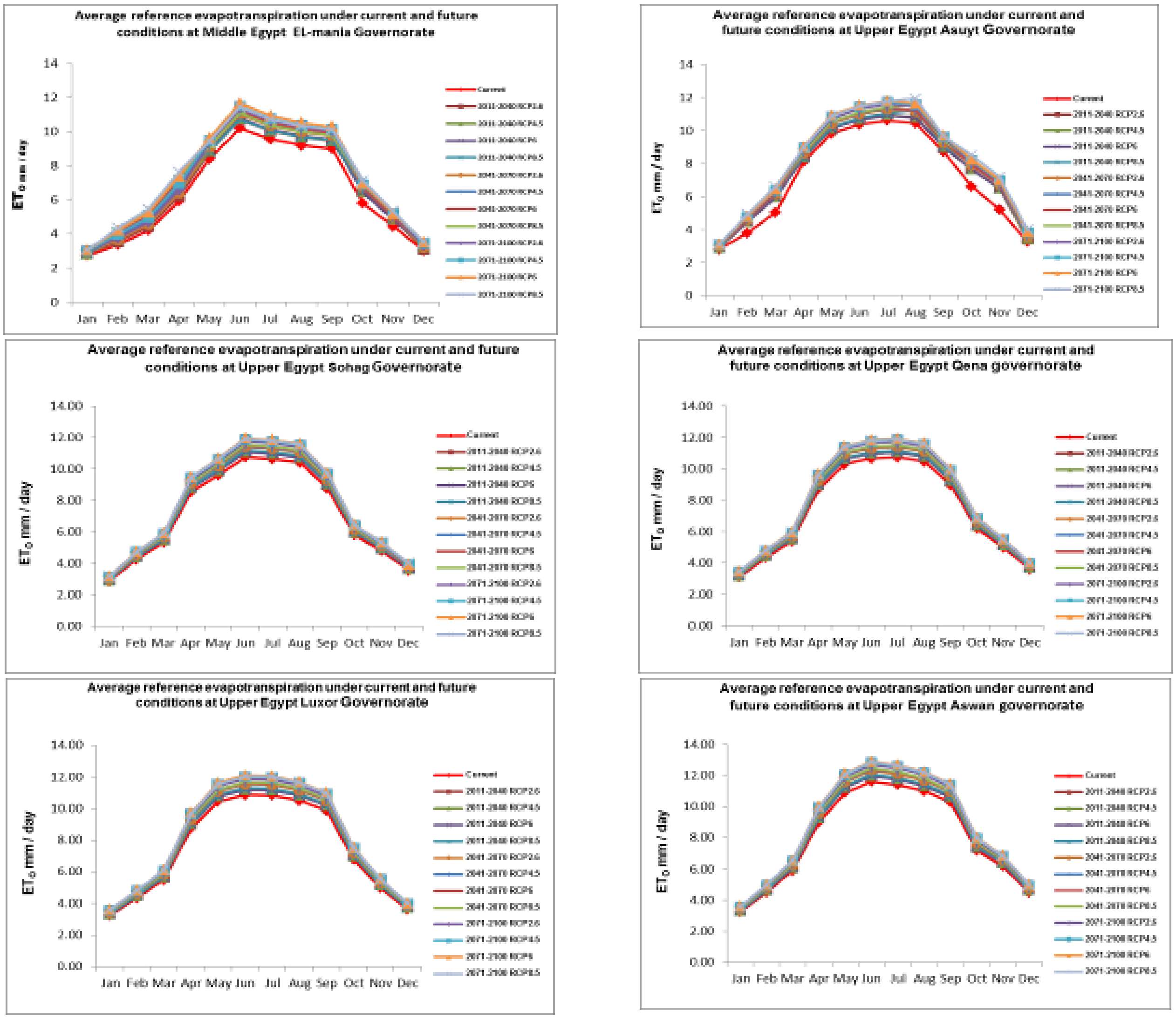

Fig 3 - Average reference evapotranspiration (mm) under current and future conditions at Middle and Upper Egypt region governorate

Generally, the RCP8.5 scenario had the highest ETo values during followed by RCP6; while the lowest ETo values were estimated under RCP2.6 scenario. Fig. (3) illustrate the results of the ETo calculations for the Middle Egypt and upper Egypt region under studied scenarios of climate change current and future. The highest monthly ETo in the Middle Egypt under the current situation occurs during June (11.41 mm/day) under RCP8.5 scenario, while the lowest ET occurs in January (2.93 mm/day) under RCP2.6. scenario for Menya governorate. The highest monthly ETo in the upper Egypt governorates under the current situation occurs as follow The highest monthly ETo occurs during June (11.92 mm/day) under RCP8.5 scenario, while the lowest ET occurs in January (3.02mm/day) under RCP2.6 for Sohag governorate.

The highest monthly ETo occurs during June (11.92 mm/day) under RCP8.5scenario, while the lowest ETo occurs in January (3.02mm/day) under RCP2.6 for Qena governorate. The highest monthly ETo occurs during June (12.05 mm/day) under RCP8.5 scenario, while the lowest ET occurs in January (3.44 mm/day) under RCP2.6 for Luxor governorate. The highest monthly ETo occurs during June (12.86 mm/day) under RCP8.5 scenario, while the lowest ET occurs in January (3.44mm/day) under RCP2.6 for Aswan governorate. The percentage of ETo increase ranged by 5.9 (RCP6.0 at 2011-2040), 13.7% (RCP 6 at 2041-2070) and 20.6% (RCP 6 at 2071-2100) compared to current conditions.

Generally, the estimated Eto values revealed that there are uneven increasing values of ETo under RCPs scenarios. The same trend was found by IPCC, 2007 who expected the increase of ETo in the Middle Egypt region by 7 to 15% and in the Upper Egypt region by 9 to 19% up to the year 2100 as compared to water requirements for major crop under current and future conditions.

Data in Table (1, 2 and 3) show the wheat as winter crop and sugarcane and maize as summer crop water requirements values in the Middle and Upper Egypt under current and different RCPs scenarios. The annual water requirements (WR) trend had the same trend in the all studied climatic regions such as ETo. Upper Egypt had the highest water requirement per feddan for sugar cane, maize and wheat crop compared to the other climate regions. There was difference between estimated water requirement values under climate change compared to the current values. The estimated water requirement is gradually increasing with time series (2011-2040, 2041-2070 and 2071 - 2100) under different RCPs scenarios to reach the maximum predicted values during 2071 – 2100.

A. Water requirements and water budget for wheat crop under current and future conditions:

Fig. (4) and (Table 1) show the total cultivated area (feddan) with wheat in six governorates at middle and Upper Egypt region during cultivation season .The Total water requirement for wheat will increase under all scenarios in comparison with the current conditions. Total water requirement in Middle and Upper Egypt show that Upper Egypt higher than Middle and due to the temperature. Total water requirement for wheat in current condition about 833.4 million cubic meters will be about 965.5 under RCP8.5 in the 2071 – 2100 time series. It is average Egypt need 132 million more of water to cultivate the same cultivated area in the current conditions cubic meters represents (16 % of the total water budget).

B. Water requirements and water budget for maize crop under current and future conditions:

Fig (5) and (Table 2) show the total cultivated area (feddan) with maize in six governorates at middle and Upper Egypt region during cultivation season .The Total water requirement for maize will increase under all scenarios in comparison with the current conditions. Total water requirement in Middle and upper Egypt show that Upper Egypt higher than Middle and due to the temperature. Total water requirement for wheat in current condition about 1793 million cubic meters will be about 2166 under RCP8.5 in the 2071 – 2100 time series. It is average Egypt need 373 million more of water to cultivate the same cultivated area in the current conditions cubic meters represents (20.8 % of the total water budget).

Table1

Total water requirement and water budget (cubic meter) for wheat area in winter season under current and future conditions for middle and upper Egypt.

Governorate	Area(Feddan)	Current* m^3/fed	future ** m^3/fed	TOTAL (m^3) Flooding *	TOTAL (m^3) Flooding **
Menia	225456	1690	2010	381020640	453166560
Asyut	91469	1780	2050	162814820	187511450
Sohag	126983	1830	2025	232378890	257140575
Qena	18943	1860	2110	36256902	43568900
Luxor	1240	1890	2177	2306400	2616400
Aswan	9870	1914	2300	18654300	21486990
Total	473961			833431952	965490875
Average		1827	2112		

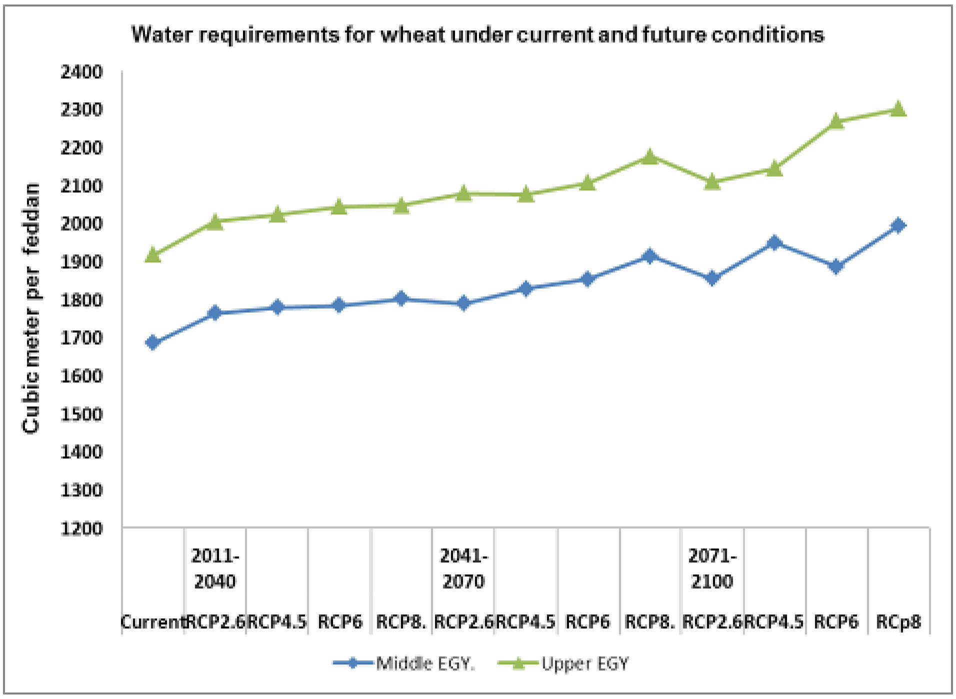

Fig. 4 - Water requirements (cubic meter per feddan) for wheat in winter season under current and future conditions for middle and upper Egypt.

C. Water requirements and water budget for sugar cane crop under current and future conditions:
(Table 3) shows the total cultivated area (feddan) with sugar cane in six Governorates at middle and Upper Egypt region during cultivation season. The total water requirement for sugar cane will increase under all scenarios in comparison with the current conditions. Total water requirement in Middle and upper Egypt show that in Upper Egypt it is higher than in Middle Egypt due to the temperature. Total water requirement for wheat in current condition is about 3878 million cubic meters and it will be about 4653 under RCP8.5 in the 2071 – 2100 time series. The average Egypt water need is of 775.6 million more to cultivate the same cultivated area taking into account that in the current conditions cubic meters represent 20% of the total water budget. According to Table 3, options can be adopted for better water management for sugar cane crop in Middle and Upper Egypt regions, using Gated pipes.

Table 2

Total water requirement (cubic meter per feddan) for maize in summer season under current and future conditions for Middle and Upper Egypt.

Governorate	Area(Faddan)	Current* m^3/fed	future ** m^3/fed	TOTAL (M^3) Flooding *	TOTAL (M^3) Flooding **
Menia	250456	3639	4279	911409384	1071701224
Asuyt	83469	3816	4745	318517704	396060405
Sohag	124983	3835	4756	479309805	594419148
Qena	19933	3900	4824	77738700	96156792
Luxor	56	3960	4938	221760	276528
Aswan	1492	4080	5075	6087360	7571900
Total	480389	3872	4770	1793284713	2166185997

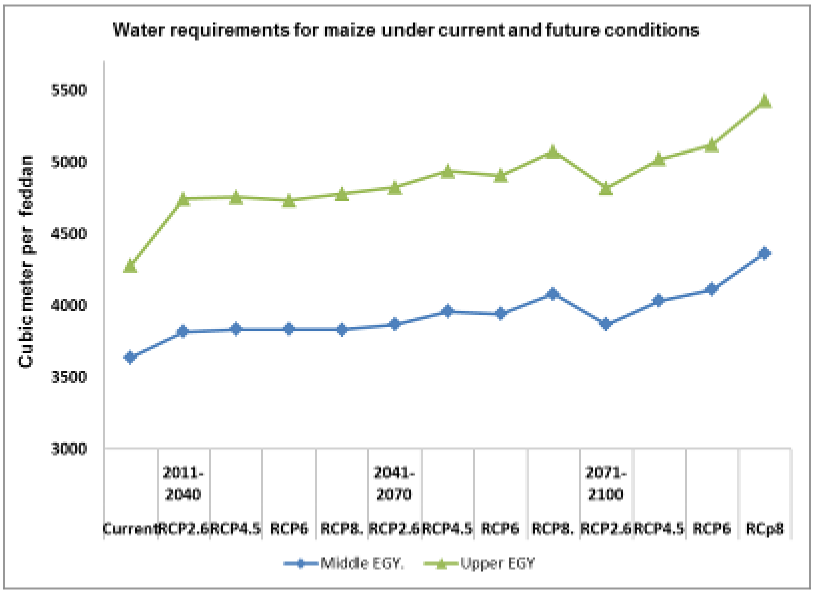

Fig. 5 - Water requirement (cubic meter per feddan) maize in summer season under current and future conditions for middle and upper Egypt.

Table 3

Total water requirement (cubic meter per feddan) for sugar cane in summer season under current and future conditions for Middle and Upper Egypt.

Governorate	Area (Faddan)	Current* m^3/fed	future ** m^3/fed	TOTAL (m^3) Flooding *	TOTAL (m^3) Flooding **	TOTAL (m^3) Gated pipe*	TOTAL (m^3) Gated pipe**
Menia	38757	10500	12600	406948500	488338200	0	0
		7800	9360	0	0	302304600	362765520
Asuyt	1181	11200	13440	13227200	15872640	0	0
		8200	9840	0	0	9684200	11621040
Sohag	15663	11850	14220	185606550	222727860	0	0
		8600	10320	0	0	134701800	161642160
Qena	114247	12450	14940	1422375150	1706850180	0	0
		8960	10752	0	0	1023653120	1228383744
Luxor	62109	12900	15480	801206100	961447320	0	0
		9300	11160	0	0	577613700	693136440
Aswan	79143	13250	15900	1048644750	1258373700	0	0
		9800	11760	0	0	775601400	930721680
Total	311100			3878008250	4653609900	2823558820	3388270584

Water use efficiency for major crops under current and future conditions:

Fig (6) shows WUE for sugar cane, maize and wheat under current and future conditions during summer and winter season. The lowest water use efficiency was recorded in the Upper Egypt climate zone. Moreover, all RCPs scenarios had lower WUE than the current conditions during different time series. Regardless of the climatic zones, due to rising air temperature above the current averages, reduction in yield led to reduce WUE for the maize under the climate change conditions.

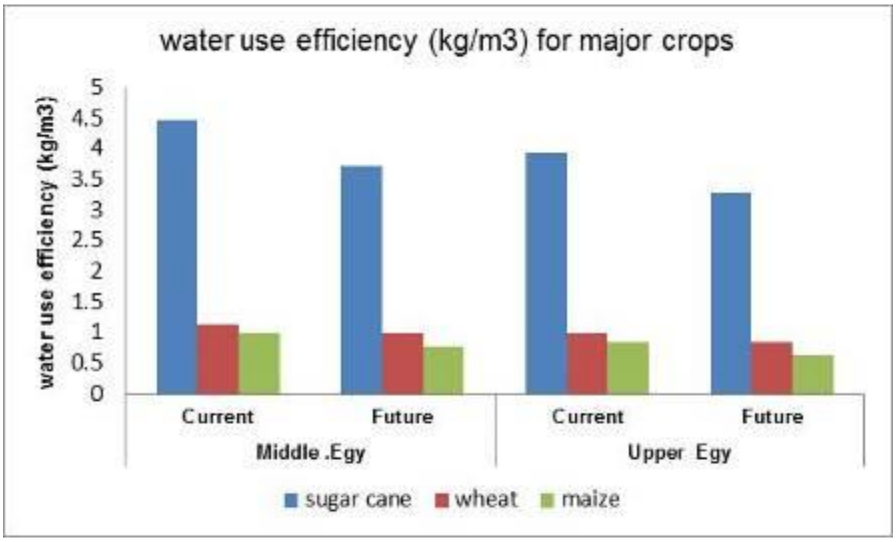

Fig. 6 - Water use efficiency for major crops under current and future conditions

CONCLUSIONS

Irrigation water requirement and water budget increased depending on climate region and climate change scenarios. The expected climate changes in Egypt according to the RCPs scenarios will cause an increase in annual ETo depending on the climate region. The increase in the Middle Egypt region by an average of 16% and in the Upper Egypt region by an average of 20% the water requirements of major crops in Egypt increased based on the increase in ETo. The water budget for major crops under the 2071 – 2100 time series will increase compared to current conditions for cultivating the same area of major crops. Further studies are needed to estimate the national water budget for all crops under climate change conditions.

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COMBINED EQUIPMENT FOR DIGGING, RESTORING AND CLEANING NEARBY FORESTRY ROADS DITCHES
/
ECHIPAMENT COMBINAT PENTRU SĂPAT, REPROFILAT ŞI CURĂŢAT ŞANŢURILE ADIACENTE DRUMURILOR FORESTIERE

Ph.D. Eng. Tudosoiu C.[1] Eng. Moise S.S. [2], Ph.D. Eng. Ganea Christu I. [2]
INCDS *„Marin Drăcea"* [1], INMA Bucharest [2]
Tel: 0720835156; E-mail: catalintudosoiu@yahoo.com

Keywords: *equipment, plow, levelling blade, forestry road, ground*

ABSTRACT

The paper refers to combined equipment for digging, restoring and cleaning ditches nearby forestry roads with a road system composed of stone layers, in order to ensure the evacuation of rainwater accumulated on the road territory. The equipment works in aggregate with an average power tractor and is composed of a frame, on which is mounted an agricultural plow with an unbalanced helical mouldboard, a blade for pushing the soil extracted by digging and a quadrilateral deformable mechanism allowing the blade to operate in the vertical plane following the road profile platform.

REZUMAT

Lucrarea se referă la un echipament combinat pentru săpat, reprofilat şi curăţat şanţurile limitrofe platformei drumurilor forestiere al căror sistem rutier este compus din straturi de piatră, în vederea asigurării evacuării apei meteorice acumulate pe ampriza drumului. Echipamentul lucrează în agregat cu un tractor de putere medie şi este compus din dintr-un cadru, pe care se montează un plug agricol cu cormană elicoidală dezaxată, o lamă de împingere a solului extras prin săpătură şi un mecanism patrulater deformabil care permite funţionarea lamei în plan vertical cu urmărirea profilului platformei drumului.

INTRODUCTION

Climate changes manifested at global level, especially those of the last decade, have led to striking manifestation of two seasons: winter - spring, summer – autumn; the duration of spring and autumn is minimum. There is precipitation like rain, with high flow rates, taking place in a short period of time, which gives them a torrential character. The power of water absorption into the soil is conditioned by its retention capacity, but the phenomena of saturation and water (rain) drain to the surface of the land cause soil erosion. The same phenomenon occurs in the case of auto forestry roads.

The existence of water accumulations, due to rainfall on roads territory surface due to the failure of drain collection system and evacuation, respectively ditches and / or gutters, lead to the formation of small ravines and small holes that damage and erode their road system [1]. In addition, the circulation of road trains carrying wood, provided in the forestry management, leads to increased degradation due to existing surface flow and pressure of the rolling system, resulting in a final sum of damages that grow exponentially. The most common degradations manifested on the auto forestry roads platform are represented by the lack of ditches that generate chain degradation.

Water stationing on road platform surface causes degradation on its superstructure, because water infiltrates in the road system and the erosion phenomenon appears.

Ditches are executed in all areas of road excavation, both along the embankments less than 0.5 m and in areas where the water accumulates [2], [3] and are designed to collect and drain water from rainfall fallen on the road platform and surrounding slopes. The geometric shape of ditches may be trapezoidal or triangular with a depth between 0.3 ÷ 0.5 m, depending on the volume of water to be evacuated. Ditch basis (ditch background) must be situated at least 0.1 ÷ 0.2 m below the bottom of the road system. The longitudinal slope of ditches followed, generally, the road slope and should be of at least 0.5% in order to ensure a normal flowing of the water [6], [7]. In the event that the land is rocky and uneven or collected water flow is reduced, are provided gutters whose cross section can be triangular or arc of a circle form. Water drainage from ditches and gullies is made, usually, by means of bridges and culverts spaced between 100 ÷ 400 m, according to the local conditions.

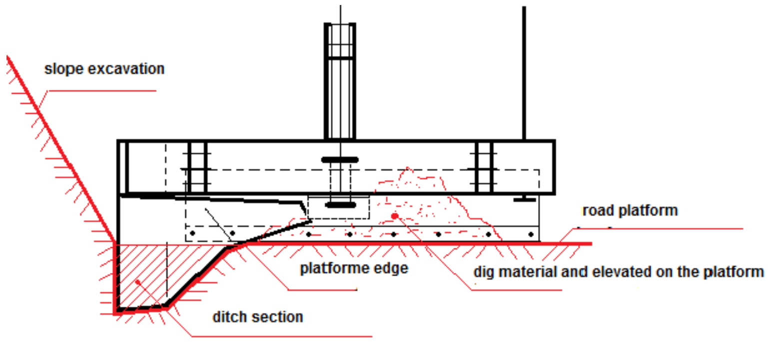
Water accumulation on the surface of the road platform leads to degradation caused by frost - thaw [8], as there are irregular bumps that affect the entire road system and to remedy them require rebuilding the entire road system and replacing the destroid soil with granular material. During the year, ditches clog and change their profile by depositing alluvium brought by water [2]. Maintenance follows to give diches the original shape and profile and to allow water flow in good conditions. [13]

Maintenance and repair, for all categories of roads involves unblocking, unclogging, cleaning and reshaping ditches, culverts and drainage channels [6], [7], moving the earth removed from ditches, digging drains or channels with lateral discharge of water from drain ditches and correcting the longitudinal part of ditches that have a big slope.

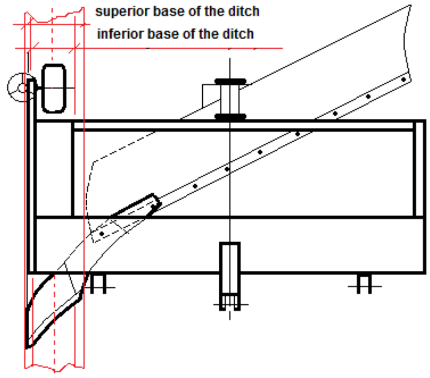
MATERIAL AND METHOD

Ditches can be made mechanically using trenchers as digging equipment [4], but the disadvantage is that they have a chain bucket digging placed in the extension of the longitudinal axis of the energy source [8], leading to increased width of road footprint and in addition they cannot achieve ditches whose transversal profile is trapezoidal or triangular as provided in the *Standard on designing forestry roads,* [12].

To preserve dimensions of the geometric elements referred to the main and secondary roads, without increasing the road footprint, respectively its platform, was designed and built by INCDS, an experimental model for the roads construction, towed, of agricultural plow type, for digging, cleaning and reshaping ditches nearby forestry roads platform, whose principle is shown in Figure 1:



a.



b.

Fig.1 - Work principle

a. *frontal view;* **b.** *top view*

RESULTS

Combined equipment for digging, restoring and cleaning ditches (Fig. 2) is composed of a frame (1), a digging body (2) agricultural plow type with helical unbalanced moldboard, an assembly (3) for supporting and fixing the digging body, a blade (4) pushing the soil is extracted by digging (in the side surface of the platform), a quadrilateral deformable mechanism (5), a support wheel (6) belonging to the pushing blade assembly, another wheel (7) fixing the digging depth equipped with adjustment mechanism (8) depth and a tensioning mechanism by pressing (10) designed to drive of the pushing blade.

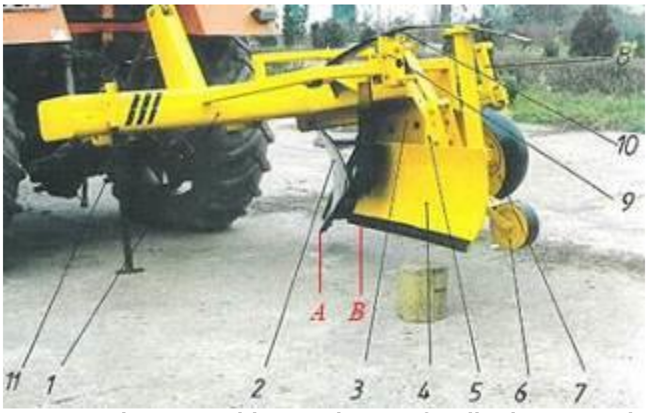


Fig.2 - Combine equipment for digging, restoring and cleaning near by forestry roads ditches – experimental model

Technical characteristics of combined equipment for digging, restoring and cleaning ditches:

- driving source: universal medium power tractor;
- mode of transport: carried;
- work mode: towed;
- dimensions of trapezoidal profile digging / cleaning:
    - small base: 30 cm;
    - large base: max. 50 cm;
    - height: 30 – 35 cm;
- an overall quota:
    - length: 2100 mm;
    - width: 1800 mm;
    - height: 1500 mm;
- machine mass: 680 kg;
- total length of rolling: 6200 mm;
- total mass of rolling: 3850 kg;
- productivity: W_{plow} = 2,4 km/day(experimental results under production conditions, for effective work time 6 hours/day);

Digging the ditch is executed through several successive passages of tractor-equipment until it achieves its desired geometrical characteristics. During adjustment the thickness of the digging work is done by operating the screw mechanism 8, which raises / lowers the fixing wheel 7 of digging depth. A second adjustment on the cutting / attack angle is obtained by actuating the screw located on upper brace found in tractor equipment. The soil is cut by ploughshare and is taken and lifted by the moldboard, whose unloading is on the edge of the road platform [8]. From the edge of the road platform, the soil is picked by the blade 4 and transported to the center of the platform. The resulting material due to multiple passes of equipment on the same path of thre ditch is taken and discharged at a sufficient distance located from the edge of the ditch, nearby the edge platform of the road so it does not fall by gravity into the ditch already dug.

CONCLUSIONS

The need for such equipment lies in the fact that forestry roads nearby ditches are often clogged with plant residues (leaves, branches etc.) and / or alluvial particles. In the case of heavy rainfall and some slopes with increased downhill, there are situations in which material within a slope not sufficiently consolidated collapses or at the base of the slope dejection cones are formed covering and obstructing (main roads) and profile drainage ditch, without being ensured meteoric water evacuation and draining.

Following the research project resulted:

- the creation of an experimental model;
- laboratory / field tests and operating conditions tests;
- patent application submitted at OSIM, with no. A-00413/2016.

The advantages of introducing, in different sectors of activity, this type of combined plow for digging restoring and cleaning nearby ditches consist in:

- the possibility of making several different types of combined operations, the technological maintenance and / or repair of forestry roads;
- the fact that the machine works unbalanced, the digging taking place on one of the paths in trances driving the tractor tires, having the ability to work in close proximity of the slopes, while enrolment dimensions road footprint;
- increasing productivity while decreasing labour;
- decreasing the financial effort of economic agents occasioned by purchasing a ditch digging machine that holds its own energy source drive;
- expansion realization of drain and evacuation ditches by local councils holding the administration of cobbled roads;
- possibility of using the equipment in the winter season, when there is precipitation such as snow, which can block the ditch section of meteoric waters evacuation.

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ASPECTS REGARDING THE COMPRESSION RESISTANCE OF GEOSYNTHETICS USED IN BUILDING MUNICIPAL SOLID WASTE LANDFILLS
/
ASPECTE PRIVIND REZISTENŢA LA COMPRESIUNE A GEOSINTETICELOR UTILIZATE ÎN CONSTRUCŢIA DEPOZITELOR DE DEŞEURI MUNICIPALE

Prof.Ph.D.Eng. Voicu Gh.*[1)], As. Ph.D. Eng. TomaM.L.[1)], Lect.Ph.D.Eng. TudorP.[1)], PhD.Eng. Ipate G.[1)]
[1)]University"Politehnica" of Bucharest, Faculty ofBiotechnical Systems Engineering/Romania;
Tel: 0724715585; E-mail: ghvoicu_2005@yahoo.com

Keywords: *geosynthetics, deformation force curve, loading-unloading, regression laws, correlation coefficient*

ABSTRACT
Choosing the physical characteristics of geosynthetics used in the construction of municipal waste landfills must be carried out according to the functions they must fulfil - sealing, filtration, protection. Since the geomembranes are subjected to significant compressive stress, and tearing by sticking against hard objects, experimental determinations are necessary to be made both in laboratory and in-situ for the determination of its resistance over time. The protection of the geomembranes shall be made, usually with geotextile, and its characteristics must also be established by experimental determinations. This paper presents the results of measurements of the laboratory tests carried out both on a membrane of HDPE and a nonwoven PP geotextile, while the values of their deformation according to the pressing force led to the identification of the best correlate experimental data by regression curve analysis.

REZUMAT
Alegerea caracteristicilor fizice ale geosinteticelor utilizate în construcţia depozitelor ecologice de deşeuri menajere trebuie efectuată în funcţie de funcţiile pe care trebuie să le îndeplinească – etanşare, filtrare, protecţie. Având în vedere că geomembranele sunt supuse unor solicitări importante de compresiune, dar şi de rupere prin înţepare cu obiecte contondente, este necesar a fi efectuate determinări experimentale, atât în laborator, cât şi in-situ, pentru stabilirea rezistenţei acestora în timp. Protecţia geomembranelor se realizează, de obicei, cu geotextil, iar caracteristicile acestuia trebuie, de asemenea, stabilite prin determinări experimentale. În lucrare se prezintă rezultatele unor determinări de laborator efectuate, atât pe o geomembrană din HDPE, cât şi pe un geotextil neţesut din PP, iar valorile deformaţiei acestora în funcţie de forţa de apăsare au condus la identificarea prin analiză de regresie a curbei de variaţie care corelează cel mai bine datele experimentale.

INTRODUCTION
In the municipal landfill construction, but also for land improvement works, geosynthetics are materials with a wide use and can perform several functions: sealing, filtration, drainage, protection, stability slopes etc.*(Giroud et al, 1992; Koerner R.M., 1998; Mandal J.N., 2014; Richardson and Zhao, 2009; Zornberg and Christopher, 1999)*.

Geosynthetics are materials made from polymers or polymer additives with various components for characteristics diversification and properties improvement. They can replace many conventional materials, with the same performance, showing guaranteed uniform properties over the entire surface. They are easy to apply, with reduced labour and costs, contributing to significant savings in materials and energy, but they also reduce the impact of construction on the environment. They also can work under load immediately after installation, and their price is comparable to the price of conventional materials.

However, geosynthetics are sensitive to contact with traditional materials (hard and tough) because they are, in general, thin and lightweight materials, thus they can be easily damaged due to the specialized structure, which makes them usable only for the purpose for which they were designed and tested in laboratory and field. They are often sensitive to UV radiation and present an aging phenomenon more pronounced than traditional materials *(Narejo et al, 1996*).

The main polymers used for obtaining geosynthetics are:
- polypropylene (PP, 0.895 – 0.910 g/cm^3, melting temperature 155 – 175°C);
- low (LDPE), medium (MDPE) and high density (HDPE) polyethylene;

- polyester (PES, density 1.38 g/cm^3, shrinkage in hot water 5–9%);
- polyamide (PA);
- polyvinyl chloride (PVC, 1.38–1.55 / 1.16–1.35 g/cm^3).

Of all geosynthetics, geomembranes and geotextiles are largely employed in municipal landfills construction and beyond. In general, geomembranes act as a barrier (seal), while geotextiles have the role to protect the membrane or act as drainage *(Wilson-Fahmy et al, 1996; Narejo et al, 1996; Koerner et al, 1996; Rowe R.K., 2012)*.

Fig.1 – Examples of geomembrane and protection geotextile utilisation in the construction of waste landfills

The protective properties, thickness and type of material that geosynthetics are made of significantly require a rational design method.

In the works mentioned above, the authors present the theoretical approach of thinning the membrane in contact with the rounded edges of the stone layer beneath it, using the theory of membrane tension and results of laboratory experiments using a special apparatus and stone or truncated push con, during short and long periods of time. Theoretical study conducted for the geomembrane with or without geotextile protection shows the need for a material protection when membrane is applied. Furthermore, the authors show that the characteristics of the protuberant object and of the protection material are important in designing structures with geomembranes *(Wilson-Fahmy et al, 1996)*.

In the experiments, high density polythene (HDPE) with 1.5 mm thickness (yield load 23 kN/m, 18% yield strain, puncture load 0.44 kN according to ASTM D 4885) and various non-woven textile, with different specific weights (per unit area) were tested. Using the results of the testing program, a design methodology for determination of the geotextile's necessary specific mass to geomembrane's puncture protection for a certain safety coefficient or vice versa has been developed *(Narejo et al, 1996)*. Thus, it was found that the puncture resistance of geomembranes increases with increasing mass per unit area of the geotextile protection for all of the prominent bodies heights. Increasing the protuberances height decreases the geomembrane's perforation resistance, regardless of geotextile protection's specific mass; puncture resistance is inversely proportional to the square of the protrusion's height. Particularly important is the protuberance's shape, the puncture resistance of subrounded stones or rounded was two, respectively four times higher than the puncture resistance using the cornerstones (sharp). Also, the puncture resistance of a geomembrane laid on a bed of stones is two times higher than laid on the isolated rocks of the same height with the previously ones. At the same time, the membrane puncture resistance decreases with time and the time impact is more pronounced with decreasing specific weight of the geotextile protection and increase the protuberance height underneath the membrane.

The maximum permissible pressure on the geomembrane, depending on the height of a single protuberance underneath the geomembrane may be determined by the relation:

$$p_{adm} = 450\,\frac{M_{gtx}}{H^2} \geq 50\ \text{kPa} \tag{1}$$

where M_{gtx} is the specific mass of the geotextile protection (g/m^2) and H is protuberance's height (mm).

Minimum pressure of 50 kN corresponds to a failure pressure of a 1.5 mm thickness HDPE geomembrane, without any protective material *(Narejo et al, 1996)*.

Therefore, the puncture resistance of the geomembrane determine required characteristics of the protection material, both in the case of coatings and to the construction of the landfill's bed foundation. Tests carried out in accordance with ASTM D5514, on a 1 mm PVC geomembrane lead to failure water pressure much higher than for the 1.5 mm HDPE membrane, (*Marcotte et al, 2009*). PVC geomembrane offers better advantages as a hydraulic barrier in designing leachate collection system, including puncture resistance is the most important. For example, under hydrostatic conditions, the disposition of PVC geomembrane on layers of 20 - 100 mm packed angular gravel has presented a decline of the minimum failure pressure when the particle diameter increases. The bottom line is that abrasion is probably the predominant factor for puncture resistance of PVC geomembranes. The authors' recommendation is to test the geomembranes with real granular materials for test results to be as conclusive as possible. Also, testing and analysis of protective geotextiles demonstrated that the use of a non-woven needle-punched geotextile with a specific mass of 270 g/m^2 increase of the burst pressure of the 1 mm PVC membrane up to 800 kPa, which is ten times higher than the value of allowable pressure calculated for a 1.5 mm HDPE membrane protected with a 550 g/m^2 geotextile. Moreover, the HDPE membrane requires a direct contact only with fine granular materials to prevent punctures while PVC geomembrane may be used over layers of coarser granular material.

Other works covering the geomembranes and geotextiles resistance are HAXO and Kamp, 1990; Peggs I., 1990; Koerner, 1998 Blond and Elie, 2006; Jones and Clarke, 2007; Bacas et al, 2011; Lin et al, 2012 ; Qiang et al, 2013; Voicu Gh., 2016.

The results of pre-compression tests performed on a HDPE geomembrane without geotextile protection to relatively small pressure forces (up to 20 N), but also on a geotextile protection using pressure devices with cylindrical or spherical roller bearings in order to identify mathematical relationship between loading force and deformation, both for loading and unloading, and energy hysteresis are presented in this paper. Experimental data are tested with known mathematical relationships and best mathematical equation that correlates the experimental data is established.

MATERIAL AND METHOD

Measurements were carried out in the specialized laboratory of the Department of Biotechnical Systems from the University "Politehnica" of Bucharest, materials used in the experiments being purchased from Chiajna waste landfill, Ilfov County. The thickness of the HDPE geomembrane was 3 mm, and the unit weight of the geotextile was 500 g/m^2 and thickness 4.7 mm, obtained from non-woven polypropylene yarns.

Laboratory bench (shown in Figure 2) has been specially adapted for the compression experimental tests on geosynthetics used, being provided with a rigid support plate (8), on which were placed100 × 100 mm square tiles of geosynthetics material (9). The hold itself (10) has been either a roll steel cylinder with a diameter of 8.1 or 11.3 mm, or metal spherical ball with a 13.4 mm diameter, reinforced with a top plate (3'), which comes into contact with an external digital comparator (5). Between the metal plates (3 and 3') there is a connecting rod (12) connected to a flexible wire (11) passing over two pulleys (6) and a balancing weight (7) to the left end. On the top plate (3') can be placed different weights (4), whose pressure force is transmitted through the stiffened chain elements (3'-12-3-10) on the geosynthetics material (10).For puncture resistance of the membrane was used a20° metal tip cone, using the same device.

Experimental determinations were performed by reading the geosynthetics material strain at different weights added to the stand's upper plate (3'), until a predefined force is reached and also on return, by reducing the pressure weight. No determinations were made at discharge for a longer relaxation time of the material. Relaxation time was estimated at about one minute (how long until weights were unloaded from the upper plate (3').

Further on, the values obtained for the material deformation were processed in analysis program Microcall Origin, by plotting data points and regression analysis with different mathematical functions and the regression curves were plotted to identify the best variation law of deformation as a function of pressure force (at loading - unloading).

Mathematical functions used in the regression analysis are:

- linear function:

$$y = ax + b \tag{2}$$

- power function:

$$y = a\,x^b \tag{3}$$

- exponential function:

$$y = a + b \cdot \exp\left(-\frac{x}{c}\right) \tag{4}$$

- logistic function:

$$y = b + \frac{a-b}{1+\left(\frac{x}{c}\right)^{d}} \tag{5}$$

Estimated calculations were made to determine the energy dissipated in the material.

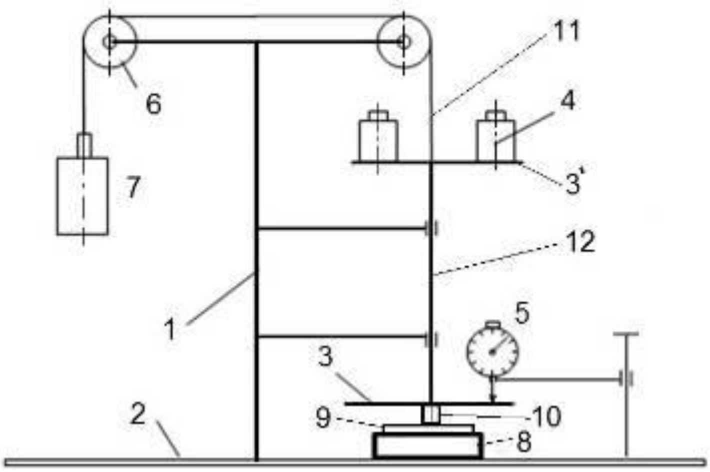

Fig.2 – Principled layout of the laboratory stand used in experimental tests

1 – support with rod and arms; 2 – support plate; 3 – pressure plate; 4 – weights; 5 – external comparator; 6 – pulleys; 7 – balancing weight; 8 – rigid metal plate; 9 – geomembrane (geotextile); 10 – pressure ball (or roller); 11 – connection thread; 12 - rod

RESULTS

The results obtained for values of deformation according to the strength load are shown in Table 1.

Table 1

Geosynthetics deformation values (in mm) for several different devices and pressure forces

4.7 mm PP Geotextile					3 mm HDPE Geomembrane											
Mass, N	8.1 mm Roll		11.3 mm Roll		8.1 mm Roll			11.3 mm Roll			ϕ 13.4 mm Ball			Edge		
	Pressure	Return	Pressure	Return	Mass, N	Pressure	Return	Mass, N	Pressure	Return	Mass, N	Pressure	Return	Mass, N	Pressure	Return
0	0	1.05	0	1.40	0	0	0.02	0.00	0	0.14	0	0	0.21	0	0	0.67
1.36	0.01	1.23	0.16	1.60	1.36	0	0.04	1.36	0.01	0.21	1.36	0.01	0.30	1.36	0.09	0.72
2.68	0.04	1.30	0.42	1.70	2.68	0.01	0.05	2.68	0.04	0.24	2.68	0.04	0.38	2.68	0.15	0.76
3.99	0.25	1.38	0.65	1.80	3.99	0.02	0.05	3.99	0.06	0.28	3.99	0.08	0.43	3.99	0.24	0.78
5.31	0.41	1.43	0.82	1.85	5.31	0.03	0.06	5.31	0.08	0.31	5.31	0.15	0.48	5.31	0.32	0.79
6.64	0.60	1.49	0.98	1.90	6.64	0.04	0.06	6.64	0.10	0.33	6.64	0.21	0.52	6.64	0.40	0.80
7.96	0.75	1.52	1.15	1.94	7.96	0.05	0.07	7.96	0.14	0.34	7.96	0.29	0.55	7.96	0.46	0.81
9.27	0.81	1.54	1.25	1.97	9.27	0.05	0.07	9.27	0.17	0.35	9.27	0.34	0.58	9.27	0.51	0.81
10.58	1.01	1.55	1.39	1.99	10.58	0.06	0.08	10.58	0.22	0.35	10.58	0.39	0.62	10.58	0.54	0.81
11.91	1.09	1.58	1.50	2.00	11.91	0.06	0.08	11.91	0.24	0.36	11.91	0.45	0.63	11.91	0.58	0.81
13.21	1.20	1.60	1.60	2.01	13.21	0.07	0.08	13.21	0.27	0.37	13.21	0.49	0.63	13.21	0.61	0.81
14.55	1.32	1.61	1.69	2.02	14.55	0.07	0.09	14.55	0.29	0.37	14.55	0.55	0.65	14.55	0.68	0.81
15.88	1.40	1.62	1.78	2.03	15.88	0.08	0.09	15.88	0.32	0.38	15.88	0.58	0.65	15.88	0.74	0.81
17.18	1.49	1.62	1.93	2.03	17.18	0.09	0.10	17.18	0.34	0.38	17.18	0.63	0.66	17.18	0.78	0.81
18.50	1.62	1.62	2.03	2.03	18.51	0.09	0.10	18.51	0.36	0.39	18.51	0.64	0.67	18.51	0.81	0.81
					19.51	0.10	0.10	19.51	0.38	0.39	19.51	0.66	0.67			
					20.28	0.10	0.10	20.28	0.39	0.39	20.28	0.67	0.67			

The curves of geosynthetics deformation, on loading and unloading, depending on the pressure force were plotted based on experimental data from Table 1. The arrangement of data points, together with the variation curves drawn by regression analysis are shown in Figures 3 and 4.

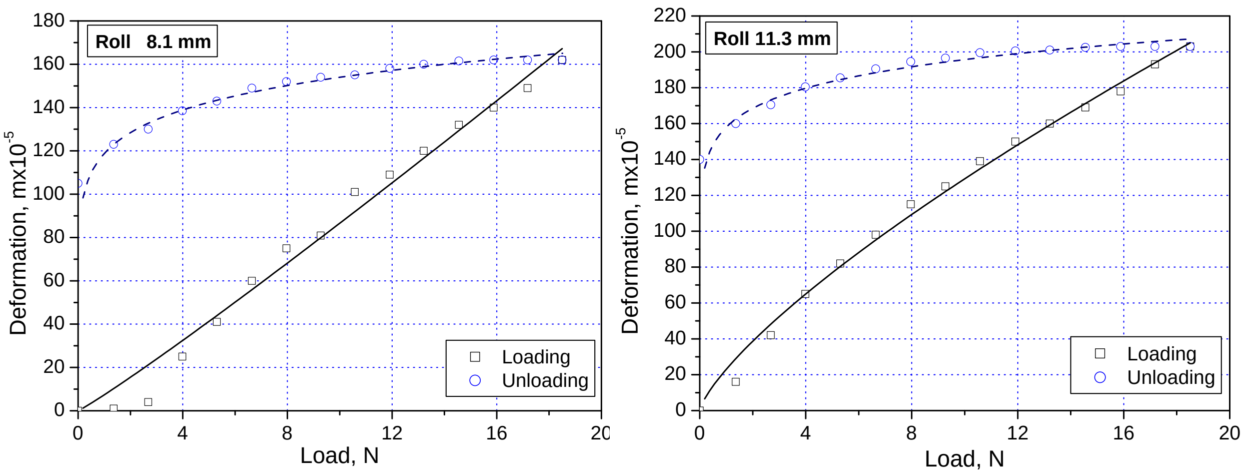

Fig.3 – The variation of the geotextile deformation curves, as a function of the pressure force, on loading and unloading, for two diameters of the cylindrical roll press

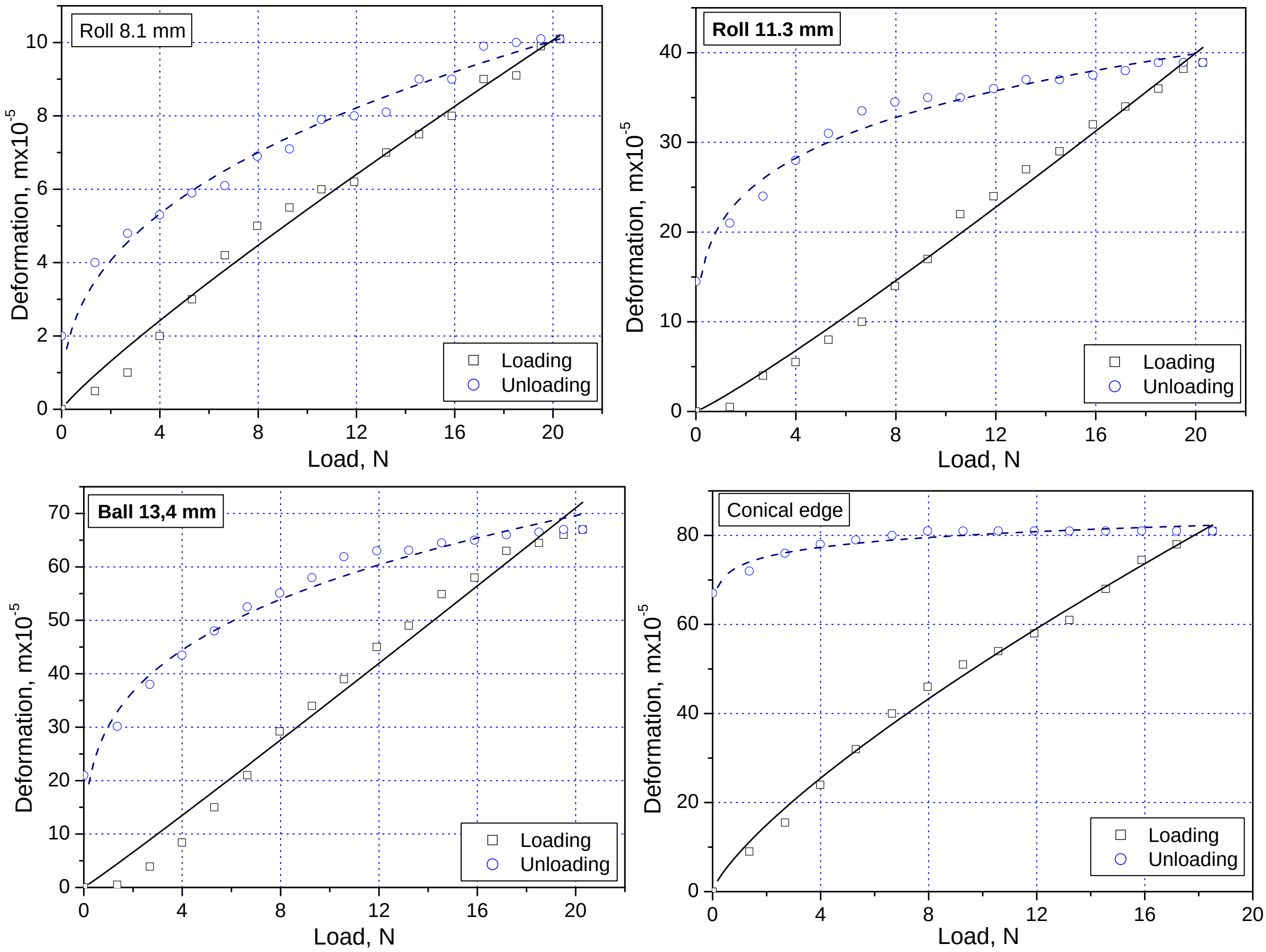

Fig.4 – The variation curves for geomembrane deformation, depending on the pressure force, on loading and unloading, for different types of work systems (rolls, ball, conical edge)

From the analysis of experimental data and plotted variation curves, it can be seen that the unload takes place on a route different from loading, which indicates that some of the strain remains stored in the material and it can be resorbed after shorter or longer periods of time. Thus, there is the possibility of material thinning and if testing continues, the material can no longer return to the initial form. This thinning inevitably leads to stretching and wrinkling of the material, which induce other types of stresses, together with the existence of an additional weight (waste or drainage material or coating) above the material.

Thus, the deformation is elastic-plastic deformation with a higher degree of recovery from the membrane, especially when cylindrical rollers are used. For geotextile protection, the strain was more pronounced as compared to geomembrane, for the same load, and return much smaller, which means that the coefficient of elasticity is also smaller.

Instead, membrane recovery was much smaller when using the conical tip, possibly due to its retention by material and its friction with the material.

Also, it can be said that a part of the energy consumed for deformation remains in the material, manifested as hysteresis both in case of deformation and consumption of the energy needed for deformation. This phenomenon occurs both for geosynthetics protection and for sealing geomembrane, but less obvious in case of the last one, for loading values used in the paper, but with a greater influence on geomembranes.

Energy stored in material (called lost or dissipated energy) can be determined by measuring the surface area between the two curves (loading - unloading). In the paper, the energy dissipation was calculated with Mathcad software, based on equations derived from regression analysis, as a difference between surface areas under the curves of unloading and loading, form the 0 N load to the load mentioned in Table 1 (18.50 N, respectively 20.28 N) for each one of the experimental samples.

If the energy dissipation for the geotextile lies between (1255–1354)$\cdot 10^{-5}$N·m, in case of the geomembrane, dissipated energy lies between (37.2–395.9)$\cdot 10^{-5}$N·m, depending on the type and shape of the pressure device (roller or ball). However, there are slight differences depending on the mathematical relation used (Eq. 2-5). Thus, the calculation error between the values of the dissipated energy calculated by the linear equation (1) and the logistic function (4) lies between 0.15–7.58%, as shown in Table 3:

$$\varepsilon = \frac{E_{linear} - E_{logistic}}{E_{logistic}} \cdot 100\ (\%) \tag{6}$$

From regression analysis of experimental data with mathematical functions mentioned above resulted the values of the equations coefficients and of the correlation coefficient R2 and they are shown in Table 2.

Table 2

The coefficients values of the regression functions (2-5) and of the correlation coefficient R2 for strain - strength variation curves of the experimental tests on PP geotextile and HDPE geomembrane

Equation	Loading / Unloading	Geotextile, roll ϕ8.1 mm					Geotextile, roll ϕ11.3 mm				
		a	b	c	d	R^2	a	b	c	d	R^2
Eq.2	Loading	0.095	-0.076	-	-	0.988	0.107	0.168	-	-	0.976
	Unloading	0.026	1.237	-	-	0.813	0.027	1.631	-	-	0.759
Eq.3	Loading	0.074	1.070	-	-	0.980	0.230	0.750	-	-	0.992
	Unloading	1.188	0.113	-	-	0.983	1.580	1.766	-	-	0.968
Eq.4	Loading	$6.6\cdot10^6$	$-6.6\cdot10^6$	$7\cdot10^6$	-	0.986	2.9512	-2.9712	16.446	-	0.998
	Unloading	1.6358	-0.5697	4.972	-	0.995	2.0395	-0.631	4.161	-	0.999
Eq.5	Loading	-0.0372	2.4744	13.146	1.718	0.995	-0.0211	4.311	21.247	1.044	0.998
	Unloading	1.0527	1.7753	4.604	1.022	0.996	1.4026	2.123	3.289	1.208	0.997
		Geomembrane, roll ϕ8.1 mm					Geomembrane, roll ϕ11.3 mm				
		a	b	c	d	R^2	a	b	c	d	R^2
Eq.2	Loading	0.005	0.0026	-	-	0.985	0.021	-0.018	-	-	0.993
	Unloading	0.0035	0.036	-	-	0.951	0.0095	0.228	-	-	0.786
Eq.3	Loading	0.007	0.886	-	-	0.987	0.015	1.100	-	-	0.990
	Unloading	0.031	0.394	-	-	0.979	0.210	0.214	-	-	0.955
Eq.4	Loading	0.1258	-0.0989	14.562	-	0.980	$-2.68\cdot10^4$	$2.68\cdot10^4$	$-1.3\cdot10^6$	-	0.992
	Unloading	$-1.456\cdot10^4$	$1.456\cdot10^4$	$-2.91\cdot10^6$	-	0.983	0.3883	0.2417	4.938	-	0.993
Eq.5	Loading	-0.0017	0.2316	25.621	1.172	0.992	0.0029	0.6539	16.393	1.784	0.998
	Unloading	0.021	27.833	$4.92\cdot10^5$	0.577	0.991	0.1461	0.419	3.950	1.250	0.993
		Geomembrane, ball ϕ13.4 mm					Geomembrane, conical edge				
		a	b	c	d	R^2	a	b	c	d	R^2
Eq.2	Loading	0.037	-0.026	-	-	0.985	0.043	0.064	-	-	0.980
	Unloading	0.0196	0.340	-	-	0.839	0.0053	0.738	-	-	0.581
Eq.3	Loading	0.032	1.032	-	-	0.978	0.088	0.766	-	-	0.995
	Unloading	0.302	0.279	-	-	0.969	0.731	0.040	-	-	0.992
Eq.4	Loading	$-1.07\cdot10^5$	$1.07\cdot10^5$	$2.89\cdot10^6$	-	0.983	1.3052	-1.3044	19.377	-	0.996
	Unloading	0.6912	-0.4832	6.209	-	0.998	0.8119	-0.144	2.698	-	0.996
Eq.5	Loading	-0.0039	0.915	11.983	1.995	0.999	-0.0041	2.2752	34.055	0.976	0.995
	Unloading	0.213	0.7559	5.171	1.287	0.997	0.6704	0.8153	2.017	1.773	0.995

Analysing the data in Table 2, it is clear that the mathematical function that has the best correlation with the experimental data is the logistic function for which the values of the correlation coefficient R^2 are higher (over 0.992 in all analysed cases). However, all four functions used in the regression analysis shows very high values of the correlation coefficient.

Table 3

The dissipated energy (N·m) and the calculation error based on the mathematical relationship used

	Nonwoven geotextile		HDPE geomembrane		
Dissipated energy N·m)	Small roll	Big roll	Small roll	Big roll	Ball
By the linear equation (2)	1255×10^{-5}	1354×10^{-5}	37.16×10^{-5}	269.35×10^{-5}	380.19×10^{-5}
By the logistic equation (5)	1271×10^{-5}	1352×10^{-5}	38.55×10^{-5}	291.45×10^{-5}	395.92×10^{-5}
Calculation error ε (%)	1.26	0.15	3.60	7.58	3.97

CONCLUSIONS

Geotextiles are widely used in the construction of waste landfills. Among them, the HDPE geomembranes are especially used for sealing the bottom and for the final coating of the deposit. These geomembranes are sensitive to mechanical actions of the weights acting on them and of the blunt bodies inside the materials with which they are in contact. Therefore, protective geotextiles are used for their protection, who's mass per unit area is chosen depending on the specific type of land.

Therefore, the compressive strength of the two geosynthetics is particularly important and needs to be determined, both in the field and in the laboratory, whether the manufacturer's technical features are known or not.

Several conclusions result from our measurements, such as:

- geosynthetics deformation under the action of compressive stresses is an elastic-plastic deformation between 1.6 – 2 mm for the pressure forces of 185 – 360 kPa in case of 4.7 mm protective geotextiles and a weight of 500 g/m^2;
- geomembrane deformation is much smaller compared with geotextile, with values of about 0.10 – 0.40 mm, for pressure forces of 205 – 398 kPa;
- the recovery degree of the geotextile (after about 1 minute) is much smaller compared to that of the geomembrane, in our determinations is in the range of 65 – 70% for the geotextile and 20 – 36% for the geomembrane, depending on the loading force and pressure device used;
- the shape of the pressure device on geosynthetics material is very important and, thus, of the objects with which it comes into contact, being transposed into different loading pressure of the various contact surfaces for the same loading degree;
- when using of a spherical ball-type pressure device, the penetration depth into the material has been much higher for the geomembrane compared to cylindrical-type pressure devices (about 1.7 – 6.7 times over);
- the return of geosynthetics material deformation occurs on a curve other than the loading one, due to its elastic-plastic behaviour, which results in the manifestation of the hysteresis phenomenon; lost or dissipated energy in the material is much higher for the geotextile, between 3 – 30 times over, in comparison with the geomembrane, at the same loading degree;
- both loading and recovery of the material has not necessarily a linear trajectory, but being closer to it in case of loading, when the deformation is approximately proportional to the pressure force; the regression analysis with the linear function showed a correlation coefficient R^2 over 0.980 at loading and between 0.759 – 0.951 at unloading, for all samples, except in tests with the conical tip;
- the mathematical function with the best correlation of the experimental data was logistic function, which showed a correlation coefficient $R^2 \geq 0.991$, both for loading and unloading curves;
- utilisation of the linear and logistic functions in regression analysis leads to errors in the verification of the dissipated energy in the material from 0.15% to 7.58%, which shows that it is very important to choose the proper law of variation of the deformation depending on the pressure force, in order to estimate the dissipated energy.

Therefore, knowing the strength characteristics of geosynthetics is particularly important for designers and builders of ecological landfills, thus the success in operation is consistent with the environmental protection laws, and the data presented in our paper can be particularly useful in this sense.

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CONSIDERATIONS REGARDING REED HARVESTING TECHNOLOGIES / *CONSIDERATII PRIVIND TEHNOLOGIILE DE RECOLTARE STUF*

PhD. Eng. Ivan Gh., Ph.D. Stud. Eng. Mircea C., PhD. Eng Brăcăcescu C., PhD. Stud. Eng. Găgeanu I.
INMA, Bucharest / Romania
E-mail: geoivan2006@yahoo.com

Keywords: *climate changes, reed, Danube Delta, humid areas, ecology*

ABSTRACT

Reed represents an inexhaustible and always available source of biomass for the inhabitants living nearby lakes, ponds, swamps and the Danube Delta. Up to this moment, this source has not been capitalized at its entire capacity or at all, although it can represent another source of income for people living in neighbourhood areas. The paper presents several aspects and considerations on technologies of reed harvesting in Romania and worldwide, emphasizing the conditions appropriate to Danube Delta Biosphere Reservation, where the equipment and machines for reed harvesting have to meet certain specific norms.

REZUMAT

Stuful reprezintă o sursă practic inepuizabilă de biomasă aflată la îndemâna locuitorilor din preajma bălţilor, lacurilor, mlaştinilor şi Deltei Dunării. Până în acest moment această sursă a fost exploatată foarte puţin sau deloc deşi poate reprezenta o altă sursă de venit pentru locuitorii din zonele adiacente. Lucrarea prezintă câteva aspecte şi consideraţii asupra tehnologiilor de recoltare a stufului din România şi din lume, scoţând în evidenţă condiţiile specifice Rezervaţiei Biosfera Delta Dunării, unde echipamentele şi maşinile de recoltat stuf trebuie să respecte anumite norme specifice.

INTRODUCTION

Current climate global system was configured after the last glaciation, about 11500 years ago. It is in course of transformation, the first stage of change consisting in climate disorder manifested by extreme meteorological phenomena, which are more frequent and intense in all the world areas, regardless the seasons. The climate system modification is due in the first time to global warming.

Global warming is the phenomenon of continuous increasing of average temperatures next to soil and ocean water, fact that was the characteristic of the last two centuries, but mostly the last two decades. [1]

Most of specialists in the field agree that the reference point of global warming is represented by the arising of Industrial Revolution in Great Britain (after 1750), moment when global average temperature was about 15 Celsius degrees.

In the period 1850-2012 the global average air temperature has increased by approximately 0.85 degrees Celsius, figure 1 represents the evolution of global average temperature during 1850-2012.

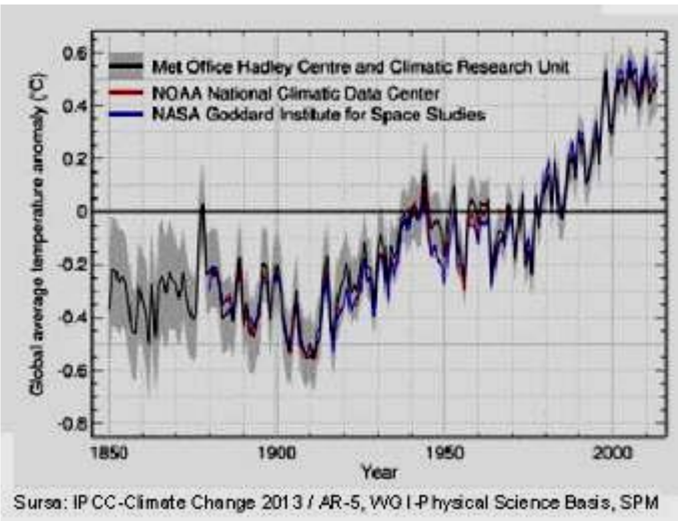

Fig. 1 – Evolution of global average temperature during 1850-2012 [1]

Climate specialists consider that when global average temperature surpasses 17 degrees Celsius, the current climate system being able to irreversibly evolve towards a new configuration and living conditions on Earth at which human being should adapt.

Climate modifications, which this team is putting in relationship with greenhouse gas emissions determined by human activities are frequently causing floods, draught, desertification, species disappearance, etc. Study is emphasizing that human being has less than ten years at its disposal to make an end to ecosystem degradation and become aware of the damages caused by its behaviour in terms of resource consumption. The price for our faults is high but it is too late to envisage the situation in a pessimistic way.

Because of lack of an environmental-friendly technology, reed harvesting equipment and lack of a national strategy regarding the identification of resources generating alternative energy and due to the necessity of regenerating the reed areas, large surfaces from these areas are being burnt year after year. According to statistics of Administration of Reservation of Danube Delta Biosphere (ARBDD) it has resulted that about 200,000 hectares are being annually burnt while in December 1990, Danube Delta acquired its maximum international recognition by being accepted within UNESCO List of World Natural and Cultural Patrimony as Biosphere Reservation.

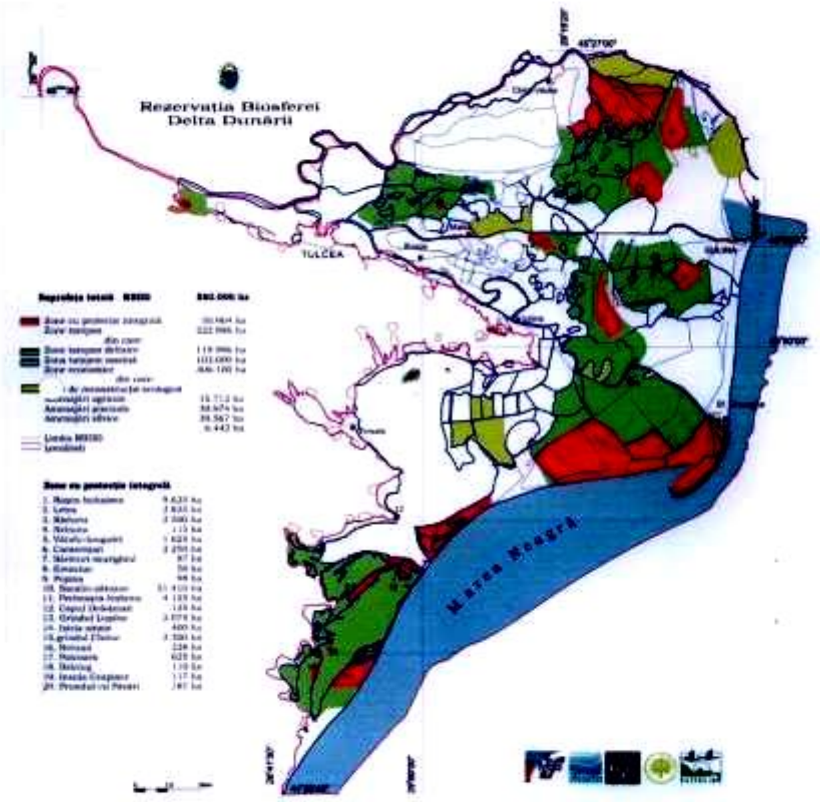

Fig. 2 – Danube Delta Biosphere Reservation (RBDD) [2]

Danube Delta surface is of 4180 km^2 and is divided in three area types. The first type of area is represented by Reservation of Danube Delta Biosphere, which comprises 18 strictly protected areas, whith a surface of 506 km^2. A second type of areas are the buffer zones with 2233 km^2 surface and the third type is represented by economic areas with a total surface of 3060 km^2.

Reed is covering approx. 70% out of the whole surface of Danube Delta, namely 2900 km^2, being the largest area of reed plot in the whole world. [2]

Reed (*Phragmites australis*) is a perennial herbaceous plant with creeper rootstock, vertical rigid stem of 1-4 m height (exceptionally reaching up to 7 m), lanceolate bluish-green leaves of 40-50 cm length and flowers disposed as terminal panicles. It blossoms during July-September and is being harvested in November-March, at 1 or 2 years, for the reed dominant areas and at 3-4 years for maritime a zones. Reed has two morphological-physiological characteristics that impose its harvesting during these time limits. [3]

The first characteristic is represented by the fact that reed has permanently its respiratory pores opened, producing a massive evaporation of water, namely 30-50 l. of water evaporated per reed for whole Danube Delta, 3-4 million cube meters in a single summer.

The second characteristic is the fact that reed on the edge of channels, ponds and reed from floating isles, as areas appropriate to Danube Delta, when it is under water level, alters (dies), determining the degradation of environment by diminishing the oxygen in water and causing the destruction of aquatic fauna.

Approximately 400 km^2 are represented by floating vegetation (reed isle). Reed floating isle is an isle made of a thick layer of 1-1.6 m, made of a mat consisting in reed root-stock and other aquatic plants roots mixed with organic waste and soil.

Initially established, the isle detaches from the channels and lakes transforming in floating reed isle of different sizes which is pushed by the wind movement on water surface. The floating isle flora differs from the other reed plots, the isle reed growing in the best conditions, being higher and thicker, both characteristics presented above being more powerfully manifested.

According to data from Administration of Danube Delta Biosphere Reservation (ARBDD), the companies capitalizing the reed are succeeding at this very moment to harvest only a small part from the whole quantity of reed, a little over 15% (120,000 tons per year). The quantity of reed not harvested remained must disappear for ensuring reed regeneration and a new production. That is why the reed is burnt.

Each summer, in Danube Delta sand banks are starting fires that burn tens of hectares of vegetation. Fire could simultaneously start in many sites and it is impossible to be controlled by fire-fighters, because of the lack of technique for fire extinguishing, so fires could extend farther in localities and are noticed very late. By reed burning, the environment is highly polluted and protected flora and fauna are destroyed.

Vegetation in Romania's humid areas

Since 1991, Romania has established 19 humid zones of international importance or sites *Ramsar*, with a total surface of 1,158,448 hectares (11,584,48 km^2), namely:
1991: Danube Delta;
2001: Small Island of Braila;
2006: Dumbravita Fisheries, Techirghiol Lake, Mures Meadow;
2011: Natural Park Comana, Natural Park Portile de Fier, Stampei Meadow;
2012: Bistret Mountain Lake, Calarasi, Olt-Dunare Junction, Suhaia;
2013: Blahnita, Borcea Arm, Calafat-Ciuperceni-Dunare, Channels from Harsova, Dunarea-Bugeac-Iortmac Islets, Jiu-Dunare Junction, Dunarea Veche-Macin Arm, Bistret, Suhaia and Calarasi islet are cross-border Ramsar sites, which management is achieved due to collaboration of authorities from Romania and Bulgaria.[2]

Within the flora from humid areas in Romania are several types of characteristic vegetal species and species mixtures.

- *aquatic and floating isle vegetation*, presented in water catchment of 300-400 square meter surface and water depth of 1-1.5 m;
- *meso and hygrophile vegetation* of plants subjected to an excess of humidity appropriate to river meadows and around springs and small water accumulations;
- *Hygrophile weed vegetation* often found around springs and water channels, where animals come to drink water during the grazing.

Aquatic and floating isle flora comprises plant varieties which develop in areas fully covered by water during the whole year, in ponds or rivers.

This flora can be found in Danube Delta and water accumulations resulted from meadows impoundment and is achieved by submerged aquatic plants, such as: soft hornwort (*Ceratophyllum submersum, Ceratophyllum demersum*), spiked water-milfoil (*Myriophyllum spicatum*), whorl-leaf water milfoil (*Myriophyllum verticillatum*) and duckweed (*Lemna minor*), a plant which floats on water surface.[2]

Floating isle flora (helofila) is made of plants which underground organs (roots, rhizomes) are covered by water and stems grow at surface. The most prevalent isle plants are: **reed (*Phragmites australis*)**, Knotweed (*Glyceria plicata*), Arrowhead (*Sagittaria sagittifolia*), Water knotweed (*Polygonum amphibium*), Rice cut grass (*Leersia oeyzoides*), etc. [2]

Fig. 3 - Reed (*Phragmites australis*) [10]

Meso hygrophile and hygrophile vegetation comprises plants growing on humid or wet fields. Most representative species that accept an excess of humidity are: hard rush (*Juncus inflexus, Juncus effusus*), willow herb (*Epilobium hirsutum*), purple loosestrife (*Lythrum salicaria*), gipsywort (*Lycopus europaeus*), water mint (*Mentha aquatica*), creeping buttercup (*Ranunculus repens*), brookelime (*Veronica beccabunga*), swamp meadowgrass (*Poa palustris*), creeping bentgrass (*Agrostis stolonifera*) etc. [2]

Vegetation of hygrophile weeds comprises the nitrofile varieties growing in swamps or rivers and ponds border, as well as in areas where water is excessive. Organic materials stored along the time in places where animals drink water, enrich the soil with nitrogenous substances and achieve the optimum conditions for annual apparition of nitrofile weeds. Among the species appropriate to this group, we may notice: three-lobe beggarticks (*Bidens tripartita*), barnyardgrass, wild mint, yellow dock, etc. [5]

Reed is a perennial plant from grass family, able to reach, depending on soil and water available quantity, up to 10-12 m length, out of which 0.5-2 m under the water level. Main mass of rhizomes (80-90%) is located under the layer of 0-60 cm from water surface. Rhizomes are creeping, having vertical or horizontal position and form a great number of buds. Starting from these buds, the aerial erect horizontal or inclined stems are forming. Rhizomes are destroyed by chain harvesting machines.

Horizontal stems can reach 5-8 m length. From stem knots new roots and vertical strains are going to form, thus generating a huge plant. Vertical strain is rigid, empty inside and smooth with a common height of 1-4 m and 2-2.5 cm thickness. The stem has a silicon content determining the rapid wear of cutting blades of cutting apparatus comprised in reed harvesting machines.

Leaves are plane, rigid with rough lanceolate-linear limb of 40-50 cm length and 1.5-3 cm width.

Flowers are grouped into a pyramid-shaped panicle of 20-30 cm length, with thin branches and numerous ears. Ears are lanceolate-linear dark-brownish lilac or yellowish coloured, with 3-7 laterally compressed flowers. They bloom in July-August. [2]

Following the analysis of plant morphological and physiological characteristics, it can be concluded that reed can be mowed with cutting devices with fingers and cutting blades thicker than those used when harvesting cereals, the minimum cutting height being of 15-20 cm measured from level of soil or water, and height of orienting devices of harvesting equipment must be suitable to plants height.

MATERIAL AND METHOD

Although the numerous touristic locations and travelling possibilities appeared, Danube Delta represents a touristic and economic potential of great value able to be highly capitalized (reed representing a valuable economic resource) if investments in manufacturing harvesting machines and equipment, as well as in alternative energy producing equipment, are made.

Danube Delta inhabitants' needs are small, because in this region it is not building so much, people owning villas or holiday houses rarely using reed as building material. But reed is mostly required in Western Europe's countries and Mediterranean countries for constructions and soil protection in olive and citrus growing cultures, but also for other economic activities.

If in the 60s in Danube Delta there were large reed areas and every winter, hundreds of thousands tones gathered, while nowadays, only 50,000 t. of reed can be obtained. The cause of this reduction must be found in communism regime, during which many experiments in Danube Delta were made, such as those in the 60s, when huge reed harvesting equipment was brought, equipment that rusted without producing anything (in Maliuc area there is a real cemetery of reed harvesting machinery). Then, the big dam works of '70s and '80s came, following which the lakes situated at Danube mouth were transformed in agricultural lands, diminishing even more the reed cultivated areas. Nowadays, there are several productive reed crops in maritime Delta and aquatic basin Razelm-Sinoe. In recent years, a relative revival of business in the field can be seen. Three companies, two from Tulcea and one from Constanta are running businesses with reed harvested during winter in Danube Delta. They have leased eight perimeters of reed and are exporting their production in Western Europe's countries. Reed is used at manufacturing building walls, being known its efficient thermo-insulating characteristic. Furthermore, this building material is also environmental-friendly. One ton of reed is sold on international market by approx.50 Euro. If it was totally harvested, reed from Danube Delta would represent a business of about 40 de million euro per year.

Being a hard and badly paid work, reed harvesting represents a big problem. This work is performed only in winter and only if channels and ponds are frozen. Manual manpower is necessary for cutting the reed, preparing the sheaves and loading them in carts and only few people are willing to work in total isolation conditions during winter in Danube Delta. Years ago, this operation was made by Periprava and Chilia Veche prisoners, but those prisons were abolished. Therefore, only eight out of the 16 perimeters cultivated with reed auctioned in recent years by ARBDD were leased.

There are certain companies in Tulcea that are harvesting the reed next to Crisan and Valea Nucarilor localities, are transforming it into mats and then are exporting it to owners of orange and olive crops in countries situated in Mediterranean Sea area. These cultures owners are using mats for covering their crops, grass being impeded to grow and thus, they reduce water evaporation in soil, as well as the maintenance expenses. Reed mats are also used by melons growers for controlling weeds and keeping water in soil. Approximately 2,000 tons of reed mats are annually being exported.

Beginning with 2004 summer, when ARBDD management has allowed reed harvesting in strictly protected areas, reed became more interesting for investors. This was possible by taking into account the fact that the access of unauthorized people and machines and any economic activity in fields ecologically protected were forbidden. *ARBDD has explained this decision by the fact that if reed remained not harvested in Lupilor and Chituc areas would create great ecological problems.* Since then, the huge surfaces with reed in Danube Delta became a big business that annually brings up to hundreds of millions profit to companies involved.

Though, according to ARBDD data, companies and family associations are succeeding this very moment to harvest only a small part of total quantity of reed, a little over 15% (120,000 tons annually). The remained amount not harvested must disappear to make room to a new production. This is the reason for which the reed is burnt.

Having in view the fact that an important quantity of solar energy accumulated by reed is stored in cellulose, reed from Danube Delta is wholly capitalized.

Cellulose from reed composition is varying between 40-50%, and its main utilizations are:

- raw material for paper production: at the present moment, a unique factory producing cellulose is operating (factories of cellulose are polluting air, water and soil with chlorine dioxide and sulphur dioxide, and the lack of a national economic strategy led to the failure (closing) of factory of cellulose and paper from Chiscani);
- by enzyme hydrolysis, the cellulose forms glucose, from which can be obtained fertilizers, yeasts, ethyl alcohol, glycerine, pentoses, acetaldehyde, ethylene, butadiene, dichlorethane 17, chloroform etc;

Other use:

- when is minced and mixed with a plastic-based substance, reed becomes an excellent row material for producing double-glazed window frames, parquet, doors and many others, the total cost being smaller by 40% than of classic PVC;
- building fascia for dams protection;
- food for animals: young reed is used for animal feeding during winter;
- touristic resource: reed mass is able to house and fed birds, fish and a large variety of flora;
- reed is the most important fuel for Danube Delta inhabitants, wood being scarce in this area.

The management of reed areas is of a great importance, reed being able to be harvested as green matter for obtaining biomass, in order to turn it into alternative energy. Reed harvesting is made at 1-2 years period. Reed in maritime area must be harvested at 3-4 years (for giving it the time to regenerate).

RESULTS

Reed harvesting technology in Danube Delta

Reed harvesting technology in Danube Delta comprises manual harvesting, sheaves gathering (small heaps) and their transport to intermediate storing points and final locations.

Manual harvesting is made in difficult working conditions, with seasonal workers from November to March, paid approx. 5 Euro per day. A man with experience in reed harvesting can achieve 15-20 sheaves per hour. The utensil used for reed cutting is named "*târpan*", being a sort of reaping hook with straight blade of 15-20 cm length and 2-3 cm width, put on wood handle long of 40-50 cm.

Sheaves transportation to intermediary storing place is made by cart if transport is made in dry field or on frozen water.

In recent years, reed harvesting machines with tilting platforms are also used at sheaves transport. There are not many of this sort of machines, they are of big size and are expensive (in comparison with limited local possibilities), are used at harvesting only in deep water areas (60-100 cm), where people cannot harvest.

The manually harvested sheaves are loaded on machine's platform and transported to intermediary storing points, from where they are charged in barges and transported to final storing places.

The final storing places are covered precincts, where sheaves are dried, sorted, bound per length and prepared for being conveyed with a diameter of 60 cm designed to roofs or mats for plantations.

In order to make reed mats, these storage bases are endowed with looms designed to different width and length mats.

Fig. 4 – Reed industrial processing [11]

The harvesting technology presented is available for reed in economic area of Danube Delta and maritime area but not in Danube Delta Biosphere, where strict protection regulations of flora and fauna do not allow the access of large transport machines and equipment.

- **Worldwide reed harvesting technology**
- Reed harvesting technology at world level consists in reed harvesting, as a regular basis, with specialized machines, but also with motor mowers or even manual harvesting.

At world level, reed is poorly spread and therefore the important machinery manufacturing companies do not produce specialized harvesting machines designed to reed. Locally speaking, especially in Baltic States, there are small-sized companies that are manufacturing a small number of machines designed to reed harvesting, being also interested in exporting it in Eastern Europe countries.

Specialized machines manufactured by those companies are mostly self-propelled wheeled or caterpillar machines, but there are also a few types of motor mowers with two or three wheels, which are multifunctional, or more concrete, are used for many crops.

Self-propelled machines designed to reed harvesting are manufactured in Denmark, Hungary, Estonia, Great Britain, Netherlands and motor mowers are manufactured in Italy and China.

Self-propelled machines for reed harvesting comprise an equipment for reed cutting and binding it in sheaves, a driving position endowed or not with a cabin, a tilting platform or a hopper and sometimes plants or sheaves conveyors between the cutting apparatus and platform or transport hopper.

These machines are not so well manoeuvred because of their big size and are not able to harvest the reed when water is deep. Machines buoyancy is without load or with small load, and equipment is not able to float. The harvesting process is performed by 2-6 men.

Wheeled self-propelled machines have low pressure tyres of large width, a small number being manufactured and designed at existing manufacturers.

Wheeled self-propelled machine Seiga Reed Harvester is an efficient machine, being hard to handle in Danube Delta channels and it is not balanced so that it could harvest the reed in deep water areas.

Most of self-propelled machines are equipped with metallic or rubber chains. These machines are harvesting reed of maximum 2 m height in dry areas and reduced water level zones (maximum 60 cm). Metallic chain machines are destroying reed rhizomes located at surface, and therefore the rubber caterpillars appeared. Cattail and chufa have replaced reed, the vegetal carpet reduction having bad consequences on housing and feeding fish and birds.

Motor mowers can harvest reed only in dry areas and are occasionally used for small surfaces harvesting. Motor mowers have two or three wheels and are endowed with different parts according to crop type to be harvested, harvesting consisting in reed cutting and gathering as sheaves. Gathering and storing the cut plants or sheaves are subsequently performed using other equipment (much manpower and risk of damaging reed areas because of machine passing).

These machines characteristics will be presented in the following chapter, but we must notice that these machines are used to harvest in unprotected areas, not the case in RBDD.

- **Modern technology designed to reed harvesting**

This technology provides the harvesting of vegetal matter specific to RBDD, located on channels and ponds banks, as well as the land flora. This flora represents an ecological great danger if it is not harvested in due time, namely at 1-2 years interval.

Fig. 5 – Flora (reed) located on channels banks [3]

At the same time, it is envisaged the possibility of reed harvesting as sheaves, during the whole year, but especially in warm season, when reed preserves its leaves, thus, the harvested matter being suitable to obtaining of alternative energy.

Reed sheave harvesting will allow to store, chop and transform it in biofluel or pellets, through activities during the whole years, thus enabling the increment of manpower occupation and raising the human resources professional skill level in Danube Delta areas.

In order to harvest the reed located on banks of channels and lakes, as well as land reed, the harvesting machine must have access to it, move even when water is deep and be easily handled.

Therefore, the machine will comprise a buoyancy equipment for cutting and binding the sheaves, a driving platform, a platform for storing and transporting the reed to storing base, an internal combustion engine a hydrostatic transmission for equipment displacement and driving, motor wheels endowed with low pressure tyres, with big width so that the harvested reed rhizomes be not affected and which ensure the machine floating with/without load, hydraulic installation for elevating/lowering the equipment, electric installation necessary to machine operation and movement on public roads etc. Three men will work with the machine, among which one will drive it, the second will take over the reed sheaves and transmit to the third, who will store them on platform.

When the platform is loaded (reed sheave height on platform is 1.8 m, and 750 daN maximum weight), the machine will be unloaded by the two men on dry field or on a barge, the harvesting continuing.

This technology meets the requirements of protected areas of RBDD, but can be also used in economic zone of Danube Delta, based on a reed harvesting machine that could be found at a cheap selling price, being manufactured inside the country, Danube Delta being recommended.

CONCLUSIONS

Reed represents a renewable energy source of biomass that could bring substantial benefits to inhabitants living in humid areas and especially to those from Danube Delta.

Because of the continuous growing of reed, if it is not harvested in due time many damages will appear due to waterways restriction, suffocation of certain fish species because of water acidification, fact for which harvesting is the only solution that could bring substantial incomes (through reed processing).

During many years, the harvesting technologies have evolved from manual harvesting up to self-propelled machines that can move along or through the channels due to their tyres able to assure buoyancy and an increased autonomy (increased storing capacity).

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TECHNOLOGIES FOR THERMAL CONTROL OF WEEDS
/
TEHNOLOGII DE COMBATERE TERMICĂ A BURUIENILOR

Muscalu A.[1)], Bobit D.[2)], Matache M.[1)], Barsan M.[1)], Pruteanu A.[1)], PhD. Eng. Sorică C.[1)]
[1)]INMA Bucharest / Romania; [2)]Dacia Plant SRL Bod Brasov/ Romania
Tel: 021/269.32.50; Fax: 021/269.32.73; E-mail: amuscalis@yahoo.com

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ABSTRACT

Normally, crop maintenance also requires weed control, which in recent years has become a major challenge for conventional farming systems. Compared to those, in organic farming systems it is even more difficult, because it is not possible to apply herbicides. For this reason, weeds from organic crops are controlled only by the means of so-called physical methods. These achieve weed destruction by using manual, mechanical, thermal or mulching means.

Thus, obtaining maximum crop yields involves synchronization between the time of weeding using an appropriate physical method and the so-called "critical period of weed competition". Among the physical methods for weed control there is also thermal weed control.

The paper presents a synthesis regarding current technologies for thermal weed control. Therefore are presented the principles of thermal control, technologies used, equipment types, their characteristics and performance, as well as the results obtained.

According to the new common European vision on the organic sector, in the following years, before 2030, is desired for more than half of the arable land in Europe to be managed in compliance with organic principles.

In this context, it is necessary for thermal control technologies to be more known and used, and their agronomic, economic, technical and environmental aspects to integrate more and better in plant protection.

REZUMAT

In general intretinerea culturilor presupune si controlul buruienilor, care, in ultimii ani, a devenit o mare provocare pentru sistemele de agricultura conventionala. In comparatie cu acestea, in sistemele de agricultura ecologica acest lucru este si mai dificil, neexistand posibilitatea aplicarii ierbicidelor. Din acest motiv, buruienile din culturile ecologice sunt controlate numai cu ajutorul asa numitelor metode fizice. Acestea realizeaza distrugerea buruienilor prin utilizarea unor mijloace manuale, mecanice, termice sau prin mulcire.

Astfel obtinerea unor randamente maxime ale culturilor implica o sincronizare intre momentul efectuarii plivitului utilizand o metoda fizica adecvata si asa numita ,,perioada critica a concurentei buruienilor''. Dintre metodele fizice de control ale buruienilor fac parte si cele de control termic ale acestora.

Lucrarea reprezinta o sinteza referitoare la tehnologiile actuale de combatere termica a buruienilor. Astfel sunt prezentate principiile combaterii termice, tehnologiile utilizate, tipuri de echipamente, caracteristicile si performantele acestora, precum si rezultate obtinute.

Potrivit noi viziuni comune a sectorului ecologic European, in urmatorii ani, pana in 2030, se doreste ca mai mult de jumatate din terenul arabil al Europei sa fie gestionat conform principiilor ecologice.

In acest context este necesar ca tehnologiile de combatere termica sa fie cat mai cunoscute si utilizate, iar aspectele lor agronomice, economice, tehnice si de mediu sa se integreze mai mult si mai bine in protectia plantelor.

INTRODUCTION

During the recent period, awareness on the necessity to approach a healthy feeding manner manifests itself more strongly. Thus was launched a new common organic vision on the European organic sector, calling for the adoption of an organic agricultural system that protects the environment. Also, changing the agricultural management systems, a fare trade and urban agriculture are also promoted. According to this vision, until 2030, more than half of the arable land in Europe could be managed according to organic principles (*Barabanova et al. 2015*).

In general, weed management in crops represent a difficult task. The harmful plants can constitute an extremely serious problem within organic agriculture systems, because in this case, chemical weed control is completely forbidden. Besides the competition manifested against the development of cultivated plants, weeds can also be toxic (ex: European black nightshade – *Solanum nigrum*) or can fulfil the role of host for various pathogen agents or pests present in crop (*Roman et al., 2009*). Moreover, perennial weeds are even harder to control, requiring a specific approach.

Weed control in organic agricultural system is achieved through a series of measures that integrate preventive measures as well as curative measures (*Roman et al., 2009*).

Preventive measures have the purpose to impede the occurrence and spreading of weeds. They are represented by: crop rotation, soil works, the use of certified organic biological material, sowing in the optimal period, phytosanitary quarantine (*Toncea and Stoianov, 2002*), etc.

Curative measures represent methods to keep under control the weeds that have already appeared in crops (*Roman et al., 2009*). Among these methods takes part the physical control of weeds that is based on the use of several techniques. Active methods include manual weeding, hand pulling, mowing, thermal methods and mechanical weed control, by using tillage, equipped with different working organs, depending on their space of action. Mulching and flooding are classified as passive techniques (*Panneton et al. 2013*).

In accordance with the current context of impetuous development of organic agriculture in perspective, this paper presents a synthesis of technologies for thermal weed control.

MATERIALS AND METHODS

Thermal control in plant protection relies on heat transfer between two bodies (the thermal control equipment and the agricultural pest what to be controlled), that have different temperature. It is aimed at inducing injuries to the pest that will lead to death over a short period of time. The heat treatments leading to internal temperature increases of 50 to 100 ^{0}C for at last 0.1s will result the extension of cell sap and disruption of cell walls. (*Laguë et al. 2013*).

The efficiency of a thermal control treatment aimed at a specific target can be evaluated using two parameters:

- the amount of heat transferred between the thermal control equipment and the targeted organism;
- the duration of exposure of the targeted organism to the thermal control treatment.

Different species of weeds respond differently to a given thermal treatment due to physiological differences. Broadleaf weed species are more sensitive than grasses. These develop a protective sheath by the time they are approximately 25 mm tall. Perennial weeds are the most resistant. Weed heat sensitivity varies depending on the development stage, the young ones being easier to destroy. That is why is indicated that the thermal control treatment is applied when weeds have a height between 25 and 55 mm. Thus, the treatment is effective with low energy consumption (*Diver 2002, Laguë et al. 2013*).

In the case of weeds exposed directly to the flame, if after the treatment, the leaves pressed between fingers hold the thumb's print it means that the flaming was applied correctly. The flamed weeds soon wilt and die, usually in one to three days. (*Diver 2002*)

Three different techniques may be used to expose weeds to high temperature:

- direct exposure to flame;
- use infrared radiation;
- use steam and/or hot water projection.

The equipment used for directly exposing weeds to flames is similar to agricultural sprayers. They incorporate a pressurized liquid fuel reservoir, a network of pipes and hoses that carries the fuels to the burners, pressure regulators and flow controller, and a number of individual burners, where the chemical energy of the fuel is converted into heat. Two types of burners may be used: liquid burners that incorporate their own fuel atomiser and vapour burners requiring an external atomizer located upstream from the burners. (*Laguë 2013*).

In the technique exposure to infrared radiation, the burner flames are directed toward a metallic or ceramic surface that reflects infrared radiation toward the weeds to be controlled. For maximum efficiency, the generated infrared radiation must be concentred within a narrow spectral band corresponding to maximal absorption by the weeds targeted by the treatments. Infrared radiation in the 1.44 -1.93 μm band is very efficient against organisms with high body water content since it corresponds to infrared absorption band of water.

Propane which is currently the fuel used by most thermal control equipments, is generally considered to be a clean fuel since its complete combustion generates carbon dioxide and water vapour. Under field condition, propane combustion is often incomplete, resulting in the emission of significant amounts of carbon monoxide, sulphur dioxide and nitrous oxides, especially if the supply of oxygen to the burners is insufficient. It is thus important to identify the optimal operating zones for each type of burner in order to limit the emission of these pollutants. (*Laguë et al. 2013*).

Following, specialized equipment for each type thermal weed control technologies is presented.

REINERT Company METALLBAU GMBH (Germany) produces several types of equipment designed flame weeding. It uses LPG fuel in gaseous and liquid state. When gaseous fuel is used, it is already vaporized inside the container, then being lead to the burner. The burner's working capacity depends on the quantity gas extracted. In this case, the quantity of gas extracted is smaller, determining the limitation of working width for the weeding equipment. When using liquid fuel, it is extracted in this state, the evaporation taking place in special burners. This method allows to extract a larger quantity of gas and implicitly to achieve larger working widths [11].

T105R, T111R, T111K models (fig. 1, 2, 3) use 5/11 kg liquefied gas tanks for extracting gas during the gaseous phase. The equipment is carried by the users, being equipped with special frames, adapted depending on the volume of the tank. They can use burners of the type: SB100i, SB130i and SB160i, to which correspond the working widths of 100, 130 and 160 cm, a gas consumption of approximately 1.2, 1.6 and 1.8 kg/h and an outlet power of 15.5, 20.6 and 23.2 kW. The equipment are fitted with adjustable overpressure valve with pressure gauge; 1.5 or 5 m long pressure hose (model T111K), adjustment handle with repose arm, extension pipe, sliding support, burner with injection equipment.

The mobile support in figure 4 is a mobile support, placed on a pneumatic wheel, being destined for models *T 105R* and *T111R*, for an easier manoeuvrability of the burner on field or the garden. [11]

Fig. 1 - Portable flame weeding device *T 105R* [11]

Fig. 2 - Flame weeding device *T 111R* [11]

Fig.3 - Portable flame weeding device *T 111K* [11]

Fig.4 - Mobil support FR 1 for *T 105R and T 111R* [11]

Reinert company builds models of weeding equipment with flame of the type *X 1000S* (fig. 5), equipped with supports for two liquefied gas tanks, 2 support wheels (in the front part) and one direction wheel with hand brake (in the rear part), high performance burner with piezoelectric ignition, stainless steel thermal protection cover, switch (low power – manually controlled), thermoelectric safety pilot. This type of equipment can have various working widths of: 60 cm, 80cm, 100 cm and a fuel consumption of 7kg/h, 9 kg/h or 11 kg/h. Working capacity is directly proportional with the working speed thus: at a 1 km/h speed it is of 600 m^2, 800 m^2, 1000 m^2, and at a working speed of 2 km/h it is of 1200 m^2, 1600 m^2, 2000 m^2 [11].

Fig.5 - Weeding equipment with flame *X1000S* [11]

Fig. 6 - Thermal weeding equipment *X311F* [11]

Fig. 7 - Weeding equipment with infrared heating *X211Si* [11]

For working width of 100cm and 120 cm, may be used the models: *K 311 F* - suitable for 3 liquefied gas bottles 11 kg each (fig.6), *K 233 F* - suitable for 2 liquefied gas bottles 33 kg each, *K 333 F* - suitable for 3 liquefied gas bottles 33 kg each. For this equipment, the flame weeding system is fitted in front of the power source, through a three point rising system, and the gas fuel system is fitted in the back. Fuel comes in gaseous form, and ignition is achieved electrically by an ionizing detector. [11]

The *X211Si* type equipment with infrared heating (fig. 7) can also be used for flame weeding in private or public places, [10]. This equipment use gaseous fuel. The support with handle is fitted with 2 support wheels in the back and on direction wheel, with hand brake, in the front. Infrared heating systems are built of stainless steel. Burner ignition is achieved piezoelectric, by pressing a button. The equipment is fitted with thermoelectric safety system. This equipment has a better yield. They are built in constructive versions of 50 and 75 cm, for which the fuel consumption is of 4 kg/h, respectively 5 kg/h, the outlet power is 54 kW, respectively 103 kW, and the working capacity is 500 m^2 respectively 1000 m^2 for a working speed of 1 km/h. for a working speed of 2 km/h, the working capacity is of 1000 m^2 respectively 1500 m^2, and for a working speed of 3 km/h, the working capacity is of 1500 m^2 and 2250 m^2. [11]

For the ecological weed control in crops, various types of thermal control equipment were achieved, whose burners use liquid or gaseous fuel. The gas feeding system can be constituted of several liquefied gas tanks, *model A511HF* (fig. 8) or of a liquefied gas reservoir (300 l capacity, fitted in front of the tractor), *model A2000HF* (fig. 9). The equipment is of the towed type, with the possibility to adjust the working height. Each model has the heat protection cover made of stainless steel, and the lateral panels are adjustable in height. Burner ignition is done electrically, with control ionizing. For *A511HF* models, working width is between 1.5 and 2.0 m, and for *A2000HF* models, it is between 1.5-1.6 m. [11]

Fig. 8 - *Reinert – A511HF equipment* [11]

Fig. 9 - *Reinert – A2000HF equipment* [11]

HOAF Company (Netherlands) achieves several types of thermal weed combat equipment that combines infrared radiations with warm air. [12]

Manual weed control equipment is of the type *Hoaf Thermit*. They can have burners that are directly manoeuvred (fig. 10) or burners fitted and encased on a support (fig. 11). The equipment is mainly intended to be used in parks, gardens or public places. They are differentiated by the burner's working width. [12]

Fig. 10 - *Hoaf ThermHIT15* (15 cm working width) [12]

Fig. 11 - *Hoaf ThermHIT100M* (100 cm working width) [12]

Fig.12 - *HOAF Weedstar 50i* [12]

Fig. 13 - *HOAF Weedstar 100* [12]

The technical characteristics of *Hoaf ThermHIT* type manual weed control equipment are presented in table 1.

Table 1 [12]

Thermal characteristics of *Hoaf Thermhit* equipment

Model	Working width [mm]	Fuel type	Fuel consumption [kg/h]	Ignition	Power [kW]	Mass [kg]	Working capacity[m^2]
Thermhit 15	150	Propane	0.8	Piezoelectric	11	2	300 (v=2km/h)
Thermhit 25	250	Propane	1.5	Piezoelectric	20	10.5	625 (v=2,5km/h)
Thermhit 45	450	Propane	2.5	Ignition battery	35	25	1125 (v=2,5km/h)
Thermhit 75	750	Propane/ LPG	6.0	Ignition battery	82	40	1875 (v=2,5km/h)
Thermhit 75M	750	Propane/ LPG	6.0	Electrical	82	40	1875 (v=2,5km/h)
Thermhit 100M	1000	Propane/ LPG	8.0	Electrical	110	50	5000 (v=5km/h)
Thermhit 100M	1250	Propane/ LPG	13.0	Electrical	137	75	3125 (v=2,5km/h)

For parks and public places, the HOAF Weedstar type equipment was achieved. HOAF Weedstar *50i* (fig. 12) has a working width of 2 x 500 mm. In order to prevent useless gas consumption, both burner heads can operate separately. The equipment is fitted with a 2 stage power control, so that combined with air blowers to obtain a maximum effect [9]. *HOAF Weedstar 100* (fig.13) is used for burning unwanted vegetation from almost all types of paved and unpaved surfaces, having a working width of 1000 m, a robust construction and a high working capacity [12].

Also for fighting weeds in public places were created the equipment for weed control with steam, manual (fig. 14) or fitted on a power source (fig. 15). The *HOAF GreenSteam* manual equipment is compact; it has an ergonomic lance fitted with elbow support and a wheel for an easy use. The long hose (5m) offers mobility for the user to treat inaccessible places. The equipment is provided with pressure regulators for water and gas, as well as a 12 V accumulator that ensures enough energy for one day [12].

HOAF WeedSteam 100 (fig. 15) has a working width of 1000 mm. Its efficient action is due to the combined action of infrared radiations and steam [14]. HOAF *type KB* leaf burners (fig. 16) are used in organic agriculture to destroy weeds and plant residues. The use of Venturi burner and of infrared technology, combined with aerial support on the working width, results in a great capacity to penetrate large residues, such as potato leaves. The equipment is used for soil treatment, because the burners are placed on a large working width (1.5 m). Their action can destroy seeds, moulds, spores and bacteria in the soil, achieving their sterilization. *HOAF tip KB* offers a large range of working widths varying from 1.5 to 9 meters [15]. *HOAF Twin Sprite* (fig. 17) is destined for burning weeds between rows. Each burner has a working width of 250 mm and be turned on/off independently. The height of burners is adjustable. The distance between burners is of 50-75 cm. the equipment can be fitted with 4, 6 and 8 burners that have wind shields to minimize meteorological influences [12].

Fig. 14 - HOAF GreenSteam [12]

Fig. 15 - HOAF WeedSteam 100 [12]

Fig.16 - HOAF KB1,5 equipment [12]

Fig. 17 - HOAF Twin Sprite equipment [12]

WEEDTECHNICS Company (Australia) produces several models of equipment for the ecological weed control using saturated steam [13]. SW 700 model (fig. 18) operated connected to a faucet. All models can use application heads that can be of the opened (fig. 19a) or closed (fig. 19 b) type. They are manoeuvred manually, being placed at the end of a 30 m long hose made of thermo resistant material. The application heads are made of stainless steel, resistant to high temperatures and to the corrosive action of steam. Open application heads have a 50 mm length, and closed one have 350/600 mm. the company has in sight the achievement of automated systems for weed control with saturated steam that will use dome type application heads (fig. 19 c). They will be used in parks, vineyards, orchards, etc. they will actuated by single or double robust arms, on the right or on the left, the distance between the appliers that will rotate gently around plants will be 180/240 cm. they will have a diameter of 400/600 cm, being made of insulating nylon or rubber, in the shape of a dome with skirt, being provided with specialized nozzles for steam distribution.

Fig.18 - Model SW 700 [13]

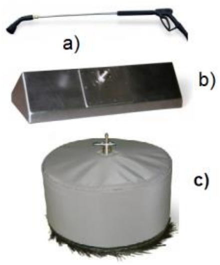

Fig. 19 - Application heads [13]

Fig. 20 - ***SW800*** **with bar frame** [13]

Fig. 21 – trailer type ***SW800*** [13]

Models (*SW 800, SW 900 and SW 900DH*) are built in several constructive versions: equipment with single bar frame, equipment with carried frame, equipment with patina frame, equipment with patina frame and reservoir, as well as the trailer type equipment. Model *SW800* (fig. 20) is destined for manual application of weed control with saturated steam in small surface organic crops. Models *SW900* and *SW900DH* are destined for orchards, vineyards and row crops, using multiple heads for applying saturated steam. Model *SW900* uses a Briggs & Stratton motor (gasoline) engine for driving the pump while SW900DH uses a Kohler engine (Diesel).

Swiss farmers have achieved a system for the ecological weed control using hot water, for perennial plants of the *Rumex* species, which invades pastures [14]. It is composed of a cleaning system with hot water at high pressure, driven by an internal combustion engine, to which was added a water reservoir and an additional reservoir for determining the quantity of fuel used to heat water. All the components are placed on a trailer, to be transported (fig. 22).

For each treated plant were measured the water consumption and temperature, by using a counter and a temperature sensor. Due to the fact that the plants that needed to be destroyed were perennial, it was required to intervene also on their root systems. For that, hot water under pressure was used, introduced in the soil by using several types of application heads (fig. 23).

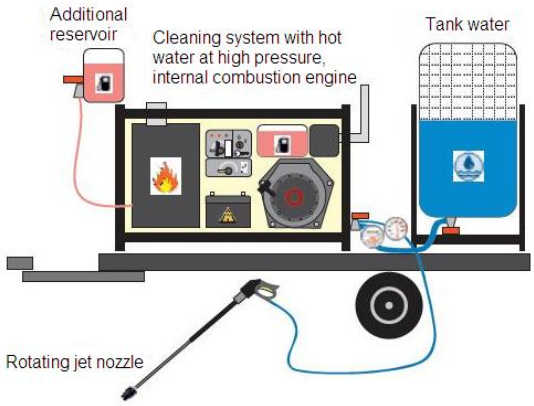

Fig. 22 - Hot water weed combat system [18]

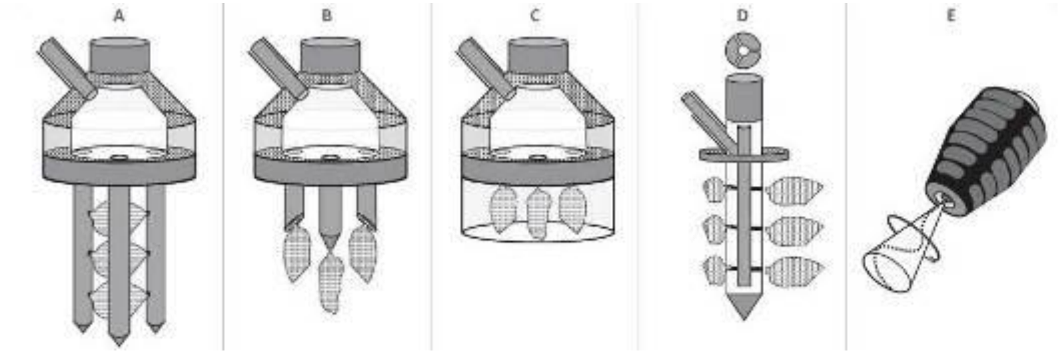

Fig. 23 – Heads for applying high pressure hot water in the soil to fight *Rumex* [18]

Thus, versions A, B and D were introduced into the ground using a hammer. Version C was pressed into the ground up to only about 10 mm, so as to obtain a sealed region. For version A, the water flows through three points at a depth of 90 mm, in the case of version B, the water flows vertically to a depth of 30 mm. Version C was designed to be used like a bell. It is important to mention that the rotating jet nozzle version was placed perpendicular to the ground so that water to penetrate all around the plant. Rotary jet destroys soil structure and leaves a mixture of water and earth, which wraps roots. By using the versions A to D, the recorded temperature varied between 70-150 °C, and for version E was used water at a temperature up to 95 ° C. [14]

RESULTS

Because the paper represents a synthesis of thermal weed control, the results obtained by using this method are presented.

Thus, in figure 24 is presented the effect of thermal weed control by applying the flame directly on the weeds that are in different stages of development, compared to its effect of corn that is other stages of development. The experiment was carried out on a few weed species common in Quebec corn fields: redroot pigweed (*Amaranthus retrofluxus* L.), wild mustard (*Sinapis arvensis* L.), lamb's-quarters (Chenopodium *album* L.) and green foxtail *(Setaria viridis L.*) (Leroux et al. 2013)

These weeds were treated at three different growth stages (0-2 leaves 4-6 leaves and 8 or more leaves) at temperature between 110 and 390 ^{0}C. At the 0-2 leaf stage, all four weed species were destroyed by temperatures at or 110 ^{0}C (fig.24). At 4-6 leaf stage, however temperatures of at least 175 ^{0}C were required to reduce biomass by 80%. Lastly, at the 8-or more leaf stage, weeds were very difficult to control and, the level of control was below 85% even at temperatures of 350 ^{0}C (data not shown). (Leroux et al. 2013)

After experiments conducted in 2002-2003 in an organic onion crop and in 2005 in an organic carrot crop by applying in parallel the mechanical and the thermal (using steam and hot water) method for weed control, their efficiency was evaluated through their effect on 16 types of weeds. So, the thermal weed control for annual weeds is 22.5% more effective, in comparison with the mechanical method, however the latter is 32% more effective for perennial weeds. (Virbickaite et al 2006)

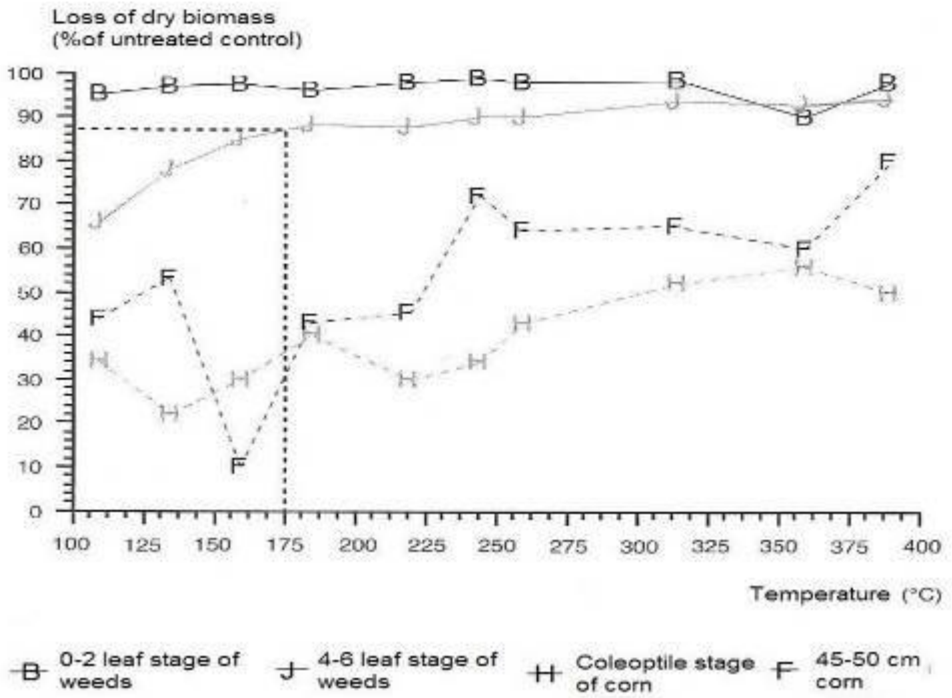

Fig. 24 - Effect of temperature on weeds treated at the 0-2 leaf and 4-6 leaf stages, compared to that of corn at the coleoptile and 45-50 cm stages (Leroux et al. 2013).

In addition, 1 kg of wet water vapour releases 2250 kJ of thermal energy to the environment, which is 3.7 to 11 times more than 1 kg of gas in flame weeding technology. Another very useful feature of water vapour medium is its ability to flow in the direction of colder plant and soil surfaces. The vapour condensation process on the surface of the plant causes this flow. All this allows a sudden increase in the temperature of plant tissues, and lasts only 1 to 2 seconds, completely destroying the weed plant. (Kerpauskas 2006)

Other experiments show that when applying 100°C water steam for weed control, the stable foam can be successfully used for crop protection from thermal destruction. So, the crops treated with a stable form layer are protected from thermal destruction when 100°C water steam is sprayed at a distance of 8 cm to the plant. In the foam covered plant medium the temperature reached 46 °C ± 2. (Nadzeikienė et al. 2009)

In the case of experiments on the control of *Rumex* plant with hot water, using different types of application heads, the results are presented in table 2. It shows the necessary water, energy and fuel, determined at a 90^{o}C water temperature and 40% soil moisture, for each version of application head, so that it will lead to the destruction of weeds from *Rumex* species in 80% proportion. According to the results obtained, Version E consumes the smaller quantity of energy.

Table 2 [14]

Consumptions for different application heads

Parameter	**Measuring unit**	**Application heads options**				
		A	B	C	D	E
Water consumption per plant	l	3.7	2.6	3.8	1.9	1.6
Energy consumption per plant	kWh	0.319	0.228	0.333	0.161	0.139
Fuel consumption per plant	l	0.044	0.031	0.045	0.022	0.019

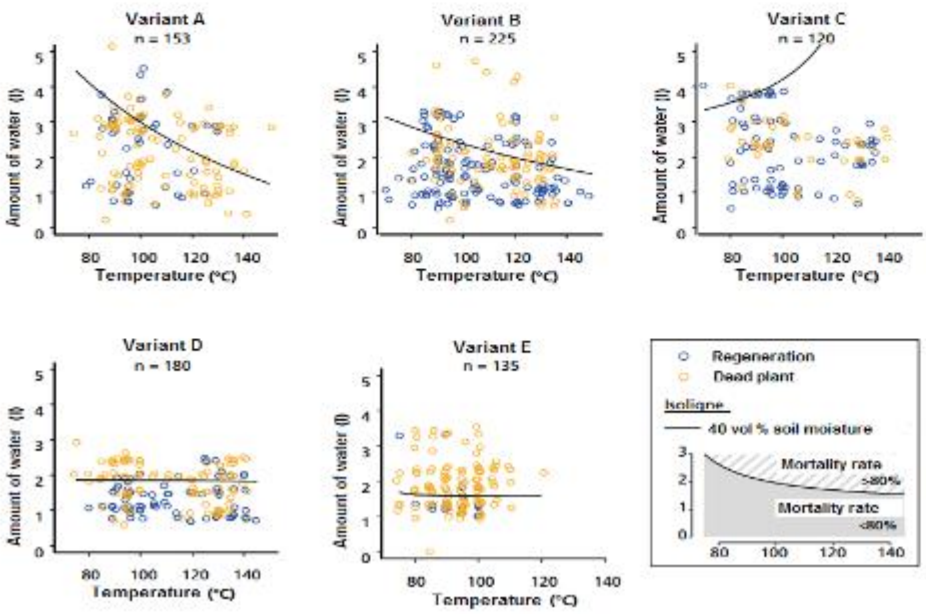

Fig.25 – Plant mortality rate depending on water quantity, water temperature and soil moisture [14]

Figure 25 shows the graphic representation of the statistic interpretation of tests from 2011, concerning plant mortality rate depending on water quantity and soil moisture, for each version of application head. The outline of the diagram symbolizes a 40 % soil moisture and the area above the contour line indicates the aimed rate of mortality >80%.

CONCLUSION

The various field equipment used in thermal control must be designed and evaluated using a few main criteria: ability to transfer heat uniformly and in a controlled manner to the weeds, energy requirements, emission of pollutants.

Currently, the flame weed control method is used most often as an alternative to chemical herbicides, but gaseous fuel used is important. The methods with infrared radiation prevent direct exposure of the crops to the flame. However the heating rate is not high and a rather long period of exposure is needed to control the weeds.

Thermal weed control using steam is a real alternative for the flame weed control method and it offers efficient, reliable, ecological and economical means of weed control. Reducing the mass of weeds using water steam produces an inversely proportional increase of cultured plant yields. The preliminary data show that in practice the energy input in weed control by water vapour would be half of the energy used in flame weeding. The water steam methods effectively destroy short-life weeds but perennials can re-sprout.

The benefits of the thermal weed control vary depending on the type of application, the performance of the equipment used to apply the thermal treatment and the timeliness of these treatments.

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ESTIMATION OF WINTER WHEAT VARIETIES SUITABILITY FOR DIFFERENCE GROWTH OF LANDSCAPE CONDITIONS
/
ОЦІНКА ПРИДАТНОСТІ СОРТІВ ОЗИМОЇ ПШЕНИЦІ ДЛЯ ЗРОСТАННЯ В РІЗНИХ ЛАНДШАФТНИХ УМОВАХ

Prof. Ph.D.Kharytonov M.M., Dr., Ph.D. Pashova V T, Dr., Dr., Ph.D. Mitsik O.O,, Ph.D. Nazarenko M.M., Dr., Ph.D. Bagorka M.O.
Dnipropetrovsk State Agrarian-Economic University, Dnipropetrovsk, Ukraine;
Tel: 380664844773; E-mail: envteam@ukr.net

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ABSTRACT
Our investigations confirmed a relation between concentration of nutrient substances in plants, their loss from soil and peculiarities of relief, variety genotype and the limits of adaptability. Winter wheat is a culture by its requirements to growth conditions. Generally, north exposition of the slope made up more favourable conditions for wheat vegetation. We recommended varieties Peremoga, Odeska n/k, Albatros for growing under these conditions according to grain productivity. Varieties like Istok, Spartanka and Samarska can be grown to reach high level of grain protein content. Variability of these traits between varieties was higher under slope conditions than on flat land. Only variety Samarska was not affected in terms of protein content under every condition. At the same time, all genotypes depended on growth conditions to reach high level of grain yield. We established that wheat grains contain more microelements than straw. At the same time the lead and nickel uptake was more in the straw samples. Thus, the influence of the relief on microelements and heavy metals content in the winter wheat grain and straw is ambiguous.

ТЕЗ
Наші дослідження підтвердили положення про зв'язок між концентрацією поживних речовин у рослинах, їх втратою з ґрунту та особливостями рельєфу, генотипу сорту і межами адаптації. Озима пшениця є культурою з певними вимогами до умов зростання. Як правило, схил північної експозиції мав більш сприятливі умови для вегетації. Ми рекомендуємо сорти Перемога, Одеська п/к, Альбатрос для отримання в цих умовах найбільших врожаїв зерна. Такі сорти як Існок, Спартанка і Самарська можна вирощувати тут заради високої кількості білку в зерні. Варіабельність цих ознак між сортами була вище в умовах схилу, ніж на рівнині. Тільки сорт Самарська мав незмінний вміст білку за різних умов. У той же час всі генотипи залежали від умов зростаня, щоб забезпечити врожайність зернових на високому рівні. Ми встановили, що зерно пшениці містить більше мікроелементів ніж солома. У той же час більший винос свинцю та нікелю зафіксований у соломі. Отже, вплив рельєфу на вміст мікроелементів і важких металів у зерні та соломі озимої пшениці не однозначний.

INTRODUCTION
In the past, wheat research was more focused on improving yield of the crop, the plant breeders having ignored the importance of growth conditions (Witcombe et al, 1996; Miflin, 2000). By “conditions” we understand the relief of lands for cultivation and exposition of land slopes which determine the properties of wheat yield and the protein content of grains (Dawson et al, 2011). These two traits together actually define the overall quality of wheat whether it is good or poor (Gepts, Hancock, 2006). Grain yield in wheat is one of the most important and complex character affected directly or indirectly by gene present in plant (Bhutta et al., 2005; Rangare et al, 2010) as well as the interaction of environment (Tester, Langridge, 2010; Serpolay et al, 2011). This has been in response to the pressure for an adequate food supply caused by constantly increasing population in Ukraine and the world as a whole (Martynov, Dobrotvorskaya, 2006; Mba et al, 2012). Wheat (*Triticum aestivum L.*) is the world’s leading cereal grain and the most important food crop, occupying top position in Ukraine’s agriculture with 48% area among cereals and contributing with 38% of the total food grain production in the country (Vaschenko, Nazarenko, 2015; Nazarenko, 2015).

Therefore, evaluation of new wheat cultivars with high genetic potential for yield, its components (Slafer, Andrade, 1993) and quality traits (Sperling et all, 2001) has become a permanent goal in the plant industry programs (Reif et al, 2005; Tuberosa and Salvi, 2006).

Disequilibrium in appearance of different nature-agricultural factors of a region determines discrepancy in land using. High-level of lands tillage, complicated landscape and high amount of technical cultivars lead to soil degradation. Erosion of slope soils is one of the main components of this problem (Kharytonov et all, 2016). Due to this fact we investigated cultivars demands under different types of slopes. One of the main nature factors of erosion is a land relief, resistance of soils after erosion, plants soil defending function, climate and hydrometeorology conditions. They determined balance of wet, character of winter, intensity of water erosion. Erosion soils are performed on slopes and intensity of erosion process depends on the peculiarity of slopes.

Here we reported about winter wheat variety demands to different relief conditions and problems of minerals losses which were caused by these demands.

MATERIAL AND METHOD

Experiments were conducted on the teaching farm of Dnipropetrovsk State Agrarian-Economic University. The farm coordinates are: 48°30'N lat. and 35°15' E long. The station is lying 245 meters above the sea level. The air temperature during wheat growing season (September/July) is 8 - 11°C; the average rainfall is about 400 - 550 mm in vegetation season respectively. The field station of Dnipropetrovsk State Agrarian-Economic University has been used for many years as an area for intensive agricultural production and research (Kharytonov et.al. 2004 Kharytonov et.al, 2009). It is located far away from the city of Dnipropetrovsk (25-30km) enough to avoid industrial pollution effect. The research field occupies an area of 14 hectares and it is crossed by three ravines.

One of them is of 30 m depth with a slope of > 7°, the other two have the slopes up to 3°. Comparison of the received information regarding the crop yield with the landscape features offers the possibility to differentiate the agricultural resource potential of the area. Studies were performed on plain (full-height normal soil), on the northern exposition slope (low eroded soil), the slope of the southern exposure (middle level of erosion). Special attention was paid to the one of the three ravines: flat terrain, slopes of the southern and the northern exposure.

Winter wheat seeds were procured form the department of breeding and seed farming of DSAEU. The recommended agronomic practices were followed. Estimation of total yield per plot and its components was conducted from 2013 to 2015. The trial was set up as a randomized block design method with three replications and with a plot size of 20 m^2 in 3 replications (Dospehov, 1985).

Normal cultural practices, including fertilization, were done whenever it was necessary. From the agrochemical investigation it resulted that soils of station have more than average fertilization and a high content of nutrition substances (not less than 30 - 40 mg/kg of nitrogen content, mostly provided by potassium, while slopes of south exposition have a low content of phosphorus). Nevertheless, slopes of south exposition contain main mineral elements two-three times less than in the case of flat lands.

The nitrogen and phosphorus concentration in plant samples was estimated using Kjeldahl method. Total P concentrations of the applied residues were determined by sulphuric acid digestion (Thomas et al., 1967). Potassium was determined with flame photometry. Trace elements were determined with method of atomic absorption spectrophotometry.

Mathematical processing of the results was performed by the method of analysis of variance, the variability of the mean difference was evaluated by Student's t-test, the grouping of lines by grain productivity was performed by cluster analysis, factor analyses was conducted by module ANOVA. In all cases standard tools of the program Statistica 6.0 were used.

RESULTS

Regarding to data obtained (table 1 and 2) winter wheat responded to growth condition, which showed in yield and uptake of mineral elements from soil. As we can see from the previous table we obtained high grain yield on slope of north exposition, especially for varieties Peremoga, Odeska n/k, Albatros. After analyse of specificity of macro elements losses with winter wheat stems and expenditures which had been requested for obtaining 1 ton of grain we determined that uptake of main nutrient components are directly depended on grain yield. Nitrogen uptake on flat interfluves varied from 144 to 183 kg/ha, phosphorus 42-52 kg/ha, potassium 105 -107 kg/ha during seven years. On the north exposition slope discrepancy in yield depended on varieties was not so clear compared to that on flat. The nitrogen losses from soil with yield were 161-176 kg/ha, phosphorus 45-63 kg/ha, potassium 123 -143 kg/ha. Nutrient loses from soil with yield on south exposition slope were considerably lower: nitrogen -111-134 kg/ha, phosphorus – 35 - 42 kg/ha, potassium 85 -104 kg/ha.

From the table 1 we can see that winter wheat require a considerable quantity of nitrogen 30.1-35.8 kg. This variation is explained by biological peculiarities of variety. Bezosta 1 needed 35.6 kg of nitrogen while Spartanka 30.1 kg. On the other hand, variety Albatros, with less expenditure in nitrogen (31.5 kg), under flat conditions gave us greater yield than Bezosta 1. Losses of phosphorus for wheat growth varied from 7.9 to 10.7 kg under flat conditions. The lowest amount was necessary for variety Bezosta 1 and the higher was for Istok. The potassium uptake was 23.0-25.7 kg and there were fewer variables. Under north exposition slope conditions short-stem varieties Odeska n/k, Albatros needed the lowest kg amount in nitrogen (31.0), while the highest amount was necessary for Istok (35.1kg) and Spartanka (34.5 kg).

According to requirements in phosphorus variety Istok was the first (12.6 kg) and Spartanka was the last (9,1 kg). The relation between potassium expenditure and the variety was the same as in the case of nitrogen. Demand in one was lowest for Odeska n/k and Albatros (22.7). the highest amount of nitrogen needed was 25.8-26.0 kg. Winter wheat on north exposition slope required 28.0-33.0 kg of nitrogen, 8.5-11.1 kg of phosphorus and 23.3-27.2 kg of potassium for 1 ton of grain depending on variety.

Table 1

Uptake and expenditure of main nutrient elements /N, P, K/ with winter wheat stems

Variety	Yield, t/he	Uptake from soil kg/he			For 1 tonne of grain, kg		
		N	P	K	N	P	K
Flat							
Peremoga	49.0	171	52	126	34.9	10.6	25.7
Istok	47.5	148	51	119	31.2	10.7	25.1
Odeska n/k	54.4	183	50	127	33.6	9.2	23.3
Bezosta 1	42.5	152	42	105	35.8	7.9	24.7
Spartanka	48.9	147	47	125	30.1	9.6	24.4
Samarska	45.9	144	44	112	31.3	9.6	24.4
Albatros	51.4	162	50	118	31.5	9.7	23.9
Average	48.5	158	43	119	32.6	10.0	24.5
Slope of north exposition							
Peremoga	55.1	176	57	143	31.9	10.3	26.0
Istok	49.0	172	63	126	35.1	12.9	25.7
Odeska n/k	55.5	172	58	126	31.0	10.5	22.7
Bezosta 1	49.5	170	50	123	34.3	10.1	24.8
Spartanka	49.3	170	45	127	34.5	9.1	25.8
Samarska	49.8	161	52	125	32.3	10.4	25.1
Albatros	54.5	169	55	124	31.0	10.1	22.8
Average	51.8	170	54	127	32.8	10.4	24.7
Slope of south exposition							
Peremoga	40.9	134	39	104	32.7	9.5	25.4
Istok	35.6	106	37	97	29.8	10.4	27.2
Odeska n/k	36.9	122	41	86	33.1	11.1	23.3
Bezosta 1	36.5	111	34	93	51.3	8.6	26.2
Spartanka	36.1	114	37	92	31.5	10.2	25.5
Samarska	36.3	118	35	97	32.5	8.6	26.7
Albatros	42.1	118	42	103	28.0	10.0	24.5
Average	37.6	118	38	96	31.4	10.1	25.5

Assaying average uptake of nutrient substances from soil we are able to conclude about the common influence on this parameter of both slope exposition and variety features (table 2).

Table 2

Coefficient of nutrient elements utilization from soil on different types of relief, %

Variety	Flat			Slope of north exposition			Slope of south exposition		
	N	P	K	N	P	K	N	P	K
Peremoga	61.7	55.9	16.7	67.7	87.7	19.9	73.2	76.4	22.5
Istok	53.4	54.8	15.8	66.2	86.9	17.5	67.9	72.5	21.0
Odeska n/k	66.1	53.8	15.8	66.2	89.2	17.5	66.7	80.3	18.6
Bezosta 1	54.9	45.2	13.9	65.4	76.9	17.1	60.6	86.7	20.1
Spartanka	53.1	50.5	16.6	65.4	69.2	17.5	62.3	72.5	19.9
Samarska	52.0	47.3	14.8	61.9	80.0	17.4	64.5	68.6	21.0
Albatros	58.5	53.8	15.6	65.0	84.6	17.2	64.5	82.4	22.3
Average	57.1	51.6	15.8	65.4	82.1	17.7	65..6	74.2	20.8

Results of general uptake of microelements calculation are presented in tables 3 and 4. We can notice that the grain of wheat contains more microelements than the straw. At the same time, the lead and nickel uptake was higher in the straw samples.

Influence of relief on microelements and heavy metals content is ambiguous.

On the other hand we have to regard downward of some microelements (Zn, Mn, Fe) in straw on the slopes and valley floor. When we determined uptake of microelements from soil with winter wheat yield we observed that meaningful quantity of iron (1918-6334 g/ha), zinc (986-17669 g/ha), manganese (1113-3430 g/ha) take out with winter wheat and wasted out of the field.

Uptake of copper was 244-479 g/ha, lead 193-323 gr/he, nickel 135-330 g/ha. Uptake of elements on the south exposition slopes were considerably less than on flat interfluves and slope of north exposition.

Table 3

Uptake of microelements and heavy metals with winter wheat grains and straw under different relief conditions

Relief element	Zn		Mn		Cu		Pb		Ni		Fe	
	mg/kg	g/ha	mg/kg	g/ha	mg/kg	g/ha	mg/kg	g/ha	mg/kg	g/ha	mg/kg	g/ha
Grain												
Flat	22.2	1077	22.0	1067	3.9	189	2.0	93	3.2	155	43.0	2086
Slope of north exposition	20.5	1062	28.9	1497	4.6	238	2.0	104	1.5	78	41.5	2150
Slope of south exposition	24.3	914	23.6	887	4.1	154	2.0	75	2.5	94	31.3	1241
Valley floor	23.0	1633	26.0	1846	3.4	241	2.5	178	1.1	78	32.3	2293
Straw												
Flat interfluve	4.3	250	17.0	407	3.1	180	2.9	168	3.0	175	73.0	4248
Slope of north exposition	2.7	168	15.0	933	2.8	174	2.8	174	1.6	100	18.0	1120
Slope of south exposition	1.6	72,0	5.0	226	2.5	90	2.6	117	0.9	41	15.0	671
Valley floor	1.6	136	5.7	486	2.8	239	1.7	145	0.8	68	12.6	1074

Table 4

General uptake of microelements and heavy metals with yield under different relief conditions

Relief element	Fe	Zn	Mn	Cu	*Ni*	Pb
	g/ha	g/ha	g/ha	g/ha	g/ha	g/ha
Flat interfluve	6334	1327	1474	369	330	252
Slope of north exposition	3270	1230	2430	412	178	278
Slope of south exposition	1918	986	1113	244	135	192
Hollow	3366	1789	2332	479	146	323
M	3722	1333	1837	376	197	261
Cv	50,0	25,2	35,2	26,3	45,9	21,0

Grain quality of winter wheat yield depended on variety and relief (table 5).

Table 5

Protein content in winter wheat grains depending on variety and relief, %

Variety	Flat	Slope of north exposition	Slope of south exposition
Peremoga	16.4	14.8	15.5
Istok	14.3	16.7	15.0
Odeska n/k	15.8	14.3	15.1
Bezosta 1	16.3	15.5	15.3
Spartanka	14.8	16.2	13.7
Samarska	14.8	15.3	15.1
Albatros	15.0	14.7	14.3
M	15.2	15.4	15.0
Cv	6.7	5.6	2.5

High protein content has been identified in the grains of three varieties Istok, Spartanka and Samarska. Slope of north exposition are preferable for higher protein content than flat ones.

CONCLUSION

To sum it up our investigations confirmed the relation between concentration of nutrient substances in plants, their loss from soil and peculiarities of relief, variety genotype and limits of adaptability. Winter wheat is an average culture according to its requirements of growth conditions. Generally, north exposition created more favourable conditions for wheat vegetation. We recommended varieties Peremoga, Odeska n/k, Albatros for growing under these conditions in terms of grain productivity and varieties Istok, Spartanka and Samarska in terms of grain protein content. Variability of these traits between varieties was higher under slope conditions than on flat land. Only variety Samarska didn't register changes of protein content under each condition. All genotypes depended on growth conditions by grain yield at high level.

We established that wheat grains contain more microelements than the straw. At the same time, the lead and nickel uptake was higher in the straw samples. The influence of relief on microelements and heavy metals content in the winter wheat grain and straw is ambiguous.

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BIOREACTOR SYSTEMS FOR WASTE TREATMENT USED IN ORDER TO ACHIEVE BIOGAZ BY DRY DIGESTION
/
SISTEME DE BIOREACTOARE FOLOSITE PENTRU TRATAREA DEŞEURILOR UTILIZATE PENTRU OBŢINEREA DE BIOENERGIE (BIOGAZ) PRIN DIGESTIE USCATĂ

PhD. Eng. Voicea I.*[1)], Ph.D. Stud. Eng. Cujbescu D.[1)], Ph.D. Stud. Eng. Niţu (Roşu) M. [1)], Ph.D. Stud. Eng. Persu C. [1)], PhD. Eng. Matache M.[1)], PhD. Eng. Vlăduţ V.[1)], PhD. Eng. Dincă M.[2)], PhD. Eng. Moiceanu G.[2)], PhD. Eng. Ungureanu N.[2)] PhD. Eng. Toma L.[2)], Eng. Dumitru I.[3)]

[1)]National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, INMA, Bucharest, Romania; [2)]UPB Bucharest / Romania; [3)]Power Group International S.R.L. / Romania

E-mail: voicea_iulian@yahoo.com

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Abstract

The paper presents a synthesis regarding bioreactors systems used at waste treatment in order to obtain bioenergy (biogas) by dry digestion. Biogas production is a good way of satisfying national and European regulations becoming more stringent in relation to the use of organic waste for energy production, followed by recycling as fertilizer. Biogas technologies contribute to reducing the volume of waste and of costs for their disposal.

Rezumat

Lucrarea prezintă o sinteză în ceea ce priveşte sistemele de bioreactoare folosite pentru tratarea deşeurilor utilizate pentru obţinerea de bioenergie (biogaz) prin digestie uscată. Producerea biogazului reprezintă o cale foarte bună de satisfacere a reglementărilor naţionale şi europene din ce în ce mai restrictive în ceea ce priveste utilizarea deşeurilor organice pentru producerea de energie, urmată de reciclarea acestora ca îngrăşăminte. Tehnologiile de producere a biogazului contribuie la reducerea volumului de deşeuri, precum şi a costurilor determinate de înlăturarea acestora.

INTRODUCTION

The essential element of a biogas company is digester, a sealed reaction tank at the entry of air, in which the raw material is subjected to an anaerobic digestion process, thus, producing biogas.

Common characteristics of all digesters, apart from being air proof, are: existence of raw materials feeding, exhaust systems and existence of biogas and digestate systems. In terms European climates anaerobic digesters must be insulated and heated [5].

Worldwide, there is a diverse building range of biogas digesters types. Thus, are used concrete, steel, brick or plastic digesters, shaped as silos, troughs or basins, located underground or on the surface.

The size of a biogas plant are determined by digesters size, ranging from a few cubic meters in the case of small household installations up to large commercial plants, possessing several digesters, each with volumes of thousands of cubic meters.

Choosing the digester construction type is determined, primarily, by water content, respective, by the dry substance of the digested substrate.

As mentioned above, the technology of anaerobic digestion operates in two basic systems: wet digestion, when the average content of dry matter (DM) of the substrate is lower than 15% and dry digestion, when the content of dry substance of the substrate is above this value, usually between 20-40% [1,2].

In agriculture, the majority of anaerobic digestion and biogas processing systems are liquid fermentation systems, or submerged fermentation systems, as they are called in industry.

This is because most garbage disposal systems from West farms lead to liquid manure obtaining.

Even in cases where the solid manure is obtained, in order to ferment and to produce biogas, companies specializing in this field aim to liquid fermentation systems.

Thus, the solid matter is mixed with large volumes of water. There are used very large capacity fermenters, and after fermentation, the solids must be separated again from the liquid phase.

At Hohenheim University in Stuttgart, the researchers developed a fermentation system for solid biomass with biogas obtaining, transferring the applied system to biodegradation of the urban solid waste, dejections and of biomass farms.

Because in farms are obtaining much smaller quantities of manure or solid residues than waste from human settlements cannot be taking over the continuous system, automated applied in the latter case, and it is necessary to apply the fermentation system used in this industry domain [7].

MATERIAL AND METHOD

The method consists in filling the fermenter one time, this closes, fermentation takes several weeks, after which opens fermented biomass to download and fill up again with another fermentation batch.

There is no mixing system; only portions of the fermented material remain in the fermenter as inoculants (leaven) to initiate the next fermentation. Because biogas production fluctuates during fermentation and is 0 at the beginning, then increase reaching maximum production and then begin to fall as the organic matter is consumed, it requires the construction of several fermenters for liquid fermentation.

Most fermentation systems in solid substrate use fermenters, garage type (fig. 1).

Basically, rooms are made by concrete, hermetically sealed, into which the solid substrate is introduced.

At the upper side is disposed a system of perforated pipes in which the solid substrate is sprayed with liquid.

The liquid is percolated through the entire solid mass and is accumulated at the bottom size in a tank where it is pumped back into the perforated pipes in order to be disperses all over the solid mass.

This washing of the solid substrate is usually done twice a day, for 15 minutes.

The used substrate should be of a structure that allows the movement of fluid throughout the solid mass.

Therefore, there are not used materials with high compaction degree (such as cows excrements), or if used, they should be thoroughly mixed with material to give them texture and aeration for liquid circulation (chopped straw, substrate plant, etc.). Best results are obtained with horse excrements, which have better structure and loose fibre [3, 10].

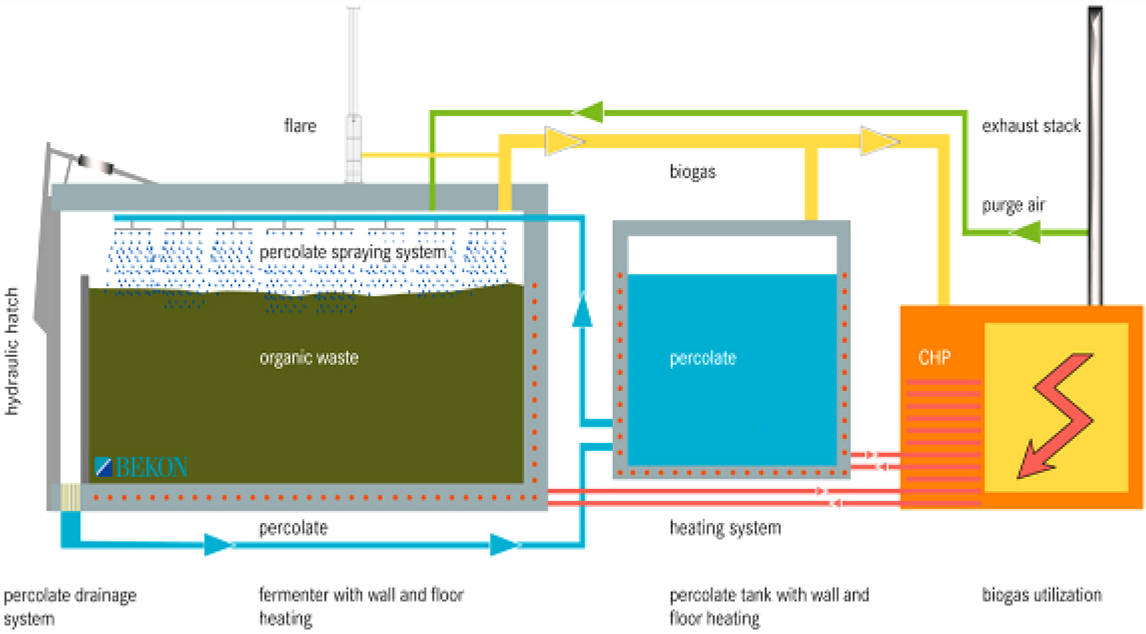

Fig. 1 - Fermentation in solid substrate with percolation [10]

Instead of the main phase of composting, organic waste is introduced into the fermenter (fig. 2) at a volume of about 58 m^3 and then producing biogas by means of a three-phase process.

The first stage is an anaerobic one, in which the material is ventilated into the fermenter. In the second stage the ventilation is stopped and begins anaerobic phase.

A percolators substance is sprayed over material and fermenting container is heated by underfloor. Generation of biogas begins and lasts approx. 2-6 weeks. When the material is analyzed in the last phase of the fermentation container is ventilated again and thus the process is stopped. The biogas is used directly, on the spot, via cogeneration unit in the form of electricity and heat. The remaining material is then processed and turned into compost through secondary composting process, [8].

Fig. 2 - MobiGas technological tank, [10]

Bioferm dry fermentation technology to produce biogas (bioenergy) manufactured by Bioferm company, differs from traditional systems of wet fermentation "digesters wet", which use a container that is loaded with raw material liquid, especially organic household waste containing the minimum solids to 25% mass of material, the materials mixed and stirred by means of mobile parts. Bioferm technology for dry fermentation (high solid content) uses a batch type of approach, in which the material remains stationary during the anaerobic digestion, internal moving parts are not necessary. These attributes allow dry fermentation digester to recover energy from almost any type of organic waste. Bioferm technology (fig. 3) uses non-continuous type digesters, where organic waste is loaded and remains in digester until material exhaustion, without internal mixing systems, [9].

Fig. 3. BIOFerm - dry fermentation technology, [11]

The digestion system (dry anaerobic fermentation) is composed of rectangular fermentation rooms, with dimensions of 114 x 23 x 17 m, in which the household organic waste and agricultural waste remain in methanogenesis process for about 28 days.

Modular design of the digestion system enables rapid adaptability of the system and a flow of organic waste annually about 8000-8500 tons.

Multitech SP-the German company (Fig. 4)-performs neutralization of organic agriculture and municipal waste through anaerobic digestion process -DFAD dry.

The process takes place in gastight premises, suitably divided; the variation is given by the amount of material available as feedstock.

The system is made up of chamber slides having more anaerobic digesters; the digestion process is continuous, the material is finished, being passed from a digester to another. Unlike the anaerobic wet fermentation process, dry fermentation system, the substrate does not have to be stirred.

Being a perfect gastight system, dry fermentation process does not emanate unpleasant odours and thermophilic environment in which the process is driven to determine final digestate that can be used as fertilizer.

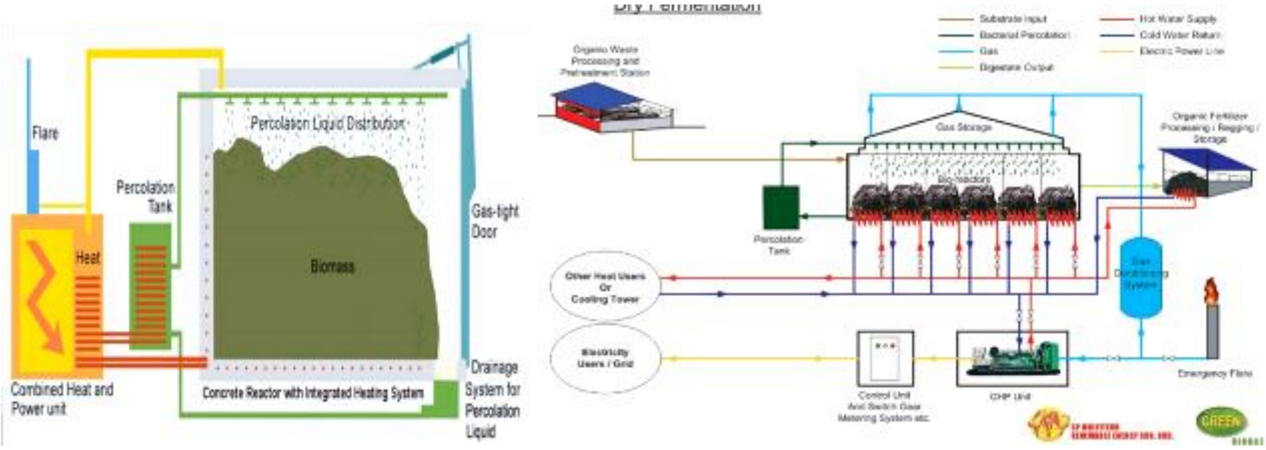

Fig. 4. - Digester and technological scheme by DFAD system [12]

RESULTS

By implementing the dry anaerobic digestion technologies, have been achieved good results with the poultry manure, which uses permanent litter.

When are used solid materials with high compaction degree, they form zones within the fluid is leaking and zones where the liquid never comes, and where the material remains undegraded.

The liquid has a crucial role in the fermentation of solid material, because it is the carrier of microorganisms to pass through the substrate and scatter them throughout the substrate table top.

The liquid has a crucial role in the fermentation of solid material, because it is the carrier of microorganisms to pass through the substrate and scatter them throughout the top table substrate.

By flowing liquid and other areas of the substrate, it will methanogenic microorganisms in areas where they are lacking.

This percolation is done because in fermentation system, in solid substrate fermentation system, there are no blenders as in closed system in order to obtain a homogenous substrate and methanogene microorganisms [5].

Table 1

Comparing the solid substrate fermentation system with liquid substrate system, [4]

Criterion	Solid substrate fermentation	Submerged fermentation system (liquid)
Substrate	Solid, wed (max. 50% total solids)	Liquid, pumpable (max 13% total solids)
Technology	Pre mixing, liquid flow through percolation flooding	Homogenization
Potential problems	Percolation system (clogged sieves, injectors)	Foaming, deposits, float, blocked pumps, agitators damaged
Equipment	Modules, fermenters in battery	Complex, continuous operating, multiphase
Malfunctions	It affects one or a batch mode	It affects the whole system
Energy consumption in the process	Low (only for pumps leaching, low power)	Low (only for pumps leaching, low power)
Energetic density of the substrate	High	Low
Emissions	Low	*High*
Necessary substrate	Solid manure	*Liquid dejections*

Dry fermentation system, achieved through technology and bioreactors (digesters) Bioferm® ™ system is most suited for operations which process organic waste with a higher total solids content of 25%, including:

- food waste,
- grooming the courts,
- dried animal manure bedding,
- other large quantities of solid waste

The anaerobic digestion substrates are classified with regard to their origin, dry substance content (DM) and methane production. In table 2 there are brief presented the characteristics of material type used in obtaining biogas. The substrates with dry substance content smaller than 20% are used for wet anaerobic digestion; manure and other wet organic waste coming from food industry are included here.

` When dry substance content is higher than 35%, the digestion type is called dry digestion. Dry digestion is specific for energetic cultures and silo materials.

Table 2

Characteristics of the digestible raw materials types [1]

Raw materials type	Organic content	Ratio C:N	DM %	VS% from DM	Biogas production $m^3 \times kg^{-1}$
Pig manure	Carbohydrates, proteins, lipids	3-10	3-8	70-80	0,25-0,50
Ovine manure	Carbohydrates, proteins, lipids	6-20	5-12	80	0,20-0,30
Poultry manure	Carbohydrates, proteins, lipids	3-10	10-30	80	0,35-0,60
Straw	Carbohydrates, lipids	80-100	70-90	80-90	0,15-0,35
Grass	-	12-25	15-25	90	0,55
Fruit waste	-	35	15-20	75	0,25-0,50

The produced biogas is collected in a special sack for storage and is then continuously fed by using biogas source.

Biogas can be used either in combined units of heat and power (CCP) for the generation of electricity and heat, or it can be improved and turned into natural gas sources (GNR) for injection into the gas grid and use as fuel vehicles as compressed natural gas (CNG). Biogas can be used either in units combined heat and power (CCP) for the generation of electricity and heat, or it can be improved and turned into natural gas sources (GNR) for injection into the gas grid and use as fuel vehicles as compressed natural gas (CNG).

CONCLUSIONS

According the new Frame Directive in 2009 proposed for RES, Romania should provide until 2020: a distribution of energy of 24% from total electric energy consumption and 10% from to total energy used in transport by biofuels.

The set of target indicators for electricity from RES set out in European Directives 2001 provide for Romania to reach by 2010 the distribution of 33% of energy from RES in electricity consumption Gross and compliance with European Directive for biofuels in 2003 to achieve in 2010 consumption of 5.75% from total bio-fuels in transport fuels.

Bioenergy obtaining (biogas) by dry methanogenesis processes by the help of technologies and digesters systems (bioreactors) presented within article is seen like a key solution for encourage sustainable development of the rural zones, which can support the production of non-food and energy crop cultivation and afforestation abandoned.

Thus the projects integration for establishment / development of plants / biogas installations in local / regional sustainable development, especially in rural areas, are a viable alternative and also suitable which can solve both energy issues and waste management and chemicalization decrease in agriculture by using digestate as fertilizer.

As long as the potential of urban and rural waste is very high it is expected that both the interest and investment in biogas to increase, especially in rural areas, biogas plants based on raw materials from agriculture (both from primary and the secondary production).

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INTEGRATED WASTE MANAGEMENT
/
GESTIONAREA ŞI MANAGEMENTUL INTEGRAT AL DEŞEURILOR

PhD. Eng. Voicea I.* [1)], Ph.D. Stud. Eng. Cujbescu D.[1)], Ph.D. Stud. Eng. Niţu (Roşu) M. [1)], Ph.D. Stud. Eng. Persu C.[1)], PhD. Eng. Matache M.[1)], PhD. Eng. Vlăduţ V.[1)], PhD. Eng. Dincă M.[2)], PhD. Eng. Moiceanu G.[2)], PhD. Eng. Ungureanu N.[2)] PhD. Eng. Toma L.[2)], Eng. Oprescu M.R.[3)]

[1)]National Institute of Research-Development for Machines and Installations Designed to Agriculture and Food Industry, INMA, Bucharest, Romania; [2)]UPB Bucharest / Romania; [3)]Condor Comimpex S.R.L. / Romania

E-mail: voicea_iulian@yahoo.com

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ABSTRACT

A major environment problem of nowadays society is the permanent increase of organic waste amount, this way the sustainable waste management, such as preventing the accumulation of waste and reducing the waste amount are major political priorities, this representing an important contribution to the common efforts to reduce pollution, greenhouse gas emission and climate change at world level. This article makes a synthesis regarding integrated waste management: municipal, industrial, waste generated by medical activities, organic resulted from agriculture and livestock sector etc., considering the possibility of using some of them for energy capitalization as bioenergy (biogas).

REZUMAT

O problemă de mediu majoră a societăţii de astăzi este creşterea continuă a cantităţii de deşeuri organice, astfel managementul durabil al deşeurilor, precum prevenirea acumulării şi reducerea cantităţii acestora sunt priorităţi politice majore, aceasta reprezentând o contribuţie importantă la eforturile comune de reducere a poluării, a emisiilor de gaze cu efect de seră şi diminuării schimbărilor climatice la nivel global. În articolul se realizează o sinteză privind gestionarea şi management integrat al deseurilor: municipale, industriale, medicinale, organice provenite din agricultură şi sectorul zootehnic etc., cu posibilitatea de valorificare energetica a unora sub forma de bioenergie (biogaz).

INTRODUCTION

The environment represents a responsibility that we should commonly take responsibility for. Taking into account the advanced environment degradation in the last decade, the involvement and responsibility degree of international actors increased. The preoccupation in respect to the environment appeared on the European agenda at the beginning of the 1970s. The European Union (EU) Environment Policy was created in the *Treaty establishing the European Community* and is aimed at ensuring the sustainability of environment protection measures. In the *Maastricht Treaty*, the environment protection becomes a European Union key-priority. There is mentioned the necessity of integrating and implementing the environment policy within sectoral policies such as agriculture, energy, industry, transport. The European Union determination regarding environment protection measures and the promotion of sustainable development at world level is recognized at international level. The sustainable development concept involves the implementation of certain mechanisms and policies that allow both economic development and conservation of the environment status at the same time, taking into account both the increase of responsibility degree as well as the increase of economic efficiency in order to minimize the costs for reducing the damages caused to the environment because of the human consumption.

The year 1992 marks the implementation of the *National Strategy on Environment Protection*, updated then in 1996 and 2002. The Strategy includes two parts and presents the national resources, items on the economic state, the quality of environment factors, environment protection principles, priorities and objectives (short-term until 2005, medium-term until 2010 and long-term until 2013).

The *National Waste Management Strategy*, adopted in 2002 following the transposition of the European legislation - Waste Framework Directive 75/442/EEC in Romania by Emergency Ordinance No. 78/2000 on the regime of waste approved with amendments and completions by Law no. 426/2001, by Emergency Ordinance No. 61/2006 approved by Law no. 27/2007 and the Government Decision No. 856/2002 on the keeping of waste management records and approving a list of waste. The Strategy was elaborated for 2003-2013 period; it was approved by Government Decision and it is revised periodically. The principles set out are: the principle of protection of primary resources, the principle of preliminary measures, the prevention principle, the “polluter pays” principle, the principle of substitution, the principle of proximity, the principle of subsidiarity and the principle of integration, while the general objective of the Strategy is to develop an integrated waste management system efficient from economic and environment standpoint. Also, waste are formally classified into municipal and assimilable waste (coming from households, institutional and commercial sources, service providers, street waste collected from public spaces, streets, parks, green spaces, construction and demolition waste, sludge from the treatment of urban waste water); production waste (generated by industrial activities) and waste generated by agricultural and livestock activities.

Based on the National Waste Management Strategy the *National Waste Management Plan* was created, comprising the actions undertaken to fulfil the objectives of the Strategy, how it is carried out, the terms and the responsibilities. At the same time, there are waste management plans at regional and county level, elaborated by Environment Protection Local and Regional Agencies, which are revised once every five years and they are aimed at creating the necessary framework for waste management objectives.

Romania ratifies by Law no. 3/2001 the Kyoto Protocol to the United Nations Framework Convention on Climate Change, adopted on 11 December 1997.

The National Strategy on Climate Change (NSCC), adopted by Government Decision no. 645/ 7 July 2005, has as general objective to fulfil the engagements and obligations Romania undertook at international level and, also, to elaborate and implement the objectives on adapting to the impact of climate change, reducing greenhouse gas emissions by the Romanian economy and using the mechanisms stipulated in the Kyoto Protocol. Romania ratifies by Law no. 24 of 6 May 1994 the United Nations Framework Convention on Climate Change, signed in Rio de Janeiro on 5 June, 1992. The Convention objective is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system.

The *National Action Plan on Climate Change* (NAPCC), adopted by Government Decision no.1877 of December 22, 2005, includes the concrete measures for implementing the National Strategy on Climate Change. These two documents were elaborated for 2005-2007 period.

In 2008, Romania adopted the *National Sustainable Development Strategy* in order to connect our country to the new sustainable development philosophy of the European Union. The National Strategy set short, medium and long-term strategic objectives:

- Horizon 2013: To incorporate the sustainable development principles and practices in the package of public programmes and policies of Romania as an EU member state.
- Horizon 2020: To reach the current medium level of European Union member states regarding sustainable development main indicators.
- Horizon 2030: To get Romania significantly closer to the medium level of the EU member states in that year in respect to the sustainable development indicators.

MATERIAL AND METHOD

- **Integration of European waste management legislation**

Romania needs to adapt national law to the European standards. The Emergency Ordinance no. 78/2000 on the regime of waste, approved with amendments and completions by Law no. 426/2001, takes into account the content of Directive 75/442/EEC on waste and Directive 91/689/EEC on hazardous waste.

National laws, ordinances, norms and technical standards on waste management can be ordered according to competence areas [2,3,4,5,6,7,8].There are different ways of waste management in order to minimize the risk for public health and environment. For a long time, waste management was made in a fragmented and relatively unplanned way. The experience showed that a sustainable approach of resources use and of waste management is necessary. The sustainable development is a balance between the needs of the economy, society and environment.

Integrated waste management systems combines waste flows, waste collection, treatment and disposal methods in a waste management system aiming the sustainable development, economic and social efforts acceptable for any specific region. It is made by combining waste treatment options including waste reduction, re-use, recycling, composting, anaerobic fermentation (biogas obtaining), heat treatment and soil controlled storage (Figure 1), [1].

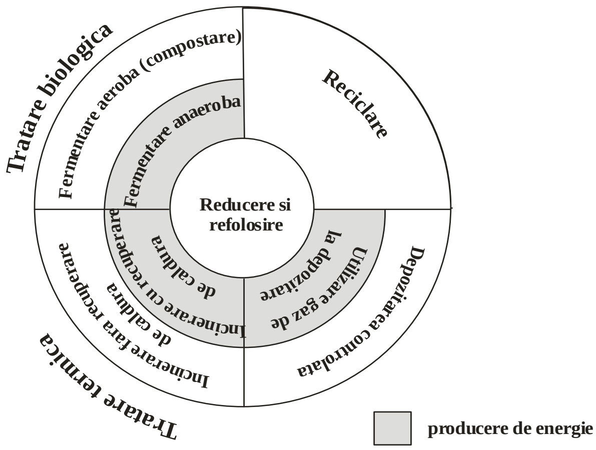

Fig. 1 - Elements of an integrated waste management system, [1]

The important thing is neither how many waste management options are used, nor if they are used in the same time, but how they are best combined as part of an integral approach. Integrated waste management takes into consideration the entire system and looks for the best combination of methods to minimize costs and maximize environment protection and the social benefit.

The integrated waste management principles are:

- integrated waste management makes possible for the decisions to be based on the best practices and transparent costs. The lower the amount of generated waste, the lower the costs for the waste generator. This offers incentives for the user to reduce the amount of generated waste;
- integrated waste management takes into account all options (collecting, recycling, composting, anaerobic fermentation, heat treatment with heat capitalization and soil controlled storage for the entire flow of municipal solid waste;
- division of responsibilities. The producers, distributors, en detail tradesmen and consumers are responsible for supporting integrated waste management.

Each group is responsible for the correct management of the waste it generates:

- three criteria are taken into consideration: the impact on the environment, economic efficiency and social acceptability;
- flexible application to different communities and regions;
- transparent costs for waste management;
- market oriented capitalization and recycling
- continuous assessment according to the quality and quantity changes of the waste flow.

Integrated waste management is a concept with different local applications and which depends on many variables such as the composition of waste flow, infrastructure, recyclable materials markets, budget, local legislation and the availability of storage soil. Integrated waste management looks for the best options for waste management with a focus on assessing all available strategies to offer more sustainable systems.

In respect to waste capitalization and recycling, within the Waste Management National Plan, several targets were set. Some of them are:

- material and energy capitalization of approx. 50% of biodegradable waste until 2013÷2016;
- energy capitalization of approx. 50% of sawdust until 2013÷2016;
- 22.5% recycling of plastic until 2013÷2016;
- 60% recycling, depending on weight, of paper and cardboard and 50% of metals in 2013;
- 60% recycling of glass, until 2013÷2016, [4, 5].

RESULTS

- **Municipal waste**

Quantities and composition Municipal waste represents all waste generated in the urban and rural environment coming from households, institutional and commercial sources, economic operators (household and assimilable waste), street waste collected from public spaces, streets, parks, green spaces, as well as construction and demolition waste collected by sanitation operators. In respect to municipal waste in Romania, the biggest part is represented by household waste (approx. 81%), while street waste and construction and demolition waste have approximately the same percentage – 10%, respectively 9%. More than 90% of this waste is eliminated through storage.

For the population not benefitting from sanitation services, the amount of generated (and not collected) waste is calculated depending on generation indicators set in the Waste Management Regional Plans, namely: 0.9 kg per capita per day in the urban environment and 0.4 kg per capita per day in the rural environment, [2, 3].

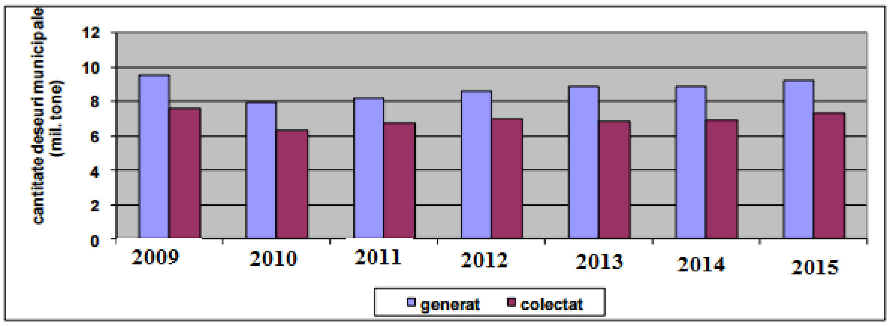

Fig. 2 - The amount of generated and collected municipal waste, in the period 2009 – 2015, [3]

In respect to household waste collecting system, the traditional mixed collection method is the most frequent, with a share of approximately 96% of collected household and assimilable waste. Selective collection still represents a reduced share, being in the process of extension.

The implementation of selective collection is to be approached in three stages, as follows:

- 2004 - 2006: experimentation (pilot projects), rising people's awareness;
- 2007 - 2017: extension of selective collection at national level;
- 2017 - 2022: implementation of selective collection in more difficult areas (collective residential buildings, dispersed rural environment, mountain areas).

In Romania, separate collection of municipal waste for the capitalization of packaging waste coming from household waste (paper, cardboard, glass, metals, plastic materials) is made on a small scale, within pilot projects initiated by sanitation operators and town halls in collaboration with economic operators which provide packages and packed products. These projects are ongoing, in collaboration with resident associations (for the population), schools, institutions and economic operators, and are in continuous extension depending on the results obtained and the available funds.

In 2009, at national level, containers for the selective collection of packaging waste were placed in 399 localities (including Bucharest 2, 5 and 6 sectors). Pilot projects are ongoing in 22 localities. The amounts collected at national level are shown in the following table:

Table 1

Quantities of waste collected at national level, in 2009

Selective collection						
Total amount of packaging collected (tonnes)	PET (tonnes)	Plastic (tonnes)	Paper / Cardboard (tonnes)	Glass (tonnes)	Metal (tonnes)	Wood (tonnes)
28,261.868	7,073.876	3,395.287	15,998.545	1,326.763	278.392	189.005
Pilot Projects						
Total amount of packaging collected (tonnes)	PET (tonnes)	Plastic (tonnes)	Paper / Cardboard (tonnes)	Glass (tonnes)	Metal (tonnes)	Wood (tonnes)
5,002.030	744.285	587.663	3,343.580	143.272	13.130	170.000

Source: National Environment Protection Agency

- **Biodegradable waste**

Romania's accession to the European Union imposed the compliance with the requirements of Community legislation on the environment in the waste management field. In the analysis of the legislative requirements it was found that, for an important field, namely the one stipulated in Directive 99/31/EEC on waste storage, transposed into national legislation by Government Decision no. 349/2005, the treatment of waste is necessary before storage, in order to reduce the fermentable content, as well as to reduce the organic matter content in the municipal waste that is to be stored. Article 5 of Directive 1999/31EEC stipulates targets to be reached in respect to progressive reduction of biodegradable waste storage, to 25% in 2006, 50% in 2009 and 35% in 2016, of the total amount in 1995 (base year). Member States which in 1995 or the latest year before 1995 for which standardized EUROSTAT data is available put more than 80% of their collected municipal waste to storage may postpone the attainment of the targets by a period not exceeding four years. This way, Romania will apply the stipulations in Paragraph 3 of Article 5(2) on the possibility to postpone by a four-year period the attainment of the reduction targets by 25%, respectively by 50%, until 16 July, 2010, respectively 16 July, 2013, [10].

In order to comply with the Directive requirements, the EU member states adopted different schemes and applied different technologies and practices to reduce biodegradable waste from storage and waste treatment before storage. The separate collection of waste to obtain the compost is a first step, useful and efficient, to recover and reduce the amount of stored organic waste. Depending on the material type and on the time necessary for composting, the member states apply different schemes, methods and technologies to obtain the compost. Composting allows obtaining a stable product, starting from an oxidative biological transformation process similar to what naturally happens in the soil, [11].

The specifications on the quality of the materials obtained after composting and their use were subject to many debates. At the EU level, there haven't been, so far, legislative regulations regarding the quality requirements for composts. Different countries, such as Germany, Denmark, Belgium, established by law very strict limit values for heavy metals, while other countries, such as Austria and Netherlands, allow guide values with bigger or smaller variations.

Biodegradable waste management in Romania remains a difficult and hard to solve problem, Although, in the last years, the share of biodegradable material coming from municipal waste decreased from 72% in 1998 to 61% in 2002 and to approximately 50% in 2008, the amount of biodegradable material per capita per year increased during this period, because the amount of municipal waste generated increased.

In Romania, the facilities for biodegradable waste processing are limited to: individual composting in rural area and the construction of micro-pilot platforms for composting biodegradable waste coming from urban area. In 2008, two composting facilities were functioning (in Piatra Neamt, Neamt County and in Chiesd, Salaj County), with a total capacity of 26,020 tonnes per year, producing an amount of approximately 2,900 tonnes of compost.

Together with the construction of composting platforms through integrated waste management systems at county level, a selective collection of biodegradable waste was made. The amount of biodegradable waste that are to be selectively collected will be established in the studies on implementing the national targets for reducing the amount of biodegradable waste stored, depending on the capacity of the composting facilities.

Biodegradable waste selective collection and its composting are solutions only for a small part of the biodegradable waste management matter. Only certain biodegradable waste flows can be collected selectively, the biggest part of them belonging to assimilable and household waste, especially coming from large urban areas. Other states' experience showed that in these areas the implementation of selective collection systems is not cost-effective and efficient. Unsorted household waste composting, as it was carried out in other countries (for example Germany), until mid-80's, proved to be inadequate, because given the important content of impurities and dangerous substances in the waste, low-quality compost could be produced and this leads to problems in respect to their use. Thus, other methods for biodegradable household waste treatment were searched. The selective collection of available flows, heat treatment and organic fraction mechanical-biological treatment have been imposed in most European Union countries.

- **Packaging waste**

Based on the Order of the Minister of Environment and Water Management no. 927/2005 on the procedure of reporting data on packaging and packaging waste, the data on packaging and packaging waste handled in 2008. Data analysis and interpretation was carried out within the National Environment Protection Agency (NEPA). The main results obtained and their interpretation are presented below. The total amount of packaging put on the market, in 2014, was of 1,170,700 tonnes, [4].

Table 2

Structure of packagings put on the market, based on material type, in 2014

Material type	Total amount of packaging put on the market	%
Glass	193,000	16.6
Plastic	332,600	28.4
Paper/cardboard	352100	30.0
Aluminium	25600	2.2
Steel	50100	4.3
Total metal	75700	6.5
Wood	215500	18.4
Others	1800	0.1
TOTAL	**1,170,700**	**100**

It is considered that the entire packaging amount put on the market turns into waste. In 2013, a total amount of 476,900 tonnes of packaging waste was recovered, out of which 392,300 tonnes were recycled.

- **Industrial waste**

During 2013, the amount of waste coming from extractive, energy and manufacturing industries was of 150 million tonnes, out of which, the biggest part (88%) is waste coming from extraction activities (mining) – 140 million tonnes, while 19 million tonnes represent waste generated by the energy and manufacturing industries. Non-hazardous waste generated by the main economic activities, except for extraction activities, in 2008-2013 period, is shown in Table 3.

Table 3

Non-hazardous waste generated, based on main economic activities, in 2008-2013 period

Economic activity	Quantity (thousand tonnes)				
	2009	2010	2011	2012	2013
Manufacturing industry	11,323.6	20,460.90	8,964.15	18,860.39	10,678.66
Electric and thermal energy, gas and water production, transport and supply	15,784.8	105,606.09	102,551.84	36,465.59	7,055.92
Water collection, treatment and supply	256.7	187.41	220.82	10.96	20.58
Other activities	219.8	595.96	483.92	1,494.34	506.52
Total	**27,584.9**	**126,850.36**	**112,220.73**	**56,831.28**	**18,261.68**

Hazardous waste, produced in 2013, of 434,941 tonnes, represented approximately 0.3% of the total waste amount (including waste coming from extractive industry). Most part of hazardous waste was eliminated by storing, co-incineration or incineration in generator's own facilities or in specialized facilities belonging to private operators. Taking into account its specific properties (for example: flammability, corrosivity, toxicity), it is necessary for hazardous waste management activities to be tackled rigorously. The amounts of hazardous waste generated by the main industrial activities in 2009-2012 period are shown in Table 4. It is to be noticed a decrease of generated hazardous waste amount, as a result of applying the best techniques in industrial activities.

Table 4

Hazardous waste quantities generated by main industrial activities, in 2004-2008 period

Economic activity	Quantity – thousand tonnes				
	2009	2010	2011	2012	2013
Extractive industry	1,214.4	997.18	497.59	11.24	31.11
Oil processing, coal carbonization industries	431.1	419.72	226.35	37.89	114.53
Chemical substances and products manufacturing	55.8	41.95	47.11	53.33	54.02
Metallurgical industry	383.5	95.43	168.76	121.62	150.78
Machinery and equipment industry	39.8	14.83	33.05	26.67	28.58
Means of Transport industry	23.5	30.72	26.19	31.06	13.33
Other activities	23.4	74.36	53.76	137.28	42.59
Total	**2,262.8**	**1,733.97**	**1,052.81**	**419.08**	**434.94**

- **Waste generated by medical activities**

The Ministry of Health, by the intermediary of the National Institute of Public Health, draws up every year the “Assessment of medical waste management system” national Synthesis and updates the national database on medical waste. The evolution of hazardous medical waste amounts is shown in Table 5.

Table 5

Evolution of hazardous medical waste quantities, in 2007-2009 period

Year	Estimate level	Estimated average quantities (t/year)	Average values (t/year)
2007	41 counties	12,373	**14,080**
	Bucharest	1,707	
2008	41 counties	10,864	**12,918**
	Bucharest	2,054	
2009	41 counties	6,607	**11,862**
	Bucharest	5,255	

Source: Bucharest Institute of Public Health

Compared to data reported for 2007 and 2008, in 2009 it is to be noticed a decrease of hazardous waste quantity coming from healthcare facilities with bed places by 15.75% compared to 2007 and by 8.17% compared to 2008. Medical waste collection, transport and storage within healthcare facilities are made in accordance with the specific regulations into force, drawn up by the central public health authority. Hazardous medical waste final treatment and disposal are made by heat sterilization (in installations belonging to healthcare facilities or in installations providing services for third-parties) and by incineration (in installations for hazardous industrial waste incineration).

- **Waste special flaws -** *Urban waste water treatment sludge*

The national legal framework for sludge agricultural capitalization was created by transposing Directive 86/278EEC on environment protection and, in particular, soil protection when sterilization sludge is used in agriculture, respectively by Order of the Minister of Environment and Water Management no. 344/2004. The limits stipulated in this normative act for heavy metals are lower than the ones in Directive 86/278/EEC, taking into consideration the project amending it. In 2008, an amount of approximately 125 thousand tonnes (dry substance) of sludge coming from urban waste water treatment was generated. Data were collected from urban treatment plants in Romania, with the proviso that, at the greatest extent, the amounts are estimated based on theoretical calculation, depending on the waste water flows that entered the treatment plant.

In order to encourage sludge recycling in agriculture, the following aspect needs to be considered: the development of sludge recycling in agriculture broadly depends on the possibilities to improve sludge quality and on increasing trust in sludge quality. This involves preventing at source waste water pollution, by reducing the possible heavy metal or organic compounds sources when entering the sewage system, and improving sludge treatment methods, as well as ensuring sludge quality assessment. These technical solutions require major investments to be made by waste water treatment companies or by local authorities for the changes in waste water treatment methods.

- **Organic waste generated by agriculture**

An important consequence of animal breeding is the production of significant dejection or organic waste amounts. In general, this organic waste coming from livestock is capitalized especially as important source of organic matter and mineral elements for agricultural soils. Animal breeding industrial farms are the biggest livestock organic waste producers but, often, they are also equipped with an entire collection, treatment, storage and/or recycling system for this waste. Medium and small farms and, very frequently, individual households generate livestock organic waste they cannot manage, which makes that these materials become, at least, harmful for the environment.

In order to underline livestock organic waste production and economic importance, we are going to make, first of all, a presentation of the main organic waste types, coming from this highly important economic sector. Amongst the most important livestock organic waste is: ***manure, manure must, urine, liquid dejections*** (also called ***slurry***) and ***semifluid dejections*** (***paste*** or ***sludge***).

The amount of dejections an animal produces depends on several factors. Animal waste, without special risks, can undergo industrial processing and producing of meat, bone or blood meal or mixed meal, through different heat treatments. By-products and other organic waste coming from animals without communicable diseases, bred in isolated farms, remote from industrial processing centres, can be neutralized by composting mixed with other vegetable organic waste.

It is admitted that, in the case of ***loose housing*** dairy cows, the amount of straw necessary for bedding per day is double compared to the tied system, which raises the manure amount to 18-20 tonnes per year per animal. Under these circumstances, it can be expected from a diary cow to produce, per year, approximately: 100 kg of nitrogen, 50 kg of phosphorus, 120 kg of potassium and approximately 2000 kg of humus, amounts that are 50% lower in the case of ***tied system***. A tone of decomposing manure contains: 700-800 kg of water; 200-300 kg of dried substance; 4.5-5.5 kg of nitrogen; 2-3 kg of phosphorus; 5.5-6 kg of potassium; 4.5 kg of CaO; 2 kg of Mg; 0.5 kg of S; 4 g of B; 2 g of Cu, etc.

An important part of the nitrogen in natural organic fertilizers coming from animal dejections can be found as ammonia, a big part of which is lost through loading, transport and application to land works. In order to maintain losses below 30%, loading and spread on agricultural field operations must be made efficiently, fertilizer incorporation must be made immediately, even superficially, especially when the application is made in warm and windy weather. Mineral nitrogen (ammoniac and nitric) in organic fertilizers is immediately accessible to plants, similar to the one coming from other sources (humus mineralization or industrial produced fertilizers).

In the process of fermentation within animal dejections platform, together with cellulosic vegetable remains from the bedding, in a period of 4-5 months up to 25% of organic substances and nitrogen contained in the fresh manure is lost. To reduce organic substances and nitrogen losses in the fermentation process it is appropriate for the placement within the platform to be as pressed as possible and if the pile is well organized to retain the entire amount of urine and manure must, the losses of phosphorus, potassium and microelements in manure fermentation process totally disappear.

- **Manure must**

Manure must is collected within platforms specially created for manure storage and fermentation, by accumulation in closed storage tanks.

- **Slurry (**fluid dejections**)**

Fluid dejections, also called slurry, are obtained by collecting the material coming from washing the stables with small amounts of water (at a ratio of 1/2-1/3 dejections to water). The chemical compound of fluid dejections differs depending on the species they come from, bedding type and amount, dilution degree, etc. For use, foreign solid parts are removed and it is homogenized (periodically and when it is used). It can also be used the liquid part separate from the solid one.

Unfermented and undiluted slurry contains approximately 0.5% total nitrogen (most if it ammoniac), 1.7% K_2O and 0.02 % P_2O_5. For use on agricultural fields, the blend must be diluted at a ratio of 1/6 when mineral fertilizers were used as basic fertilization and a dilution of 1/4 when organic fertilization is the main one. It is a very good fertilizer for grassland, fruit-growing and vegetable growing. A 30 – 50 m^3/ha amount is used, depending on the soil texture namely, a lower amount is used for sandy soils and a higher one for the clayey ones. The spread is made in cool weather (to diminish NH_3 volatilization), when there is no wind, in order to avoid drying and incorporation is compulsory, with deeper works in sandy soils and superficial works in heavy soils, [1].

Fig. 3. - Uncovered, closed tank, for fluid dejections (slurry) collection, according to EU regulations, [1]

- **Semi-fluid dejections** (paste, sludge)

Fluid and semi-fluid dejections are collected from poultry growing batteries, from shelter tanks. They contain a maximum amount of 15% dry substance and they are rich in phosphorus. In order to be used, they must have no solid parts and must be homogenized before and during usage. Used during the growing process, they have a rapid action, the mineral elements being immediately available for the plants, with extremely favourable effects on their growth and development.

- **Waste water coming from livestock**

In the last decades, together with the traditional animal and poultry breeding system, in the small individual household, the breeding system in industrial type farms developed, using modern methods in animal housing, fodder preparation, feeding automation as well as other technical measures. Specific to these livestock farms are the large agglomerations of animals or poultry in a very small space.

The composition and the ratio of solid and liquid dejections vary greatly with the type and amount of fodder. The more concentrated, the dejections have a higher content of nitrogen, phosphorus, potassium, etc. When animal food is rich in nitrogenous substances, liquid and solid dejections are richer in nitrogen. The better digested dry substance in food, bigger the content of nitrogen, phosphorus, potassium, etc. in liquid dejections and lower in the solid ones. When the food is fibrous, dry substance amount is higher in solid dejections, and when it is made up of juicy fodder, then, liquid dejections are in greater amount.

Residues removal (dejections + food remains + disinfection) is usually done by using water under pressure to take it to the sewing system. In the case of poultry complexes in breeding battery system with no added water dejections discharge or in poultry or sheep bedding growing system, dejections removal is water free.

Factors that influence the resistance of soil to the pollution occurred following soil dissemination of pathogenic germs residual products include the number and type of organisms, soil type (structure, moisture, pH, organic matter content), temperature, rainfall, amount of sunlight and microbial flora competitiveness.

Raw waste water discharged from *pig breeding farms* is separated within the treatment plant in a liquid fraction called *decanted waste water* and another solid one, the decantation sludge. Decanted water is a valuable nitric-potassic-phosphoric fertilizer that can substitute, to a certain extent, the need for chemical fertilizers, but it can generate, in certain situations, serious environment protection problems.

The characteristics of waste water coming from cattle farms are influenced by the following factors: urine composition (depending on the animal's age, weight, ratio used, physiological state), properties of the water used in the complex, bedding used, fodder remains and other impurities that are part of the hygienization process, amount and quality of products used for disinfection and deratization, removal type and climate conditions.

The final conclusion is that waste water coming from cattle can be used for irrigation in order to capitalize their high content of nutrients (N, P, K), but their high content of soluble salts requires either diluting them, or applying reduced rules, furrow application to avoid contact with the plant, only for salinity tolerant plants and on soils with proper drainage.

In **poultry units** equipped with batteries, dejections collection takes place on glass beds provided under each battery level, while removal is done by scraping at the shelter end in a transverse channel, under the floor level and from here through a screw conveyor to a tank placed outside the shelter. From the tank, which is emptied daily with the help of vacuum trucks, the dejection mixture (fodder remains, dust and water) is stored in special basins until it is used. Considering the mixture composition, treatment is necessary in order to separate the solid fraction and remains the so-called waste water which, due to the high content of nutrients (N, P, K), represents the source of fertilizing substances for plants.

- **Sludge coming from decantation of waste water from industrial animal breeding farms**

The effluent removed from shelters as raw or semi-fluid waste water, depending on the species and breeding system, must be separated in a controlled manner in a liquid fraction and a solid one, namely irrigation water and shovellable organic fertilizer, with a content of humidity of maximum 70%. In respect to dejections coming from pig farms, in the decantation plants the raw primary sludge is formed, but in the case of the other species (ovine, bovine, poultry) we cannot talk about sludge in the real sense of the word, but about semi-fluid dejections with variable humidity (85-95%) depending on dejection removal system, water loss in the system and supplementary water added to ensure the transport outside the shelter.

Sludge generated by waste water treatment plants and pig breeding farms is a mixture including solid dejections, a small part of bedding materials, food remains and different other foreign parts. The high variability of the components presented above and sludge separation method determine its chemical composition as follows:

- total nitrogen: 1.5 — 3.4 % of the dry substance;
- total phosphorus: 0.95 – 2.0 % of the dry substance;
- total potassium: 0.11 — 0.30 % of the dry substance;
- mineral salts (mineral residues): 700 - 1970 mg/100 g d.s., of which:
- calcium: 213 mg/100 g d.s.;
- magnesium: 153 mg/100 g d.s.;
- sodium: 15.2-51.5 mg/100 g d.s.;
- chlorine: 15.5 – 348.6 mg/100 g d.s.

Depending on sludge content of nutrient and salt elements, it can be considered an organic fertilizer rich in nitrogen and phosphorus, poor in potassium and with a high content of salts.

Fresh sludge is very rich in microorganisms, about 1 million cells / g sludge dried at 105 ° C, represented mostly by aerobic saprophytic bacteria. Dehydrated fresh sludge doesn't contain substances that are toxic for microbial life in the soil; on the contrary this sludge stimulates it.

- **Livestock waste agronomic value**

Organic matter is part of the terrestrial ecosystem where autotrophic green plants are the main energy carriers. It is a source of nutrients but, in the same time, it influences soil physical and physicochemical characteristics, as well as the energy material soil microflora needs and the mobility of certain nutrients.

Humus is the main compound of soil organic matter, being a stable fraction of it. Humus represents the main reservoir for plant nitrogen nutrition and is used by plants only as the organic matter is oxidized by microorganisms. It contains an average amount of 3.5-4% N, 45-60% C, 34-45% O, 0.3-5.5% H, below 1% mineral substances. Humus is the main nutrition source for soil microorganisms. Every year, in the microbiologic activity, an average of 0.5-1% is mineralized, resulting 50-100 kg N/ ha, [10].

The balance of the soil organic matter is realized when losses through organic material mineralization don't surpass soil humifiable organic matter inputs made in different ways.

In the field of livestock production, residues capitalization was imposed by generalizing the concentration and specialization process based on species and products, solving trends referring to two main ways: continuous decrease of specific consumption, improving the technologies regarding collection, storage and livestock residues treatment and the preservation of the natural environment, [11].

Agriculture can become the main user for all livestock residues, this way ensuring an energy base that can be permanently renewed and by the intermediary of which it can provide high and quality productions, while also protecting the environment.

- **Organic residues effects on agricultural soils**

Soil organic matter is made of microorganism biomass in the soil and of materials, which is different, in terms of decomposition stage and association degree, from the mineral matter. These different forms of soil organic matter are a huge reservoir of nutrients for cultivated plants.

The effects of organic residues on soils are in general benefic through organic matter and nutrients contribution which improve soil properties. Nevertheless, these beneficial effects are obvious only when the contribution of organic matter coming from organic residues is correlated with other agricultural technology elements. The effects of organic matter contributions depend, first of all, on tillage.

Soil organic carbon is considered one of the key-elements for its fertility. Soil organic carbon levels are affected by agricultural practices and complex processes in which the tillage system has a strong influence on soil stratification and evolution. Organic carbon accumulation in the soil depends on time evolution and on physical and chemical protection against microorganisms and soil erosion. Turning furrows over (reversing soil layers) and soil pulverization by annual ploughing works accelerate organic matter decomposition and this affects physical, chemical and biological properties of the soil, which represent the key of its quality attributes.

Tillage techniques have a high impact on organic matter localization. The major impact of tillage practice is especially the change that occurs on the localization of organic carbon, with a very pronounced gradient when tillage is not carried out. If performing annual tillage is the main cause of reducing an important amount of organic matter, one of the most pronounced effects of "zero tillage" system, performed continuously, is its redistribution and stratification on the soil profile. Numerous studies have proved, over the years, the hypothesis that conservation tillage allows maintaining significant proportions of organic matter in the soil and improves its structure. Also, over the time, crop productions substantially increase.

- **Use of organic waste as fertilizers**
  - **Current situation at world level. Organic waste dangers.**

Economic advantage is represented by sanitation and artificial fertilization cost reduction. In the United States, more than 24% of total solid manure is formed of vegetable and animal remains generated by households. Specialists say that organic waste should not be found in manure or at the incineration plant, because, on one hand, treating this waste, according to standards, is an expensive process, which fails to comply with many rules, fact that involves the risk of transforming it in an important source of methane and other toxic substances pollution and, on the other hand, the alternative of obtaining the compost, in individual households, is an important contribution to reducing pollution and the costs generated by organic waste management in sanitation companies.

  - **Strict recycling rules**

Composting is practiced widely by sanitation companies. In this case, observing the strict rules for obtaining the compost is very expensive, while non-observing them generates serious effects on the environment.

Defective composting can pollute soil with substances harmful to the plants, and methane which is released in large quantities, in such a situation, contributes, more than carbon dioxide, to global warming, or may cause explosions, by accumulation in enclosed spaces, where it may infiltrate. For these reasons, in 1999, the European Union issues "European Landfill Directive", with strict regulations on waste recycling by composting.

Countries like Belgium, Netherlands, Germany and Austria observe them, while Great Britain, Spain and Italy register delays. In Romania, composting issue, as ecological and economic alternative to landfill solution, has not been tackled yet. There hasn't been at least a preoccupation on training citizens how to practice composting in households.

CONCLUSIONS

National Energy Strategy, integrating the **Strategy for Capitalization of Renewable Energy Sources**, established based on the estimates of energy potential from renewable energy resources (RES), during EU accession negotiations, a system of green certificates obligatory quota that had to be reached until 2010 (33% of total electric power must be ensured by using RES) and a green certificate trading system. In this respect, all electricity suppliers must buy RES energy according to the quota stipulated by law. Non-observing this requirement involves important penalties. Unfortunately, Romania's quota has not been established according to the real situation, because hydrologic potential is already exploited at this level, which creates a disadvantage, from this standpoint, for other renewable energy resources, among which biogas.

Bioenergy (biogas) production by methanogenesis processes both dry and wet is seen as the key to encouraging sustainable development of rural areas that can support production of non-food goods, energy crop cultivation and afforestation of abandoned lands.

Waste analysis shows that Romania presents a very high potential for generating materials that can be used as raw material for biogas production:

- ✓ it presents a very high potential for biogas production by using primary production waste;
- ✓ potential for biogas production by using animal waste is a little lower;
- ✓ potential for biogas production by using solid urban waste is also very high;
- ✓ potential for biogas production by using sewage sludge is very high too;
- ✓ potential for biogas production by using food processing waste is a little lower.

In order to reach the sustainable development requirements, two biomass categories can be considered as the most suitable, especially for biogas production:

A. agricultural organic waste – resulted both from primary and secondary production;
B. other organic waste – urban waste, food industry waste and sewage sludge.

Regarding agricultural waste, Romania's potential is also high when it comes to farm-type diversity, from permanent crop farms to field plant ones and different types of animal and mixed farms, these last two types being very numerous. Nevertheless, the big number is counterbalanced by the high fragmentation degree, but the tendency to reduce farm fragmentation by aggregation and land lease is a positive factor for biogas projects implementation/development.

In the case of animal farms, biogas installations can also represent a very advantageous solution for waste management. Of course, the best areas are those with a high number of animals and a small number of farms, as Romania's South-East region.

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ECONOMIC IMPORTANCE OF LIVESTOCK FEEDING WITH WET FLATTENED CORN GRAINS
/
IMPORTANTA ECONOMICA A FURAJARII ANIMALELOR CU BOABE DE PORUMB UMED APLATIZATE

Ph.D. Eng. Ciobanu V., Ph.D. Eng. Vişan A. L., Ph.D. Eng. Păun A., Ph.D. Eng. Ciuperca R., Eng. Bunduchi G.
[1)]INMA Bucharest
Tel: 0735740689; E-mail: dns.gabriela@yahoo.com

Keywords: *wet grain, crushed, corn, forage, flattening*

ABSTRACT
The paper presents the economic advantages of livestock feeding with wet flattened corn grains, and also the flattening and ensiling technologies compared with dry corn grain technologies. Also, the paper presents the current state of research regarding the corn feeding importance and superior capitalization technologies.

REZUMAT
În lucrare sunt prezentate avantajele economice ale furajării animalelor cu boabe de porumb umed aplatizate, precum şi a tehnologiilor de aplatizare şi însilozare a acestora, comparativ cu tehnologiile de furajare a boabelor de porumb uscat. Totodată se prezintă stadiul actual de cercetare privind importanţa furajeră a porumbului şi tehnologiile de valorificare superioară a acestora.

INTRODUCTION
In 2014 the European Union is one of the largest cereal producers, according to statistics collected by the United Nations Organization for Food and Agriculture (FAO), reaching 28.5 million tons of cereals higher than in 2013 and higher with 17.4 million tons than the previous peak production that was recorded in 2008. The wheat, corn cob and corn grain production reach almost 68.2% out of cereal production registered in the European Union

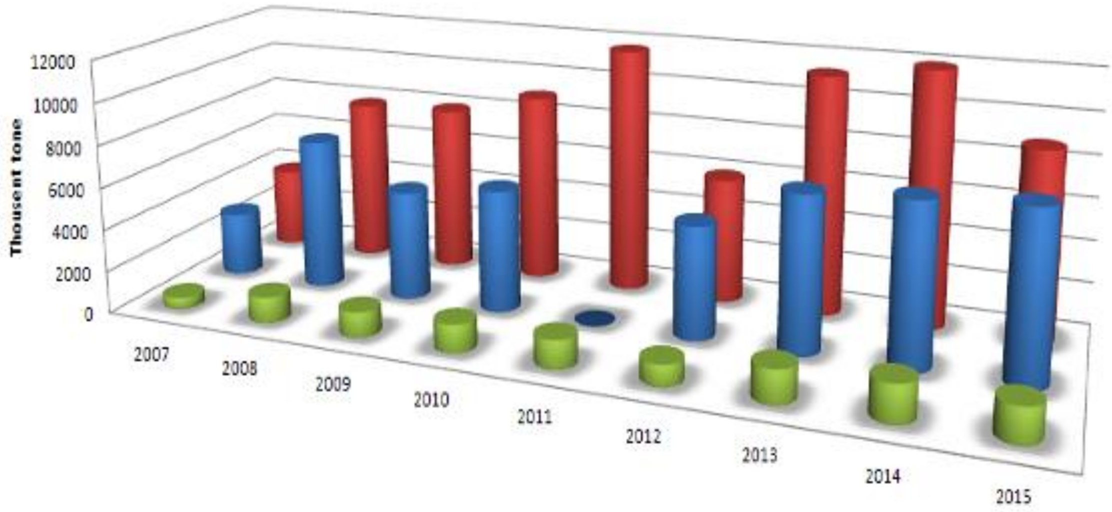
At European level in 2014, Romania achieved a production of 11.73 million tons of corn grain, from cultivated area of 2.43 million ha, which represents a yield of 4813 kg/ha. In the second place is France, that had reached a production of 18.39 million tons from 1.77 million ha of cultivated area, which represents a yield of 10,383 kg/ha, seen in Table 2 *(Ciobanu V. G., Visan A. L., Ganea I. C., Ancuta Nedelcu, 2016)*.

Table 2

Production of grain corn in 2014 at European level

Country	Cultivated surface (thousand ha)	Production (thousand tonnes)	Yield (kg/ha)
Romania	2438.0	11734.2	4813
France	1771.7	18395.0	10383
Hungary	1185.0	9168.8	7737
Italy	858.0	8332.7	9712
Poland	678.2	4468.4	6589
Germany	481.3	5142.1	10684
Bulgaria	440.0	3110.0	7068
Spain	417.5	4692.0	11238
Austria	216.3	2334.4	10792
Slovakia	213.0	1689.2	7931

Based on INS documents, the Ministry of Agriculture and Rural Development made several reports as "Romanian Statistical Yearbook 2016" and "Vegetable production for main crops in 2015", it can be stated that that corn production was on first place in the last 9 years, figure 1.



	2007	2008	2009	2010	2011	2012	2013	2014	2015
barley crop production	531.4	1209.4	1182.1	1311	1329.7	986.4	1542.2	1712.5	1582
graine crop production	3044.5	7181	5202.5	5811.8	0	5297.7	7296.4	7584.8	7851
corn crop production	3853.9	7849.1	7973.3	9042	11717.6	5953.4	11305.1	11988.6	8871

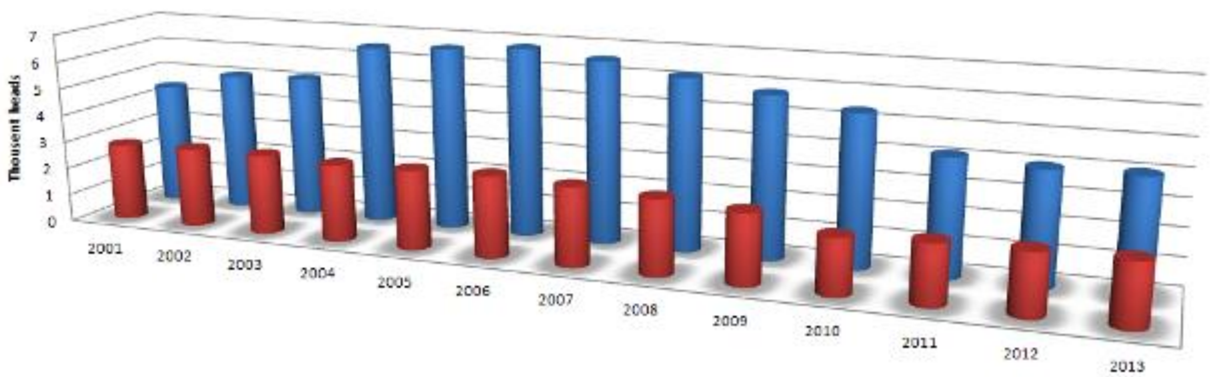
Fig.1 – Romanian cereals production evolution

Considering that the corn is one of the most important crops worldwide from economically point of view, because it's used in multiple purpose, such as: 21% in food industry; about 7 % in industry and 72 % in livestock feeding *(Marsh P. S., 2010, Pandrea R. C., 2012, Pop M., 2014).*

One of the most important cereal raw materials affecting livestock sector is corn, according the greatest specialists in this field, due to the fact that has a high concentration of digestible nutrients substances and high energetic value.

For this reason is used in all livestock sectors as feeding material, especially for those intended for meat, respectively pigs and cattle, which represent an important percentage in food industry sector. In livestock nutrition, corn grains represent an important percentage that is estimated at 80 % out of entire concentrate blend fodder administrated on pigs and cattle, 70 % for poultry feeding and only 30 %for other livestock categories *(Acatincăi S., 2003).*

At national level, the livestock number decreased in last 13 years, as may be seen in figure 2, statistic done based on Agriculture Ministry and Rural Development reports. This tendency is due to complex socio-economic measures adopted by the government and also due to meat and animal products imports from European countries.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
cattle effective	2.8	2.878	2.897	2.801	2.862	2.934	2.819	2.684	2.512	1.985	2.13	2.164	2.197
swine effective	4.447	5.058	5.145	6.495	6.622	6.815	6.565	6.174	5.793	5.387	4.153	4.011	4.054

Fig.2 – Romanian livestock evolution in animal farms

The medium and long term rehabilitation and recovery objectives in this sector are many. The most important ones are "sustaining the revival of the livestock sector in order to increase the quantity and quality of cattle meat production" and "sustaining the stimulation of protection national product scale applying the EU mechanisms".

Economical importance wet flattened corn grains as feeding material

One of the most important cereal raw materials that could significant influence the economic state of livestock breeders is corn, due to its high level of digestible nutrient and a superior energetic value.

These statements are backed up by research carried out by British researchers in this field which are dated from 1917, through which have shown that the nutritional value of corn grain is superior for the grains that register a humidity between 35 … 40 %, [11]. In table 2 is presented the equivalence between dry and wet corn grain.

Table 2

Equivalence of wet and dry corn grains [11]

Grain properties	Dry grains	Wet grains					
Humidity (%)	14	24	26	28	30	34	36
Dry substance (g/kg)	860	760	740	720	700	660	640
Digestible energy (kcal/kg)	3400	3000	2920	2840	2765	2610	2530
Equivalent weight 1 kg of dry corn grains	1.00	1.13	1.16	1.19	1.23	1.30	1.34

Thereby, at the end of 60's it was developed a technology dedicated for high humidity fodder as: harvesting, flattening and ensilage, that appeared as a result of economic pressure due to the animal products falling prices, reducing the costs of feed production, growth of animal husbandry production and reducing the feed concentrates ratio.

At European level, the use of wet flattened grain concentrates was spread especially in cattle and pig livestock units from France, Czech Republic, Germany and Denmark, due to economic benefits. Form technical point of view has been identified major benefits, such as lowering the cost of wet cereal silage from 54 % until 58 % compared to dray flattened grain; these figures were obtained by Finland TTS Institute in 2008.

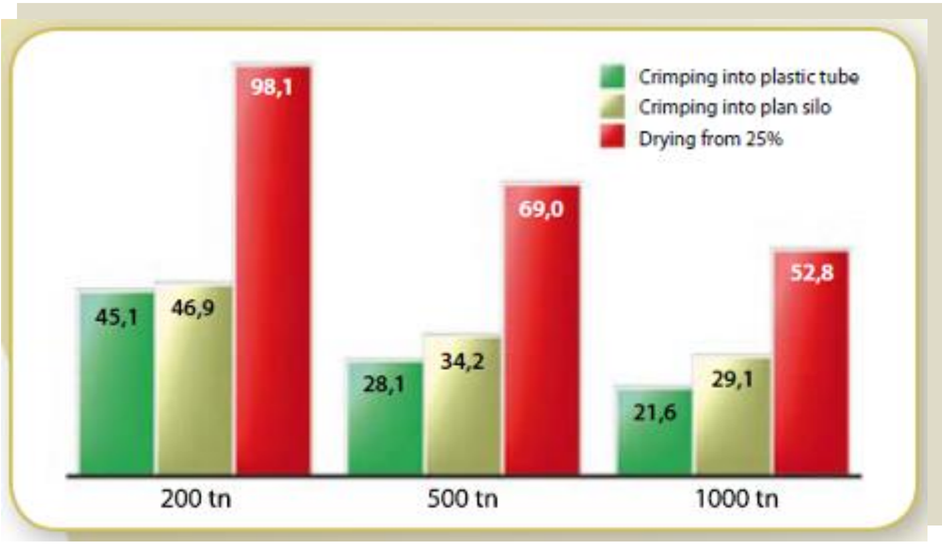


Fig. 3 - Ensilage costs of wet and dry grains

These data were also confirmed by MURSKA company, one of the largest enterprise in the field, which showed that expending this research to 100 tons of wet cereal ensilaged in large plastic bags were saved 8435 Euro/year in preservation period, that leads to a total saving of 10265 Euro/year for 200 tones, amount that can multiply proportionally with the storage capacity.

One can say that the preserving method of wet grain can be successfully adopted in national agriculture and livestock farmers sector, if it has the sustained economic impact presented above [10, 11].

Also, wet grain ensilage technology can be successfully used for considerable corn quantities obtained from varieties derived from delay or doubles hybrid crops. In this way it is superior capitalize the grain crops that do not reach maturity in autumn and the cereals are harvest in order to processed by a complex technology that comprises flattening, flaking and conservation equipments.

The superior capitalization in agricultural units of wet cereal silage requires an adequate technology to ensure good quality and high nutritional value forage, as it is claimed by French researchers from ARVALIS in the scientific papers published in 2009 and 2011, (the level of energetic digestibility of wet corn grains is with 4 and respective 8 % higher than that of dry corn grains) [10, 11].

In Figure 4 are presented two technological procedures regarding cereal flattening silage in silo cells and in polyethylene tunnel bags.

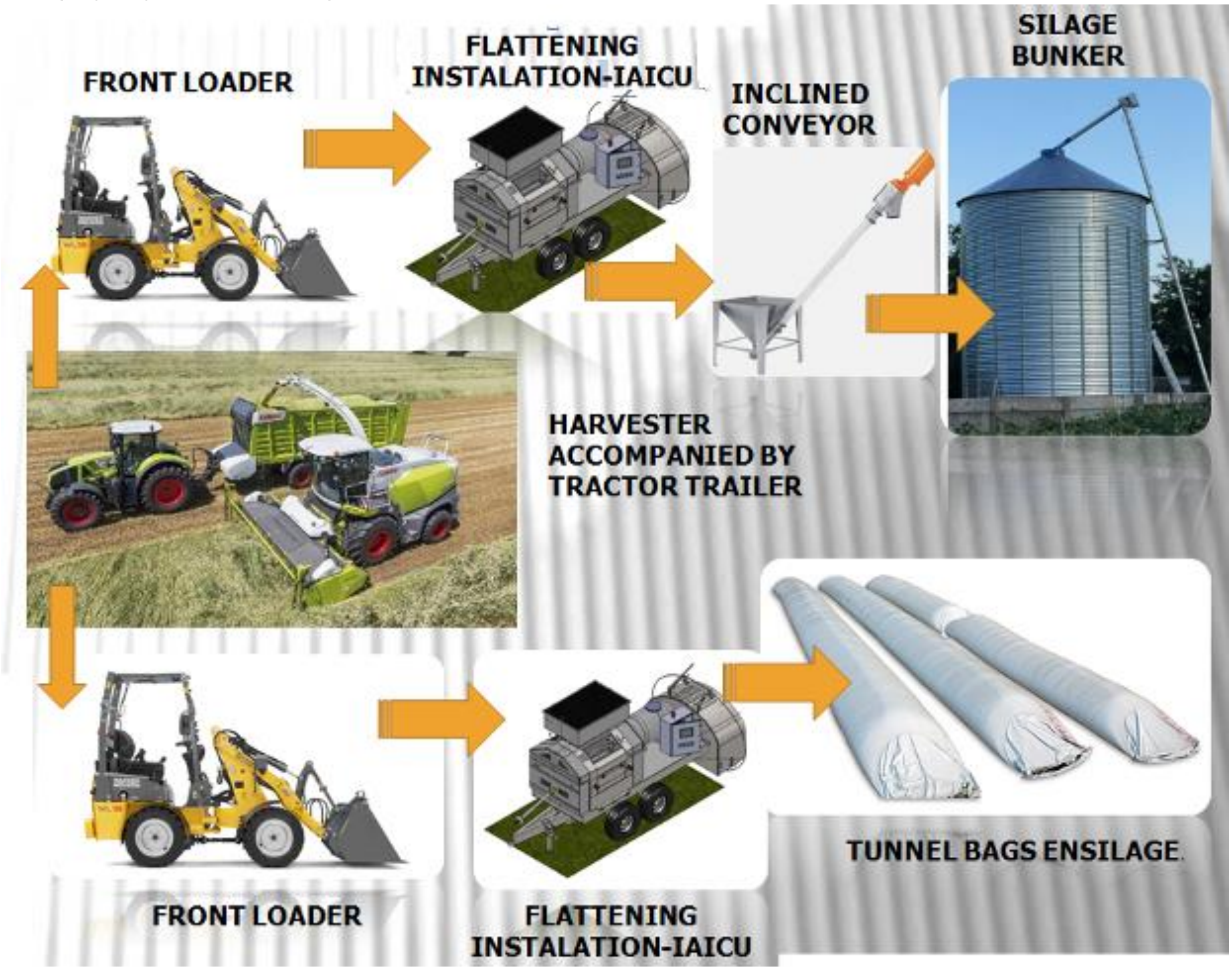


Fig. 4 - Harvesting, flattening, ensilage of wet cereal grains technological sheet
(Ciobanu V. G. , Visan A. L., Ganea I. C., Nedelcu A., 2016)

Using this technology improves farms profitability, respectively applying an advantageous method to produce high-quality livestock fodder, by reducing energy consumption and investment costs (drying, transport and storage equipments).

In addition to economic benefits, flattened wet grains have more advantages than dry ones from biologic point of view, namely: higher digestibility, higher energy value and high nutritional value. Also, it has been found that the energy digestibility of the wet corn grains is higher by 4 respectively 8 %, than that of dry one, mainly, by a better digestibility of starch and lipids, see figure 5 *(Cazaux J. G., 2011)*.

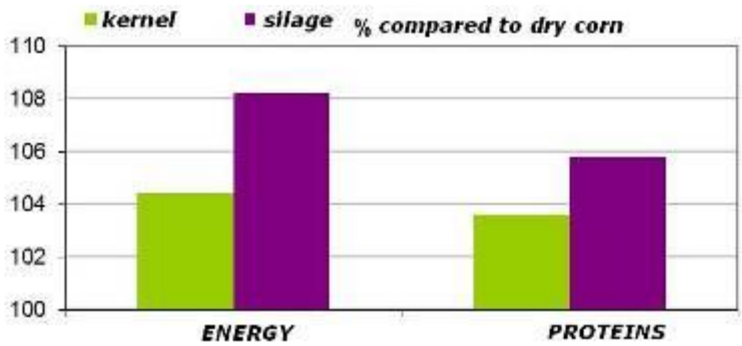


Fig. 5 - Animal energy and protein increase when are feed with wet corn grains in analogy with dry grains (=index 100) *(Cazaux J. G., 2011)*

In practice, it has been found that in swine farms where wet grains was used for feeding, the food conversion index was improved, through body weight growing and a period reduction until slaughter, in analogy to classic feeding, table 3, [10].

Table 3

Advantages of using flattened wet grains [10]

Digestibility	Dry grains	Flattened wet grains
Organic matter (%)	85	88
Raw protein (%)	81	87
Phosphorus (%)	39	53
Period until slaughter (days)	84.6	87.6
Weight growing per day (g/day)	912	876

Same results were recorded also constraints within cattle farms, which led to: weight growing from 1.5 … 3.4 kg; reduction of period until slaughter by 12.9 days; higher carcass weight from 294.6 … 286.9 kg, respectively from 51.6% … 50.8%; improvement of food conversion from 8.20 … 11.29 kg DS/ kg carcass *(Marsh P. S., 2010)*.

The flattening machines have a great economic impact also in concentrated fodder industry because it increases the diversity of livestock feeding recipes and quantity reduction.

Preservation methods of grains containing 30 – 40% humidity

Cereal grains harvested at high humidity are flattened using special machines as in figures 6 - 7, equipped with one or more pairs of grooved drums that performs the wet grains flattening process and administrate conversant on flattened grain surface by spraying. In some cases these equipment are provided with mixing conveyors to ensure that the bio-conservation/conservation substances to be evenly distributed over the flattened material which will be ensilaged.

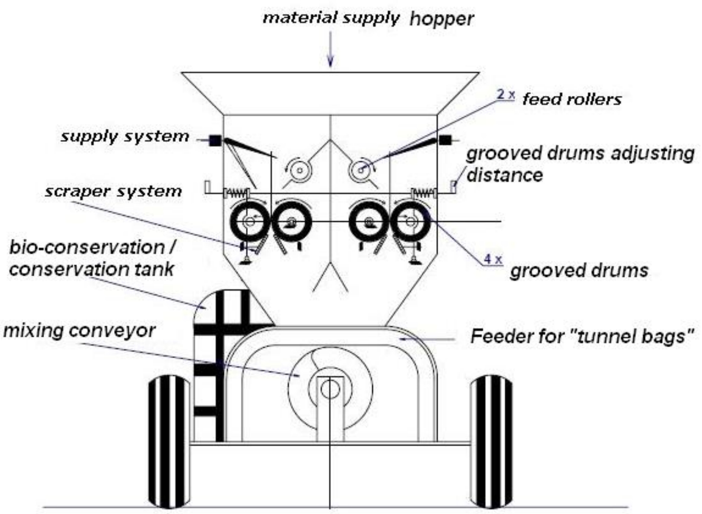


Fig. 6 - Wet cereal flattening machine – Frontal view
(Ciobanu V. G. , Visan A. L., Ganea I. C., Nedelcu A., 2016)

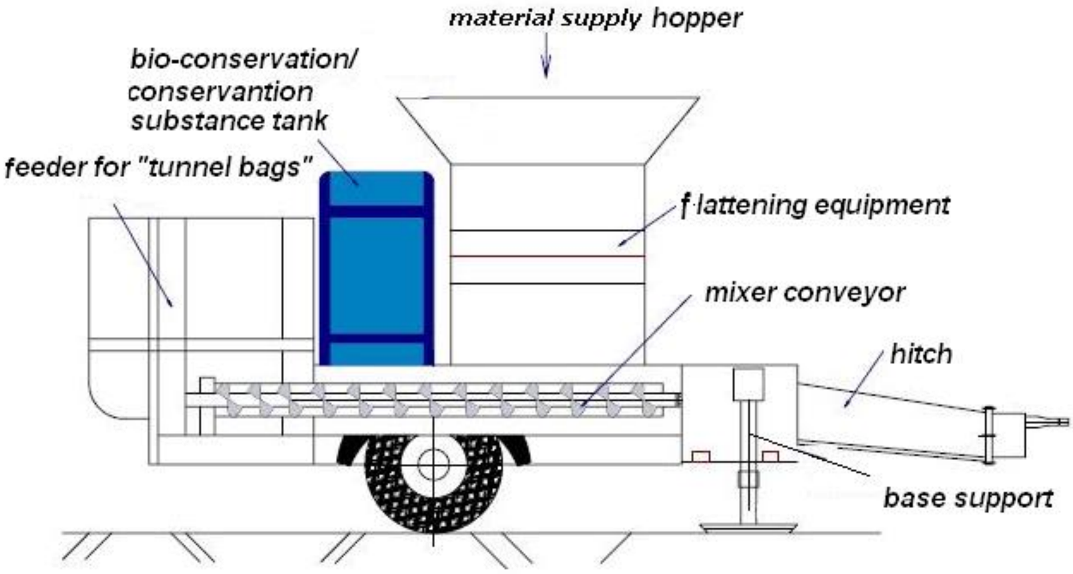


Fig. 7 - Wet cereal flattening machine – Lateral view
(Ciobanu V. G. , Visan A. L., Ganea I. C., Nedelcu A., 2016)

Wet cereal flattening machines present the advantage that can also be used in the dry grains preservation process without grain flattening, by adjusting the distance between rollers at maximum.

Flattened wet grains preservation process is achieved by ensilage. Due to compaction of the feed silage material, the oxygen is removed from flatten grain mass, and the carbohydrates are decomposed by anaerobic bacteria in lactic acid, which determines silo acidification *(Mănişor P., 1994).* The lactic bacteria (which are active at acidic pH), are rapidly multiplying, colonize the silo and prevent the pathogenic bacteria development, especially Clostridium genotype (because are sensitive to acid environment).

The crop is harvest when humidity is between 30 … 40 % and when physiological maturity has been reached, respectively when grains have accumulated the maximum of dry substance and the black dot is formed at the caryopsis bottom). For this reason the corn maturation stages must be carefully observed in order not to miss the optimum harvest period. If harvesting is delayed and humidity is lower than 30 %, the quality of conservation process may diminish, because compaction is no longer achieved and are created several air spaces between the crushed grains, phenomenon that is unfavourable because creates the assures micro flora develop environment and the storage space is larger. If the corn is harvest when humidity is between 24 … 32%, then grains must be stored in a short time in a sealed silo. Case in which, grains respiration and the micro flora consume rapidly the oxygen (in 15 hours since silo sealing) and the resulting carbon dioxide inhibit any enzymatic activity, respectively the Clostridium genotype (*Vintu V., 2004).*

Choosing the suitable storage silo type (plastic tunnel bag, bunker or tower) depends on: the livestock exploitation size and its needs, the financing possibility and the available workforce. At a higher humidity, the lack of oxygen entails a more intensive fermentation process which favours the development of lactic flora. In all cases, the silo must remain sealed.

In now days there are developed several flattened grain storage technologies:

- ***"big bag" type storage,*** allows storing 800 kg of wet flattening cereals. This equipment is adequate for small livestock farms. The "big bag'' ensilage system is formed of an outer shell and an internal storage space, where grains are stored and ensures a sealed environment, fig. 8.

Fig. 8 - "Big bag" type storage

- ***Sealed flexible silo*** (with a capacity ranging between 20 and 200 tons) is very suitable for anaerobic conservation of whole corn grains. It is equipped with a cone in order to facilitate bottom sampling.
- ***tower silo*** is more suitable for large exploitations, having a capacity between 200 and 1,200 m^3. This silo type is made of vitrified steel.

Advantages of preserving flattened or whole high humidity grains: mechanical harvesting using cereal harvesters; bottleneck prevention of large technological process, that have in their structure cereal drying installations or intermediary storage spaces, used until the humidity for grains preservation is reached; storage space reduction and assuring the use of simple constructions, which are less costly; decrease the feeder cost; field release of the field earlier for successive crops; preparing the field for autumn crops.

CONCLUSIONS

By applying the conservation technology of wet flattened corn grains are obtaining economic and technical advantages: land rational use for early cereals harvesting that leads to land early release in favour of the next rotation crop; reduction of investment costs (drying, storage) and energy (oil, electricity, crop transport); costs reduction by 35% and demand by 40% due to additional works like: cereals threshing and drying; wet grain corn storage in silage is better with 3.6 ... 5.8% compared to dry corn; low grain transport costs of approx. 15%; reducing crop loss by approx. 6%; losses elimination through spoilage wet grain stocks; providing an additional amount of concentrated feed with high digestibility compared to technologies that rely on cobs and corn grain.

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USE OF ADVANCED MULTI-CRITERIA ANALYSIS (FRISCO), APPLIED FOR RETROFITTING WORKS OF FOREST ROADS MAINTENANCE AND REPAIR
/
UTILIZAREA METODEI DE ANALIZĂ MULTI - CRITERIALĂ AVANSATĂ (FRISCO), APLICATĂ ÎN CAZUL RETEHNOLOGIZĂRII LUCRĂRILOR DE ÎNTREŢINERE ŞI REPARARE A DRUMURILOR FORESTIERE

Ph.D. Eng. Tudosoiu C.[1)] **Ph.D. Eng. Ganea Christu I.** [2)]
INCDS *„Marin Drăcea”* [1)], INMA Bucharest [2)]
Tel: 0720835156; E-mail: catalintudosoiu@yahoo.com

Keywords: *system equipment, maintenance and repair of forest roads, trailed grader, experimental model, similar machines in Europe, FRISCO method*

ABSTRACT

Within the research on the maintenance and repair of forest road networks were designed, made and tested under laboratory, field and production conditions, four experimental models of equipment: plow for digging and cleaning ditches, forest roads scarifier, trailed grader and trailed static roller-compactor.

The purpose of the research was to determine the place occupied by trailed grader designed by ICAS compared to similar equipment produced by European companies in the field of construction equipment manufacture and sale. In order to make comparisons, the advanced multi-criteria analysis method (FRISCO) was applied.

REZUMAT

In cadrul cercetarilor privind lucrările de întreţinere şi reparare a reţelelor de drumuri forestiere, au fost concepute, realizate şi încercate în condiţii de laborator, de câmp şi de producţie, patru modele experimentale de utilaje: plug de săpat şi curăţat şanţuri, scarificator drumuri forestiere, greder tractat şi rulou compactor static tractat.

Scopul cercetărilor a fost determinarea locului ocupat de grederul tractat conceput de ICAS, comparativ cu utilaje similare produse de firme europene din domeniul fabricării şi comercializării utilajelor pentru construcţii. Pentru acesta s-a aplicat metoda de analiză multi-criterială avansată (FRISCO).

INTRODUCTION

Within a project called " Mechanized technology for forest roads maintenance", conducted in partnership with RNP ROMSILVA and I.N.C.D.S. "Marin Dracea" (National Institute for Research and Development in Forestry “Marin Dracea”), an experimental model of a trailed grader, driven by a universal medium power tractor (U-651 DT), for forest roads repairing and maintenance was designed, dimensioned, produced and tested under production conditions.

At the end of the research works, the team compared the experimental grader model [3], [7] with similar equipment manufactured by companies producing equipment for construction works, namely the creation and maintenance of forest roads. For this it was applied the advanced multi-criteria analysis method (FRISCO) generating a hierarchy of trailed graders. In the set of trailed graders subjected to the analysis was also included the experimental grader model resulting from the above mentioned applied research activities.

MATERIAL AND METHOD

Method presentation

It was considered a multidimensional decision-making process, in which were selected a total of six trailed graders for repair and maintenance of auto forest roads, accompanied by their technical characteristics [3], [8], [9], [10], [11], [12], presented in table 1. The question is to compare the trailed grader designed, produced and tested by ICAS present in the system of equipment, respectively the trailed grader (EID), with graders produced by companies that have an important sale segment for such equipment.

The states of nature considered are based on the market situation, namely [1]:

- trend of increasing the cost of materials and raw materials;
- trend regarding energy and fuel prices;

- fluctuations of delivery price;
- fluctuation of labour costs.

a. LGK EQUIPMENT - V. EMME

b. LOS ANTONIOS - BB 1

c. TAR INDUSTRIES - GTU 3,2

d. S. HOULE - LFA 08

e. PÖMA - AG 225

f. I.C.A.S. – EID (model exp.)

Obviously, following direct comparison of the six variants, a "verdict" on the most favourable variant cannot be given. Such an analysis involves a degree of subjectivity of the man who performed the comparison. To avoid subjectivity, economic sciences experts have conceived various algorithms and non-subjective analysis methods, including advanced multi-criteria analysis, also found under the name FRISCO multi-criteria analysis.

Mentioning the elements of decision-making process. Establishing comparative criteria

Elements of decision-making process are presented in Table 1, where can be found both the variants subject to comparison (M_i - manufacturer and trailed graders type) and their comparison (X_i) criteria (technical - economic data).

The criterion is a clear and well defined standpoint, issued by a specialist in this field, delimiting, individualising and defining properties and/or attributes of variants subject to comparison [1].

Table 1

Presentation of the decision-making process elements and the comparison criteria in case of advanced multi-criteria analysis method (FRISCO)

Variants analysed	**Manufacturer and trailed grader type (M_i)**	**Comparison criteria (X_i)**					
		Blade length (mm)	Blade Height (mm)	Equip ment mass (kg)	Blade angle of rotation in the horizontal plane	Blade angle of rotation in the in vertical plane	Required power of driving tractor (CP)
		X_1	X_2	X_3	X_4	X_5	X_6
M_1	LGK EQUIPMENT / V.EMME 2500HD - 2700HD	2700	400	950	± 35°	54°	70
M_2	LOS ANTONIOS / BB-1	2500	600	1300	± 120°	20°	130
M_3	TAR INDUSTRIES / GTU 3.2	3200	550	2000	± 33°	60°	80
M_4	S.HOULE / LFA 08	2200	510	750	± 26°	65°	120
M_5	PÖMA / AG 225	2600	530	1900	± 18.5°	75°	140
M_6	I.C.A.S. / IDE	2400	540	580	± 30°	25°	60

Utilities calculation

Utility is a subjective size, depending on the assessment of the decision-maker. To reduce subjectivity in estimating utility can be achieved by observing the utility concept, formulated by a number of axioms set by mathematicians M. Von Neumann and O. Morgenstern.

The main issues raised by the theory of multi-criteria analysis are [1]:

a) Estimating utilities, when the criterion on the line is compared to the criterion in the column is:

- more important, then value 1 is assigned;
- equally important, then value ½ is assigned;
- less important, then value 0 is assigned.

The main diagonal of utilities table contains only 1/2 value, given that comparing a criterion with itself only this value can result. Utilities for the chosen criteria are presented in Table 2.

b) Utilities' additivity is expressed by a score that represents the summation of all utilities assigned (on the line) to a variant and is calculated using the following relation [2]:

$$U(M_i) = U(X_{i1}) + U(X_{i2}) + \dots\dots\dots + U(X_{in}) \tag{1}$$

or score: $$p = U(M_i) = \sum_{i=0}^{n}(X_{in}) \tag{2}$$

The calculated scores are presented in Table 2, (column 7).

Establishment of criteria level

The first position (first level) will be occupied by the criterion with the highest score and the last position (last level) will be occupied by the criterion with the lowest score.

Problems arise in the calculation of intermediate positions.

The authors cited above (M. von Neumann and Morgenstern O.) formulated a number of five axioms on utility. Based on these axioms it was possible to introduce the utility function. Utility function $U(M_i)$ has as definition domain the set of analysed variants (M_i) and as value domain (co-domain) the set of real numbers.

Properties of the utility function:

M_i and M_j two decision-making values [2], [4]:

a) $M_i > M_j$ if and only if $U(M_i) > U(M_j)$;

b) $U\,[p \cdot M_i(1 - p) \cdot M_j] = p \cdot U(Mi) + (1 - p) \cdot U(M_j)$ conferring finding "mixed probabilities" where p is the probability of accomplishing variant M_i and $1-p$ probability of accomplishing M_j variant;

c) if the function complies with the properties a and b then it may be described as a function of the first degree (linear):

$$f: M_i \longrightarrow \mathbb{R} \quad M_j = a \cdot U(M_i) + b \;;\; a, b \in \mathbb{R}\,; a \neq 0 \tag{3}$$

So, based on score, the values of each criterion situated between the first and last position can be determined. In this respect, for the function U (M_J) has been built the variation table:

$U(M_i)$	1,0	5,0	(4)
$U(M_j) = a \cdot U(M_i) + b$	5,0	1,0	(5)

The function of the first degree or its explicit form can be stated when coefficients are found. Since the points given in the variation table are solutions of the equation attached to the function, the system of two equations with two unknowns can be established as follows [6]:

$$\begin{cases} U(1) = 5{,}0 \\ U(1) = a + b \end{cases} \Rightarrow\; a + b = 5{,}0 \quad (*) \;\;;\;\; \begin{cases} U(5{,}0) = 1 \\ U(5{,}0) = 5{,}0a + b \end{cases} \Rightarrow\; 5{,}0a + b \quad (**) \tag{6}$$

By solving the system of equations $(*)$ and $(**)$ we obtain: $a = -1; b = 6$.

Once the coefficients determined, the function can be specified: $U(M_j) = -1 \cdot U(M_i) + 6{,}0.$

Through the explicit form of the function, we can calculate the intermediate values of other criteria that are shown in table 2, in the column specifying points *p* (*p* – also called level):

$$U(1{,}5) = (-1) \cdot 1{,}5 + 6{,}0 = 4{,}5 \quad (7)$$

$$U(4{,}5) = (-1) \cdot 4{,}5 + 6{,}0 = 1{,}5 \quad (8)$$

$$U(3{,}0) = (-1) \cdot 3{,}0 + 6{,}0 = 3{,}0 \quad (9)$$

Table 2

Calculating the number of *p* points, belonging to the number of outclassed criteria *m* and weights K_i

Criterion (X_i)	X_1	X_2	X_3	X_4	X_5	X_6	Average (level) *p*	Number of outclassed criteria *m*	The difference in points from the last level Δp	The difference in points from the first level $-\Delta p'$	Weight K_i
0	1	2	3	4	5	6	7	8	9	10	11
X_1	½	½	0	0	0	0	**1.0**	0	0.0	4.0	0.214
X_2	½	½	0	0	½	0	1.5	1	0.5	3.5	0.538
X_3	1	1	½	1	1	0	4.5	3	3.5	0.5	3.286
X_4	1	1	0	½	½	0	3.0	2	2.0	2.0	1.500
X_5	1	1	0	½	½	0	3.0	2	2.0	2.0	1.500
X_6	1	1	½	1	1	½	**5.0**	4	4.0	0.0	4.500
							$X_i = \Sigma 18.0$				

Note: The existence condition (Bobancu 2010) of the tabular matrix on scores implies that the sum of the points have a value of half the square of the number of criteria X_i (i = 6, 6^2 = 36, Xi = 18).

Calculation of weight coefficients

It uses the empirical formula FRISCO, widely recognized as the most used and which generates minimal errors [1].

$$K_i = \frac{p + \Delta p + m + 0{,}5}{\frac{N_{crt}}{2} - \Delta p'} \quad (10)$$

where: K_i - is the criterion weight (X_i);

p - sum of points obtained for each criterion;

Δp - difference between the score of the considered element and the score of the element at the last level;

m - number of criteria outclassed by the considered criterion;

$\Delta p'$- difference between the score of the considered element and the score of the element at the first level (it is taken into account that also negative values can result);

N_{crt} - number of criteria considered (N_{crt} = 6).

a. Establishing outclassed criteria *(m)*

As regards the number of outclassed criteria *m*, the following explanations are necessary.

The figures recorded in the scoring column are considered as a string of positive rational numbers (Q_+). The score of the string terms is arranged downwards 5.0; 4.5; 3.0; 3.0; 1.5; 1.0. The value of *m*, corresponding to a criterion, is represented by the number of terms having a value strictly lower than the value of the considered criterion score. It should be noted that there are two criteria with the score value 3.0 and that both outclass the same number of terms with strictly lower value [6].

Thus, considered on the line (table no. 2) criterion X_1 (which has p_1 = 1.0) does not outclass any strategy. It results that m_1 = 0. For criterion X_2 (which has p_2 = 1.5), it surpasses the number of points belonging to X_1 (p_1 = 1.0), so that m_2 = 1. The criterion X_3 (p_3 = 4.5) surpasses the points of X_1 (p_1 = 1.0), X_2 (p_2 = 1.5), X_4 (p_4 = 3.0) and X_5 (p_5 = 3.0), so it outclasses three values, namely m_3 = 3. Finally, the criterion

X_6 (p_6 = 5.0) outperforms the rest of the score values, respectively four values, which means m_6 = 4. The values thus obtained for the number of outclassed criteria *m* are entered in table 2, respectively on column 8.

b. Determination of *Δp* and *Δp'*

At the first level is the criterion that obtained the maximum score (respectively X_6).

At the last level is the criterion that obtained the minimum score (respectively X_1).

Δp – is the difference between the score of the considered element and the score of the element at the last level (respectively X_1) [1], [6]. Thus:

$$\Delta p_1 = 0.0;\ \Delta p_2 = 0.5;\ \Delta p_3 = 3.5;\ \Delta p_4 = 2.0;\ \Delta p_5 = 2.0;\ \Delta p_6 = 4.0$$

Δp' – is the difference between the score of the considered element and the score of the element at the first level (respectively X_6) [1], [6]. Thus:

$$\Delta p'_1 = -4.0;\ \Delta p'_2 = -3.5;\ \Delta p'_3 = -0.5;\ \Delta p'_4 = -2.0;\ \Delta p'_5 = -2.0;\ \Delta p'_6 = 0.0$$

In table 2 are inserted the differences of calculated scores *Δp* and *Δp'*, respectively the 9th and the 10th columns.

c. Calculation of weights K_i

It is made by using the formula for weight (FRISCO) as follows:

$$K_1 = \frac{p_1 + \Delta p_1 + m_1 + 0,5}{\frac{6}{2} - \Delta p_1'} = \frac{1,0 + 0,0 + 0.0 + 0,5}{3 - (-4,0)} = \frac{1,5}{7} = 0,214 \quad (11)$$

$$K_6 = \frac{p_6 + \Delta p_6 + m_6 + 0,5}{\frac{6}{2} - \Delta p_6'} = \frac{5,0 + 4,0 + 4 + 0,5}{3 - 0,0} = \frac{13,5}{3} = 4,500 \quad (12)$$

Based on the same algorithm, the other weights are calculated, namely [6]:

$$K_2 = 0.538;\ K_3 = 3.286;\ K_4 = 1.500;\ K_5 = 1.500$$

K_i weights calculated values are found in table 2, column 11.

Granting the importance mark

By applying the method of multi-criteria analysis (FRISCO) a hierarchy of six strategies is proposed, taking into account the criteria of comparison (X_i), mentioning that there will be adopted a system of giving marks, between 1 and 10, for each considered criterion. The mark must be an integer, less than or equal to 10, being called importance mark and being granted to each criterion [1]. Thus:

➢ **Blade length (X_1)**

The constructive characteristics of the blade for levelling and pushing the gravel material for road system restoration, or the material resulted from scarification operation of the platform, finally lead to determine the productivity and quality of work.

The longer the grader blade, it can "train" and distribute the material for restoring the road superstructure under optimum conditions. A small blade length implies, for uniform distribution of a certain quantity of material, several passes of the tractor-equipment, thereby increasing the working time and reducing productivity [3], [6].

The grader with the longest blade is given the higher mark of the strategy.

➢ **Blade height (X_2)**

When "dealing with" the deposited material by overturning form a means of transport, on the road platform or if there is a large amount of material resulted from the scarification operation prior to the levelling one, it is possible that, due to the high volume, it passes over the top edge of the levelling blade.

A small blade height favours the transport and translating of a reduced volume of material appearing the possibility of "discharging" it over the blade. The blade height determines the equipment productivity, implicitly the time allotted per operation [3], [6].

The mark granted increases directly proportional to the height of the working part, namely the pushing and levelling blade.

➢ **Equipment mass (X_3)**

The robustness and solidity of equipment does not always mean safety in operating. Material consumption, which contributes to the completion of the equipment, can be optimized through sizing calculations and, finally, the use of more "valuable" steel.

On the other hand, it must be taken into account that a large mass equipment (respectively with heavy weight) will require a stronger drive source, will have a lower manoeuvrability possibility and will thus contribute to higher fuel consumption recorded during transport from one point to another.

The mark granted is inversely proportional to the equipment weight. Thus, the equipment with smaller mass (lower weight) is granted a higher mark due to lower fuel consumption, for driving, and to a better manoeuvrability in operation [3], [6].

➢ **Blade angle of rotation in horizontal plane (X_4)**

The blade angle of rotation in horizontal plane enables tilting the grader blade under different angle values towards the driving direction of the aggregate tractor-grader. Levelling blade can "deal with" the material necessary to repair the road system, at perpendicularly to the longitudinal axis of the road, or inclined at a certain angle (left-right) to it.

If the blade is inclined reported to the longitudinal axis of the road, the material involved will present a forward movement combined with a movement of translation on its surface. This allows movement in one side of the material for repair and maintenance, bringing the surplus in the location wanted by the driver of the tractor-machine. Material transport through a combined move of going forward with translation is a plus for the machine. The translation possibility of a large quantity of material is directly proportional to the angle to the longitudinal axis of the road platform [3], [6].

The possibility to handle the active working part by applying higher values of this angle gives the material levelling and thrust blade the possibility of translating, in order to distribute it in places that require extra material. The mark granted is directly proportional to the rotation angle value.

➢ **Blade angle of rotation in vertical plane (X_5)**

Vertical plane rotation is represented by the angle made by the edge of the grader's scraper blade with the rode system cross-section. Tilting of the blade can shape profile, with two flat sides, connected or not connected. This rotation gives the thrust blade the possibility of making roadway with a side profile plan used when connecting small-radius curves. Making super-elevation of curved track can be done by changing the rotational angle of the blade in vertical plane [3], [6]. The proposed mark is under the auspices of direct proportionality with the angle that the working part can execute, namely the levelling blade.

➢ **Tractor necessary drive power (X_6)**

It refers to the power developed by the tractor engine. The importance of this criterion is determined by the fact that forestry uses, predominantly, tractors whose power held by the drive source or motor is between 65 HP and 80 HP. Higher power involves the purchase of tractors with more powerful engines, and thus higher fuel consumption and a higher price at purchase.

A bigger mark is granted for tractors that have driving power, generated by power source (engine), between 60 and 80 HP. Since engines that provide more power have higher fuel consumption, higher mark shall be given to tractors that have driven engines with reduced powers [3], [6].

Table 3

Granting of importance mark for each criterion considered

Criterion comparison (X_i)		**Marks given the variant** (range 1 ÷ 10)					
		M_1	M_2	M_3	M_4	M_5	M_6
X_1	Blade length (mm)	8	6	10	4	7	5
X_2	Blade height (mm)	4	10	9	6	7	8
X_3	Equipment mass (kg)	8	7	1	9	2	10
X_4	Blade angle of rotation in horizontal plane(°)	7	10	6	4	3	5
X_5	Blade angle of rotation in vertical plane (°)	7	2	8	9	10	3
X_6	Tractor necessary drive power (HP)	9	3	8	4	2	10

RESULTS

Establishing the hierarchy of the analysed variants

In the purpose mentioned the consequences matrix is made, presented in table form (table no. 4). In this table, the importance mark of each variable / criteria (Table no. 3) is multiplied by the weights coefficient K_i of each studied variant [1]. For example, for the equipment mass criterion (X_3) corresponding to M_5 variant (PÖMA / AG 225), the importance mark is 2, while the importance coefficient (K_3) is 5.75. The product of these two values is quantified at 11.5 (inserted in the table no. 4), present at the cross of the third line with M_5 column [6].

Weights values are found and taken from Table 2, namely column 11.

Making a summation on vertical of algebraical products variant-criterion with specific weight coefficients, the total scores at the bottom of table 4 are obtained. The higher the score value obtained, more important the "place" owned in variants' hierarchy is [6].

A minimum value of algebraical products' vertical summation leads to positioning at the bottom of the list of considered alternatives, when applying the FRISCO method of multi-criteria analysis.

Table 4

Presentation of the consequences matrix with establishing the ranking of analysed variants

Criterion		Coefficient of importance K_i	Variant											
			M_1	$M_1 \cdot K_1$	M_2	$M_2 \cdot K_2$	M_3	$M_3 \cdot K_3$	M_4	$M_4 \cdot K_4$	M_5	$M_5 \cdot K_5$	M_6	$M_6 \cdot K_6$
X_1	Blade length (mm)	0.214	8	1.712	6	1.284	10	2.140	4	0.856	7	1.498	5	1.070
X_2	Blade height (mm)	0.538	4	2.152	10	5.380	9	4.842	6	3.228	7	3.766	8	4.304
X_3	Equipment mass (kg)	3.286	8	26.288	7	23.002	1	3.286	9	29.574	2	6.572	10	32.860
X_4	Blade angle of rotation in horizontal plane	1.500	7	10.500	10	15.000	6	9.000	4	6.000	3	4.500	5	7.500
X_5	Blade angle of rotation in vertical plane	1.500	7	10.500	2	3.000	8	12.000	9	13.500	10	15.000	3	4.500
X_6	Tractor drive power (HP)	4.500	10	45.000	3	13.500	8	36.000	4	18.000	2	9.000	9	40.500
Ranking				96.152		61.166		67.268		71.158		40.336		90.734
			LGK EQUIPMENT		LOS ANTONIOS		TAR INDUSTRIES		S.HOULE		PÖMA		I.C.A.S.	

Advanced multi-criteria analysis (FRISCO) leads, finally, to the hierarchy [6]:

- 1st place $M_1 \rightarrow$ LGK EQUIPMENT / v.EMME 2500HD - 2700HD;
- 2nd place $M_6 \rightarrow$ I.C.A.S. / IDE;
- 3rd place $M_4 \rightarrow$ S.HOULE / LFA 08;
- 4th place $M_2 \rightarrow$ TAR INDUSTRIES / GTU 3.2;
- 5th place $M_3 \rightarrow$ LOS ANTONIOS / BB -1;
- 6th place $M_5 \rightarrow$ PÖMA / AG 225.

CONCLUSIONS

The ranking obtained as a result of using the complex decision-making analysis method FRISCO leads to propose as "winner" the trailed grader produced by LGK EQUIPMENT (v.EMME type HD 2500 - HD 2700), occupying the leading position.

As regards the trailed grader (IDE) designed and tested by ICAS, produced by UM Mizil, it is ranked second according to the method of comparative analysis. This suggests that the machine is designed at European standards, surpassing, in terms of hierarchy, brands present in the profile segment of the market.

FRISCO complex decision-making analysis method can be applied following the algorithm presented and it can also be applied for other homogeneous subsets belonging to various fields. The detailed (Scholastic) manner of the algorithm could also be used as calculation example in other applications, considering that it is a useful approach in the process of adopting a relevant decision.

The conclusions upon completion of the research indicated that the system of machines operated by average-power tractor is an alternative solution to the technologies in use nowadays, it can be implemented in a short time-frame, with unquestionable financial benefits in different economic sectors (forestry, agriculture, land improvement, road construction etc.), leading to increased productivity while decreasing works' costs.

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CONSIDERATIONS FOR BIOFILTERS USE IN AQUACULTURE / CONSIDERATII PRIVIND UTILIZAREA FILTRELOR BIOLOGICE ÎN ACVACULTURA

PhD.Stud. Eng. Andrei S., PhD. Eng. Pop A., PhD. Stud. Eng. Laza E., PhD. Eng. Păun A., PhD. Stud. Eng. Muscalu A., Ph.D. Stud. Eng. Mircea C.
INMA Bucharest / Romania
E-mail: andrei_sg85@yahoo.com

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ABSTRACT

In intensive fish farming process, filtering plays an essential role because fish being bred in fixed locations (basins), dejections and uneaten feed remain in the water and, in time, it generates bacteria and infections leading to the death of basin bred fish. Therefore, water in these basins is permanently recirculated in order to be filtered and refreshed. This article presents the current biofilter systems used in the country and at world level in recirculating acvacole systems (RAS) for intensive fish farming.

REZUMAT

În procesul de creştere intensivă a peştilor, filtrarea are un rol esenţial deoarece peştii fiiind crescuţi în locaţii fixe (bazine), dejecţiile şi mâncarea neconsumată rămâne în apă şi în timp generează bacterii şi infecţii ce conduc la moartea peştilor crescuţi în bazine. Ca atare, apa din aceste bazine este recirculată permanent pentru a fi filtrată şi reînprospătată. in această lucrare se prezintă sistemele actuate de filtrare biologică utilizate în ţară şi pe plan modial în sistemele acvacole recirculante (SAR) de creştere intensivă a peştilor.

INTRODUCTION

Biofiltering is the following essential step after mechanical filtering in the treatment process of water that is to be reintroduced in breeding basins. Biofiltering ensures a series of functions vital for the good functioning of a RAS, part of them being fulfilled by the living organisms present in the filter, the rest being obtained by physical methods not depending on the living organisms in the filter [16]. The functions that a biofilter must perform within a RAS are the following:

- ammonia removal;
- nitrites removal;
- dissolved organic solids removal;
- oxygen addition;
- carbon dioxide removal;
- removal of nitrogen and other dissolved gas excess;
- suspended solids removal.

Biofiltering is the main method used for ammonia control, this method involving two types of chemical transformation, from ammoniacal nitrogen to nitrites and from nitrites to nitrates, these transformations taking place within the filter following Nitrosomonas and Nitrobacter actions [3].

Malone says that one of the biofilter roles, which is often disregarded, is the removal of organic matter (sugars, starch, fats, proteins) fish excreted [12]. According to Wortman and Wheaton (1991) classification, biofiltering equipment is divided into two categories: fixed-film biofilters, with the filtrating agent represented by the support where nitrifying bacteria get fixed and grow, respectively suspended-film biofilters, with the filtrating agent being maintained suspended [6].

MATERIAL AND METHOD

Nowadays, a major interest in respect to water biofiltering in RAS is represented by biofilters with suspended filtering agent.

For the biological treatment of water coming from acvacole systems there is a large variety of nitrifying filters. Depending on the constructive solution chosen and the way of operating, the following nitrifying filter types can be distinguished: submersed, disc drum, fluidized bed and with bead [7, 2].

The most widespread biofilters among the commercial recirculating systems are RBC, trickling or bead filters. A part of these filters operate either totally immersed, or partially immersed, while others are not at all submersed [2].

By construction, trickling and RBC filters are the only types in the case of which the oxygen needed for the nitrifying process in ensured by free air.

RESULTS

- **Submersed filters**

Submersed filters are called like this because the filtering substrate (filtering material) is constantly submerged, and this is illustrated in the constructive drawing in Figure 1.

The operation principle of submersed filters is a relatively simple one and consists in water passing through a filtering material, which is obtained from different mineral aggregates (sand, gravel, crushed stone) or other plastic materials [3].

According to Lawson (1995) a mineral aggregate frequently used in the case of submersed filters is represented by calcareous rocks. They also have a buffering role against the rapid pH changes, capacity that can be diminished if the filtering environment within the biofilter gets overcrowded with nitrifying bacteria [9].

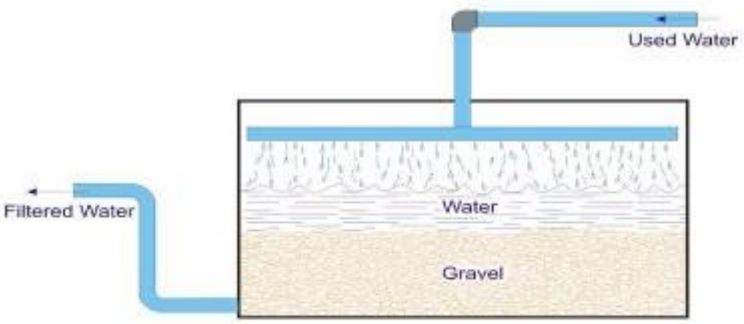

Fig. 1 - Submersed filter – constructive drawing [3]

The size of the particles forming the filtering material of submersed biofilters is usually quite big, therefore the crushed stone has a particle diameter bigger than 5 cm, while the diameter of plastic particles is over 2.5 cm [4].

One of the important factors to be taken into account when projecting a submersed filter in order to reduce its clogging risk, according to Lawson (1995), is the size of filtering material particles, which, in the case of downflow submersed filters, should not be smaller than 19-25 mm [9]. Water passing through the filter can be either upward or downward. This way, the time of hydraulic retention by adjusting water flow rate in the filter can be controlled [16].

A characteristic of waste water sent to submersed filters is that it has to be oxygen saturated for the nitrification process to take place, this aspect representing the main limitation of submersed nitrifying filters. During their functioning the filtering speed and filtered water flow rate, respectively the output, are established by the height of the water column determining water movement within the filter at a certain speed [3].

- **Trickling filters**

Trickling filters are some of the oldest biofilters that are successfully used also in the applications of recirculating system aquaculture [13].

Trickling filters are made of a cylindrical tank, as it can also be seen in the constructive drawing in Figure 2, inside of which the filtering material is [3].

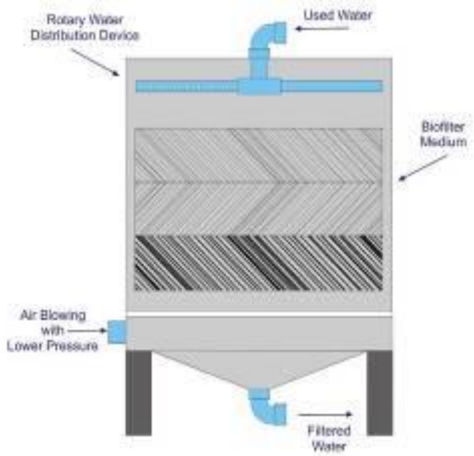

Fig. 2 - Trickling filter – constructive drawing [10, 3]

Biofilter must be dimensioned in such a way that it can support the weight of the medium filter, water as well as the biofilm. In case of trickling filters, the depth is directly proportional to the cost of the pumping [8]. In the same way as RBC filters, trickling filters can become clogged due to the intense activity of heterotrophic bacteria, thus blocking the activity of nitrifying bacteria because of these similarities; their nitrifying degree is similar to the nitrifying degree of RBC filters.

In the case of trickling filters, the filter material composing the support for the nitrifying bacteria in general has a relatively low specific surface area values less than 330 m^2/ m^3 [10].

Operation method of trickling filters is similar to submerged filters, the difference between the two types of filters is given by the manner in which the flow of water through the filter.

Therefore, if in case of the submerged filter, the water flow through the filter is carried out under forced regime, in the case of the trickling filters the flow of water through the filter is carried by gravity, the water is first pumped to the filter top, where it is then uniformly distributed over the filter material, which in this way, is kept wet [7]. With regard to efficiency of trickling filters one of the advantages they have is that oxygen necessary to nitrification process is taken from the air, thus trickling filters are well aerated and water flow is independent of the oxygen supply [8].

One of the problems facing the trickling filters is that during their operation inside if organic matter accumulates in excess, they can become clogged in some cases leading to termination of operation [7].

- **Disc Filters (RBC)**

Disc Biofilters (RBC), as well as other filters used in acvacole systems, have been initially used in domestic applications. Currently on the market there are many models for aquaculture [2]. From constructive point of view RBC filters are composed of plane or curly discs. These discs are placed perpendicularly on a central axis central (fig. 3), [3]. According to Sanimas (2005), discs size which composes RBC filter discs may vary from 0.6 to 3 m [17].

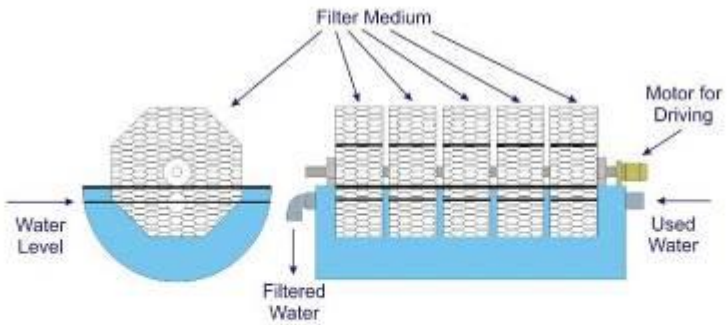

Fig. 3 - RBC filter – constructive drawing [10, 3]

RBC disc filters system is placed in a basin; in filter basin about 40% of discs surface are immersed in water full of nutrients, the rest remaining exposed to air, and according to Hochheimer et al, discs submerging level is between 35- 45% out of the total surface [16, 8].

Another aspect of interest for RBC filters is the distance between plates, that according to V. Cristea [3] is 20-30 mm, and according to Tetzlaff and Heidinger [7] is between 6-13 mm; it can be seen that in both cases there are small enough distances which facilitate both development of a biological film and optimal hydraulic conditions for water flowing through the filter [7, 3].

The discs, which represent the nitrifying bacteria support, are made of plastic material. This presents two characteristics, namely: high porosity and low specific surface. In case of nitrifying bacteria existing on the discs of RBC filter they will fulfil their role as long as the exposure time ratio of 40% to air and 60% to water is observed. The nitrification process requires an important amount of oxygen, the lack of oxygen compromising the nitrification process, which is why biodiscs alternative immersion makes of RBC filters an efficient waste water biofiltration system [1].

Usually, electric motors are used to drive RBC filter shaft, but studies in the field have shown that shaft driving can be performed by water using an air-lift pump [1, 17].

Rotating biofilters (RBC) are characterised by the fact that the filtering environment is not a fix one; on the contrary, it is dynamic, making a rotating movement in the water full of waste [3]. According to Ebeling (2006), the rotating movement of the axis on which the RBC filter biodiscs are placed, is between 1.5 and 2 rpm [5], while other sources reported a rotating movement between 1 and 5 rpm [16]. Because of the specific rotating movement, discs surface loaded with biological film, will be alternatively immersed in the water full of organic substances, respectively exposed to free air, this way the oxygen necessary for the nitrification processes being ensured [8].

The dynamics of the nitrification process in the case of RBC filter determines both the free air exposure time and the frequency of biological film immersion [3]. In respect to RBC filters use in recirculating system aquaculture, it is justified by the numerous advantages these filters have:

- provide a steady efficiency in the nitrification process;
- during functioning the operating pressure is low, resulting a low electric energy consumption;
- it doesn't need a very high oxygen amount, the entire process resuming to the oxygen water contains;
- their use can improve the process of dissolved gas (BOD) and ammonia elimination;
- during operation biofilm thickness remains constant, without the risk of filter clogging;
- the special construction allows observing the way of functioning and monitoring of biofilm on the discs [3, 16].

Two of the main disadvantages of RBC filters are: RBC filter cost is higher than expanded granular filters or trickling filters and the second disadvantage is given by their reliability, due to the mechanical problems that can be caused by power failure during filter functioning [16].

- **Fluidized bed biofilters**

Fluidized beds represent the sand layer which is maintained in a permanent state of expansion and fluidization [12, 3]. Fluidized bed filters (Figure 4) are widespread especially in applications using cold water, ensuring in a relatively small space a large specific surface of development for nitrifying bacteria.

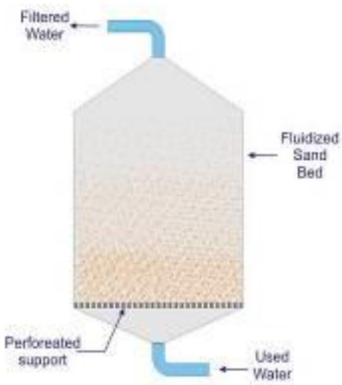

Fig. 4 - Fluidized bed biofilter - Constructive drawing [10, 3]

From constructive standpoint, these filters are made of a cylindrical tank [3], and according to Summerfelt [13], their form can be cylindrical or rectangular. Tank size is established by the water flow rate passing through the filter and also by loading rate of toxic nitrogen compounds (ammonia and nitrites) [3].

The operation principle of fluidized bed filters consists in high speed water injection at the bottom of the filter, with an upward movement within the filtering environment. The flow rate grows gradually until hydrodynamic force is big enough to maintain sand particles floating [3]. By sand layer fluidization the development of nitrifying bacteria on the entire surface of the sand particle is ensured.

Flowing rate through the filter must be high enough to ensure particle bed expansion and also to supply the necessary oxygen to maintain the nitrification process at a constant level [13].

The use of fluidized bed filters also has some disadvantages such as: pressure drop (2 – 6 psi) and a higher flow rate necessary to maintain the fluidized layer in balance [13].

Fluidized bed filters use as filtering material granules with a size smaller than 3 mm, allowing the filter to have a large specific surface reported per volume unit, where nitrification bacteria can grow [13].

According to [3], in order to maintain aerobic conditions in the filtering bed, the following aspects must be considered: sand granules with a size bigger than 1 – 2 mm will be used in the case of high concentrations of the substrate (TAN>1mg/l), while for a lower concentration of the substrate (TAN< 0.3 mg/l) fine sand granules with a size of 0.1 – 0.2 mm will be used [3].

Fluidized bed filters are, both in terms of capital costs and space used, an efficient method for the nitrification process in RAS [13].

The main disadvantage of fluidized bed filters consists in the costs of the operating systems which are relatively higher compared to other filters, because of the use of a high-pressure pump which serves to move the sand bed, but also to maintain it in the required floating state [15].

- **Bead filters**

Bead filters are similar to fluidized bed filters, both from the point of view of construction and functioning (Figure 5). They use, as filtering material, light beads that can be made floating rapidly [15]. One of the advantages of using bead filters is the fact that, while operating, they play a double role, making in the same time a mechanical and a biological filtering of waste water coming from recirculating systems [**3**]. When the counter-flow washing process of bead layer is necessary, this operation needs to be made delicately not to eliminate the bacteria on the beads [11]. The size of beads forming the filtering layer must be as small as possible, with values between 2 and 3 mm, in order to be able to ensure a specific superficial surface as big as possible. Usually, the bead filter active surface is between 1150 and 1475 m^2 [11].

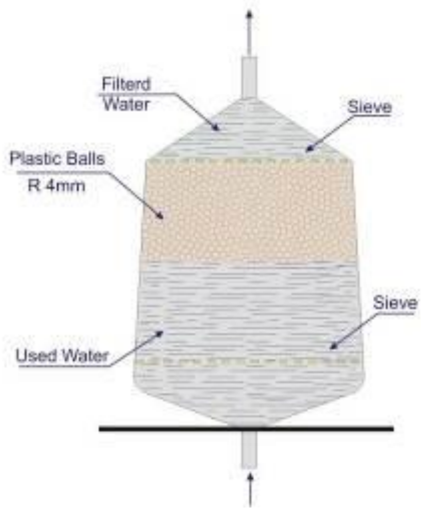

Fig. 5 - Bead filter - Constructive drawing [10, 3]

Table 1

Main characteristics of the most used biofilters

Biofilter types	Process	Biofiltration activity	Nitrification rate	Operational problems
RBC	Biofiltration	Passive	1.250	Clogging
Trickling filters	Biofiltration	Passive	1.250	Clogging
Fluidized bed filters	Biofiltration	Active - counter-flow washing	17.500	Flow speed
Bead filters	Biofiltration – suspended solids removal	Active - counter-flow washing	8.750	Counter-flow washing regime
Note: Volumetric nitrification rate is based on the surface of a medium-sized filtering environment				

CONCLUSIONS

Biofiltration is one of the most often used methods for ammonia control in acvacole systems; this method provides two types of chemical transformations:

- from ammoniacal nitrogen to nitrites and
- from nitrites to nitrates.

These transformations take place within the filter following Nitrosomonas and Nitrobacter actions.

Biofilters also have the role to remove organic matter (sugars, starch, fats, proteins) fish excreted from basins; this matter may cause intoxication and subsequent death of fish.

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MICROBIAL AIR CONTAMINATION IN INDOOR ENVIRONMENT OF FACULTY OF BIOTECHNICAL SYSTEMS ENGINEERING
/
CONTAMINAREA MICROBIOLOGICA A AERULUI DIN INTERIORUL FACULTATII DE INGINERIA SISTEMELOR BIOTEHNICE

Prof. PhD. Biochem. Ferdes M.*, PhD. Eng. Toma L., Lect. Ph.D. Eng. Dinca M, As. PhD Stud.Eng. Zăbavă B.
University "Politehnica" of Bucharest, Faculty of Biotechnical Systems Engineering
Tel: 0729 821 256, E-mail: marianaferdes@yahoo.com

Keywords: *IAQ, air sampling, bacteria, fungi*

ABSTRACT

Microbiological indoor air quality in five places of Faculty of Biotechnical Systems Engineering was evaluated in the period 1 - 22 April in the following places: entrance hall, 1st floor hall, Secretariat, D 009 room, D 116b room.The air samples were analysed in terms of the content of bacteria and fungi, on suitable culture media. The results indicated a normal level of bacteria and fungi in the evaluated rooms, with some exceptions. The number of the investigated microorganisms varied with the day and time and depended on the sampling place.

REZUMAT

În perioada 1 – 22 aprilie a fost analizată din punct de vedere microbiologic calitatea aerului din cinci încăperi ale Facultăţii de Ingineria Sistemelor Biotehnice, în următoarele săli: hol intrare, hol etaj 1, Secretariat, sala D 009, sala D 116b. Probele de aer au fost analizate din punct de vedere al conţinutului de bacteria şi fungi, pe medii de cultură specifice. Rezultatele au indicat un nivel normal de bacteria şi fungi în încăperile evaluate, cu unele excepţii. Numărul microorganismelor investigate a diferit în funcţie de zi şi oră şi a depins de locul de recoltare a probelor.

INTRODUCTION

Indoor air quality (IAQ) is one of the most significant factors affecting the health and well-being of people who inhale approximately 10m^3 of air every day, and spend most of their time, over 90%, indoors. Therefore there has been a growing interest in indoor microbe research in recent years, as evidenced by studies (*Stryjakowska-Sekulska M.et al., 2007*).

Indoor air quality is a concept used to assess the quality of the air in rooms and other building environments (Vlad C.D. et al., 2013). Because it was demonstrated that most bacterial cells could not survive very long in the air, many researchers lost the interest in air microbiology but in the last decades this interest has been stimulated with the construction of relatively air-tight houses and buildings. Heating and air conditioning systems have created environments that allow various microorganisms to survive and adversely affect the health of people (*Mc Kinney R.E. et al., 2004*).

The air inhaled by people contains so-called bioaerosols, a colloidal suspension formed by liquid droplets and particles of solid matter having attached to them vegetative and sporulated bacterial cells, fungal spores or hyphal fragments, viruses, fragments of plants or organic compounds derived from micro-organisms such as endotoxins, metabolites, toxins and other microbial fragments. Bioaerosols vary in size from 20 nm to more than 100 μm (C*olbeck I. et al., 2010; Kalwasińska A. et al., 2012; Mirzaei R. et al., 2014; Makut M.D.et al., 2014*). The microorganisms in the air can be dangerous as pathogenic living cells, can be allergenic and cause serious diseases. Some bacteria and fungi can secrete toxic metabolism products harmful for health such as the mycotoxins. Various studies have shown that many health problems related to air quality are the results of the reaction of human organism to moulds. The fungal flora may cause allergies, SBS symptoms ("sick building syndrome"), irritation of respiratory membranes, bad physical condition, tiredness, headaches, decrease of concentration, dermatosis, respiratory diseases (including asthma) and cancers (*Stryjakowska-Sekulska M. et al., 2007; Chin Ming E. et al., 2014; Mirzaei R. et al., 2014; Popescu S. et al., 2014*).

The quality of air in office buildings depends on numerous physical, chemical and biological factors. Regarding microbial pollutants, among their typical indoor reservoirs are people, plants, animals, soil and water as well as human-made materials. Biological particles suspended in the air can be present in viable (culturable and nonculturable) as well as nonviable forms. They can either exist as individual entities or create aggregates of biological structures. They can be also attached to dust particles formed from inorganic matter or to water or saliva droplets (*Kalwasińska A. et al., 2012; Gołofit-Szymczak M., et al., 2010*). The air microflora depends on the complex interactions among building occupants, indoor environment (temperature, humidity), insufficient outdoor air intake, building materials and furnishing, and air contaminants (chemicals, bacteria, molds, vapors) (Vlad C.D. et al., 2013). It was found that the amount of pathogenic microorganisms is higher in indoor than outdoor air (*Stryjakowska-Sekulska M. et al., 2007*).

Studies have shown that an excessive humidity can help the microbes survive in the unfavourable air environment. Microorganisms are part of suspended particles dispersed in the air and gravity is the major force affecting the removal of them from air. Large particles quickly settle onto solid surfaces while the small ones settle slowly. Wind currents determine the ability of suspended particles to remain in suspension and can move suspended particles for hundreds of miles. As the water evaporates, the active microorganisms lose their protective environment and quickly die. Spore forming microorganisms have the ability to survive as spores in the air environment, since the spore coating protects the nuclear material from drying out (*Mc Kinney R.E., 2004*).

So far there have been no Romanian standards or guidelines for microbiological quality of indoor air. Because there isn't any European Union directive addressing this, it is assumed to be based on particular European countries' requirements and scientific propositions. It can be noticed that in the last 20 years the opinions concerning innocuous microbial cells amounts in the indoor air have greatly varied. According the guidelines of American Industrial Hygiene Association (AIHA) published in 2001, the amount of fungal spores for residential buildings should be less than 500 CFU/m^3 and for commercial buildings less than 250 CFU/m^3. In Hong Kong good microbiological class air should include less than 1000 CFU/m^3 of bacteria and in Singapore less than 500 CFU/m^3 (*Stryjakowska-Sekulska M. et al., 2007*).

The aim of this work is a medium-term time observation of microbiological quality of indoor air in selected rooms and halls of Faculty of Biotechnical Systems Engineering located in Bucharest, where hundreds of people spend several hours studying and working in enclosed spaces every day and where microbiological quality of indoor air can influence their health and physical condition. This publication presents preliminary results of an indoor air study conducted in April 2016. The study represents an analysis of the incidence of bacteria and fungi in the air of selected rooms of faculty.

MATERIAL AND METHOD

Culture media

For microbial air analysis two culture media have been used. Bacterial colonies were grown on non-selective medium Plate Count Agar containing tryptone 5 g/L, yeast extract 2.5 g/L, glucose 1 g/L, agar 9.0 g/L. The fungi were determined on Chloramphenicol Yeast Glucose Agar (dextrose 20 g/L, yeast extract 5.0 g/L, chloramphenicol 0.1 g/L, agar 15 g/L).

Air sampling

Air samples were collected with a microbiological air sampler CANTIUM SCIENTIFIC model Micro Bio MB1, with the sampling rate of 100 L/minute and the sampling range 25 – 2000 L. The sampler allows the use of Petri dishes with the diameter of 90 mm. The air flux carrying the airborne particles is directed toward the Petri dishes located inside the air sampler, which contain the specific culture media for each group of investigated microorganisms, i.e. bacteria and fungi. The air sampling procedure was conducted in spring, between 1 and 22 April, 2016. The samples were collected in triplicate in five locations from the building of Faculty of Biotechnical Systems Engineering: entrance hall (area 230 m^2, high 3.5 m), 1st floor hall (area 180 m^2, high 7.5 m), Secretariat (area 41.2 m^2, high 3.5 m), D 009 room - Engineering and Environmental Protection (area 126 m^2, high 8 m) and D 116b room - CAD Systems (area 40.3 m^2, high 3.5 m, air conditioning). The daily sampling has been conducted at 12 noon. For April 18, the samples were collected from 8 am to 6 pm, every two hours. The cultures were incubated at 30^{0}C for bacteria and at 25^{0}C for fungi. The counting was carried out after 48 and 72 hours for bacterial colonies and at 120 and 144 hours for fungal colonies. Their number was expressed as colony forming units per cubic meter of air (CFU/m^3).Air temperature and level of precipitations in Bucharest during the period 1-22 April (table 1) have been taken into account (http://www.accuweather.com/ro/ro/bucharest).

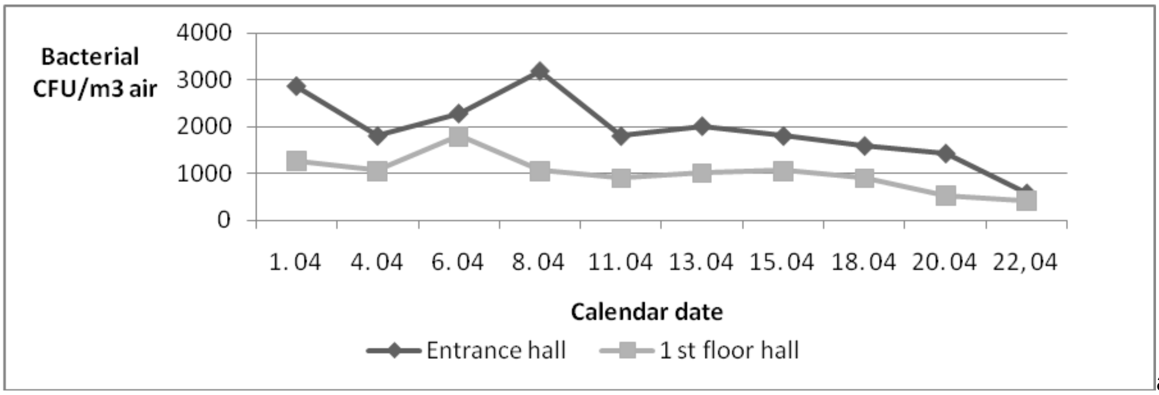
Table 1

Air temperature and rainfall in the period 1-22 April

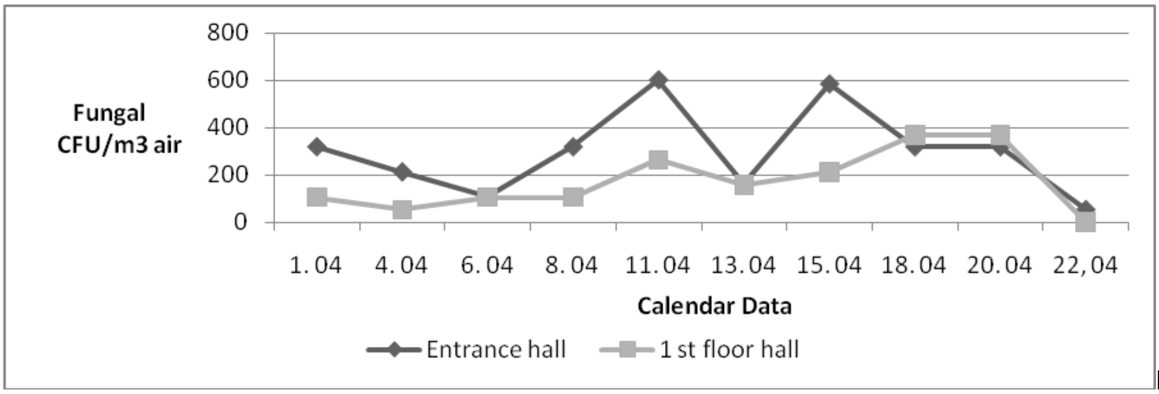
	1.04 Fri	4.04 Mon	6.04 Wed	8.04 Fri	11.04 Mon	13.04 Wed	15.04 Fri	18.04 Mon	20.04 Wed	22.04 Fri
Temperature (^{0}C) Max/Min	26/6	20/0	28/10	20/8	15/13	25/7	22/6	30/0	13/4	21/1
Rainfall (mm)	0	0	0	1	6	0	0	0	21	0

RESULTS

The results of air microflora analysis are presented in figures 1 – 3 and demonstrate that in the indoor of the building the level of bacteria and fungi is in normal range, depending on the day of the week and on the hour. The recorded data show that the number of bacterial cells in m^3 of indoor air varied between 160 CFU/m^3 air and 3100 CFU/m^3 air, and the number of fungi between 0 and 600 CFU/m^3 air. As seen in figures 1 and 2, the highest level of contamination was determined for the entrance hall, for bacteria and fungi. This can be explained by its position in the building (at the entrance), by the large number of persons who move through the hall and by the ornamental green plants.



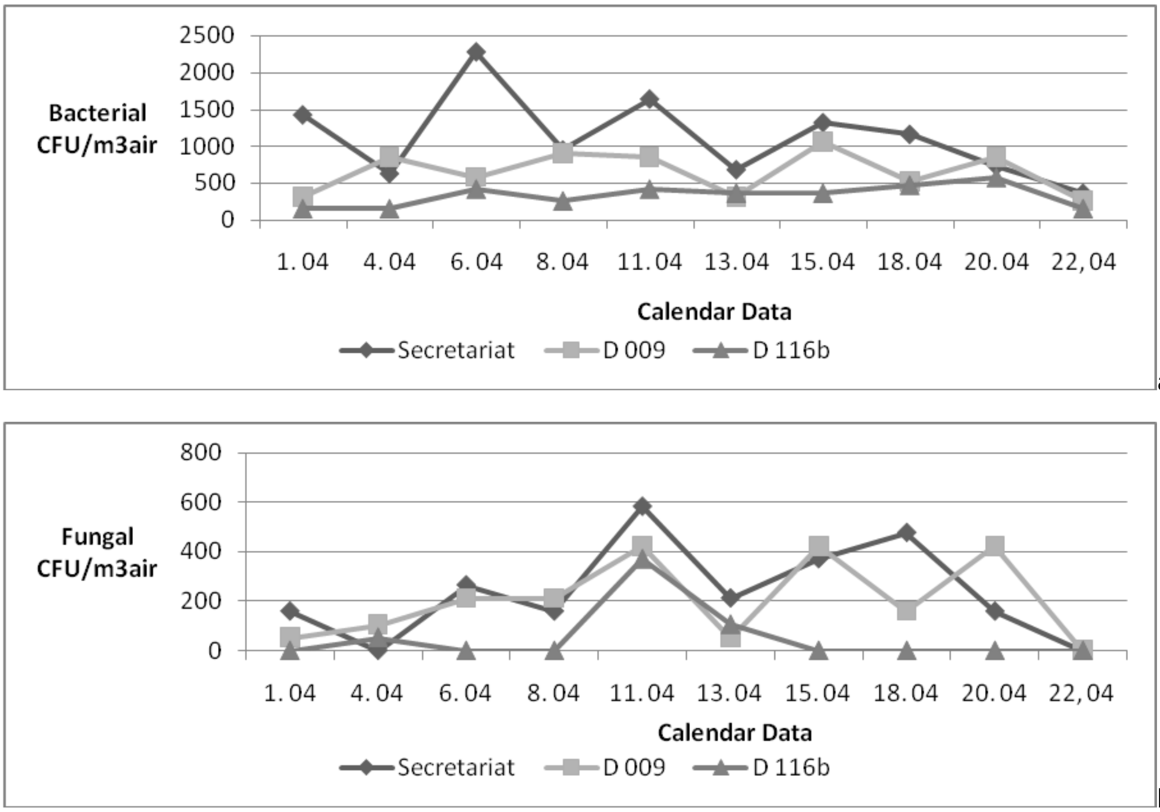
a)



b)

Fig. 1 - Estimation of bacterial (a) and fungal (b) CFU/m^{3}of air in the entrance hall (a) and in the 1st floor hall(b) in the period 1 - 22 April 2016

The microbial load of the other three rooms – Secretariat, D 009 and D 116b is lower compared with the halls. The highest level of contamination was recorded for Secretariat, a room where the number of persons is quite high and the flow of persons through doors is significant. For D 116b, a smaller room equipped with air conditioning, the number of bacteria and fungi seems to be the lowest, although the number of students in every day is great.

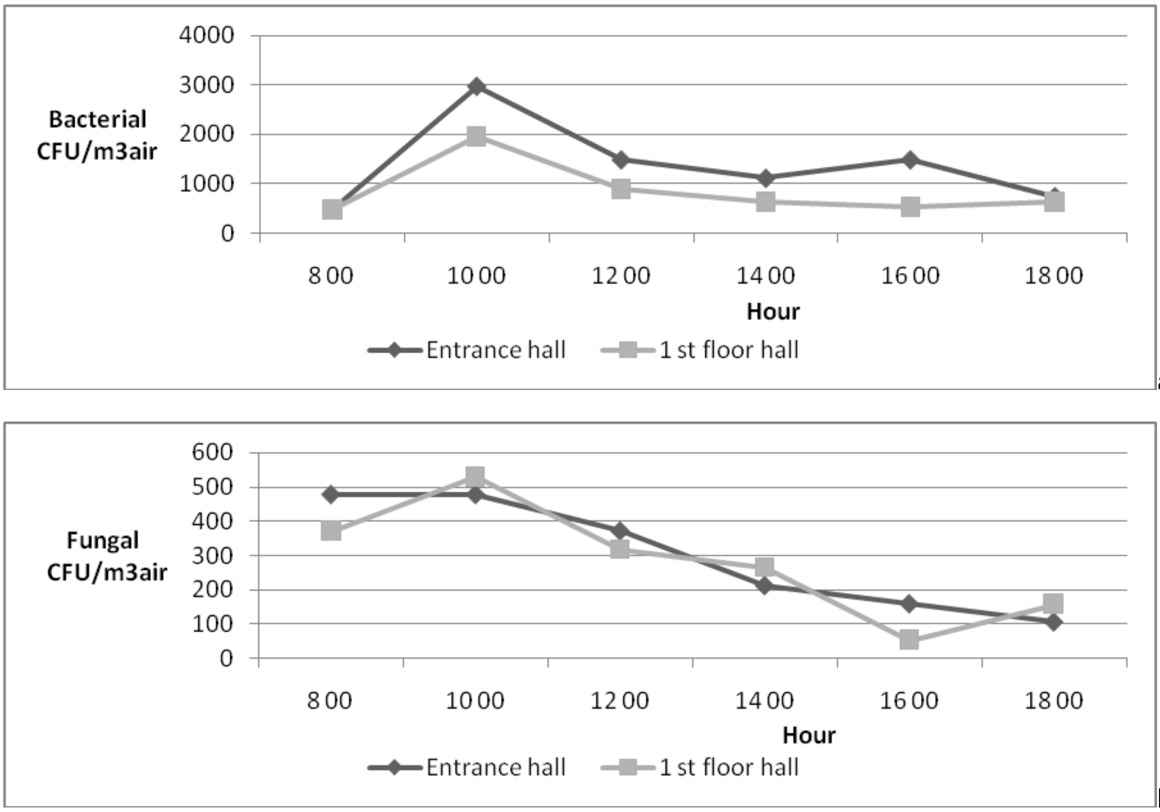


a)

b)

Fig. 2 - Estimation of bacterial (a) and fungal (b) CFU/m^{3}of air in the Secretariat, D 009 and D 116b rooms in the period 1 to 22 April 2016

D 009 room is a laboratory with different equipment for teaching and research use, without air conditioning, with a smaller number of students and a lower movement of persons. This classroom has a medium level of microbial contamination.



a)

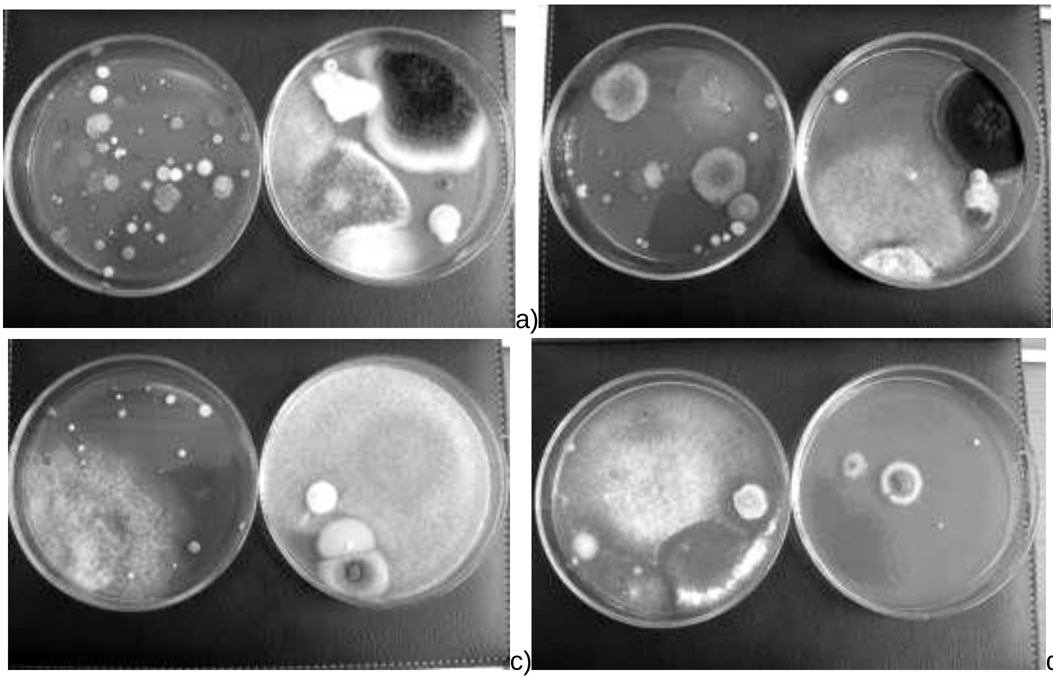
b)

Fig. 3 - Estimation of bacterial and fungal CFU/m^{3}of air in the entrance hall (a) and in the 1st floor hall (b) in 18 April 2016 at different times

Figure 3 shows the dynamics of microbial load of the air in the entrance hall and in the 1 floor hall between 8 a.m. and 6 p.m. when the number of people is higher. The number of bacterial colonies was several times greater than the number of fungal colonies. The CFU/m^3 for bacteria ranged between about 500 and 3000, instead the fungal CFU/m^3 was between 100 and 500.

In both places, the values of CFU/m^3 air seem to reach the maximum at 10 a.m. and decrease until 6 in the evening.

The aspect of bacterial (Petri dishes of the left side) and fungal (Petri dishes of the right side) cultures are presented in figure 4. The highest level of microbial contamination was recorded at 10 a.m. for both bacteria and fungi (a); the analysis of microbial species has not been performed yet, but a great diversity of bacterial and fungal colonies is evident.



a) b) c) d)

Fig.4 - Bacterial (right images) and fungal (left images) cultures in the samples of air collected from entrance hall at 10 00 (a), 12 00 (b), 14 00 (c) and 18 00 (d) hour

The obtained results demonstrated that, in accordance with other research, although indoor environments are considered to be protected, they can become contaminated with particles that present different and sometimes more serious risks.

Mold, mildew, fungi, bacteria, viruses, microorganisms, chemical fumes, organic odours, dust pollen and other floating particles are potential threats in many buildings. Most people assume that this particular problem is partially solved if they filter the air. The truth is that filters will not remove all the particles from the air; dust particles smaller than 3 microns will pass through unhindered (*Yassin M.F. et al., 2010*).

Various environmental conditions such as UV light, temperature, humidity and dryness, play a major role in controlling the growth of microorganisms. Because of the lack of air circulation and increase in number of air conditions inside buildings now days, the chance of airborne infections has grown up (*Sheik G.B. et al., 2015*).

In the building of the Faculty Biotechnical Systems Engineering the microbial air load in April 2016 was related to the number of people and the indoor conditions. Airborne bacterial concentrations were in each case higher than fungi. In addition, bacteria and fungi had similar diurnal variation patterns (figure 3). The weather conditions have not influenced the number of microbial cells in the indoor air. The data in table 1 and figures 1 – 3 demonstrate that there was no correlation between the values of temperature and rainfall and the microbial load in the indoor air samples.

CONCLUSIONS

The presence of indoor airborne microorganisms in the public institutional buildings such as schools and universities is considered a potential health hazards to the buildings' users.

Air samples were collected with a microbiological air sampler from five selected locations in the Faculty of Biotechnical Systems Engineering, University “Politehnica” of Bucharest: entrance hall, 1st floor hall, Secretariat, D 009 room, D 116b room. The air sampling procedure was conducted in spring, between 1 and 22 April, 2016. The results show that the values of microaeroflora are in normal range and depend on the number and circulation of people, the air conditioning and other factors, but not on weather conditions. The values of CFU/m^3 for bacteria range between 500 and 3000 and for fungi between 0 and 500; in all cases the number of bacterial colonies are greater than the fungal ones.

The higher concentration of microbial cells is recorded for entrance hall and for 1st floor hall, places where the flow of people is high and air currents are produced. The lowest values for air microflora were determined for D 116b room, equipped with air conditioning and in D 009 room, less traffic classroom. Medium and high values for microbial load were recorded for Secretariat.

The necessity of the study of microbial load of indoor air in the rooms of faculty is evident and the research should be extended.

Because of IAQ in educational buildings may affect people well-being of people and their teaching and learning performance, regular monitoring of the air microbiota is fully justified.

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USING THE METHOD OF FAILURE AXLE FOR A STUDY ON THE SAFE FUNCTIONING OF A TECHNICAL SYSTEM
/
FOLOSIREA METODEI ARBORILOR DE DEFECTARE PENTRU STUDIUL SIGURANŢEI ÎN FUNCŢIONAREA UNUI SISTEM TEHNIC

Lect. PhD. Eng. Mihai P., Assoc. Prof. Ec. Vlăduţ O.*, Lect. PhD. Eng. Duţu M.F., PhD. Stud. Eng. Vlăduţ D.-I., Lect. PhD. Eng. Duţu I.-C.
University Polytechnica of Bucharest
E-mail: oanavladut2016@gmail.com

***Keywords**: axle failure, technical system, defect.*

ABSTRACT

The failure axle represents a logical diagram which indicates the connection between a certain failure of the system and the components' failures. The system failure is expressed in relation to a specific characteristic. The analysis supposes first a research on the way of system operating, its dependence on component parts and establishing the failure criteria. The method supposes the known failures and, also, the structural connection between failures. These elements are obtained by applying the AMDE method. The failure axle represents in a graph the connection between failures and justifies the choice of the analytical calculation relation between the probability of the system critic failure and the probabilities of the components' elementary failures. The secondary causative failures are not taken into account.

REZUMAT

Arborele de defectare reprezintă o diagramă logică care indică legătura între un defect anumit al sistemului şi defectele componentelor. Defectarea sistemului se exprimă faţă de o caracteristică specifică. Analiza presupune mai întâi o cercetare a modului de funcţionare a sistemului, a dependenţei acestuia de elementele componente şi stabilirea unor criterii de defectare. Metoda presupune defectele cunoscute şi, de asemenea, legătura structurală între defecte. Aceste elemente sunt obţinute din aplicarea metodei AMDE. Arborele de defectare reprezintă grafic legaturile dintre defecte şi justifică alegerea relaţiei analitice de calcul dintre probabilitatea defectului critic al sistemului, şi probabilităţile defectelor elementare ale componentelor. Nu sunt luate în consideraţie defectele secundare de tip cauzal.

INTRODUCTION

The failure axle represents a logical formalization technique the systems in relation to an unwanted state of refusal, called top event.

As formalism, as success diagram, it represents a graph made from nodes and connections, where the nodes are either events or logic gates correlating the events, and the connections are their links.

It has a deductive character; its construction is based on step-by-step deduction of the events contributing to the state of refusal analysed.

AdD, the symbol for the failure axle, has the following advantages:

- A very advanced logical structure of cause-effect type;
- Showing in a structural way the failures generating the analysed undesirable event;
- The possibility to introduce events that normally cannot be easily taken into account to another formalization technique: conditioning, timing, human failures (*Keller G. u.a*).

AdD disadvantages are:

- They are very big for big and complex systems, with memorization and evaluation difficulties;
- Difficulty of use for the systems with dependent events;
- Difficulty of shaping the dynamic behaviour;
- It provides a limited image regarding the general behaviour of the analysed system, for its expanding we must restart the process by re-defining the top events;

The formalization of the systems with the help of the failure axles represents the previous stage of the of the safe model description.

This supposes the complete definition of the system by functions, structure, rules and obviously the definition of components and their failure modes.

MATERIAL AND METHOD

Constructing AdD covers the following important stages:

- Preliminary analysis of technological knowledge structuring by:
  - System decomposition and definition of the component elements taken into account in the analysis;
  - Definition of components failure ways;
  - System reconstruction from the functional perspective.
- Definition of the regimes, restrictions and rules:
  - Establishing the regimes or ways of functioning;
  - Definition of the interaction with the environment;
  - Specific hypothesis regarding the components selection.
- Building the failure axle:
  - Definition of the TOP event;
  - Successive decomposition of the events until we obtain the basic elements.

Three types of events that are more important can be outlined:

a) TOP event;
b) intermediary events;
c) basic events.

First of all we define the TOP event, or undesirable event, which is the final purpose of the safe or security analysis.

The intermediary events are the events resulting from the successive decomposition of the events which compete at producing the TOP event and the ones that will suffer immediate decomposition at the following level.

Basic events are the results of the final phase of decomposition of an intermediary or TOP event. They constitute the multitude of events that participate to the logical description of the mathematical model (*Blockwell, P. and Davis, R.*).

RESULTS

1) System decomposition and definition of the component elements:

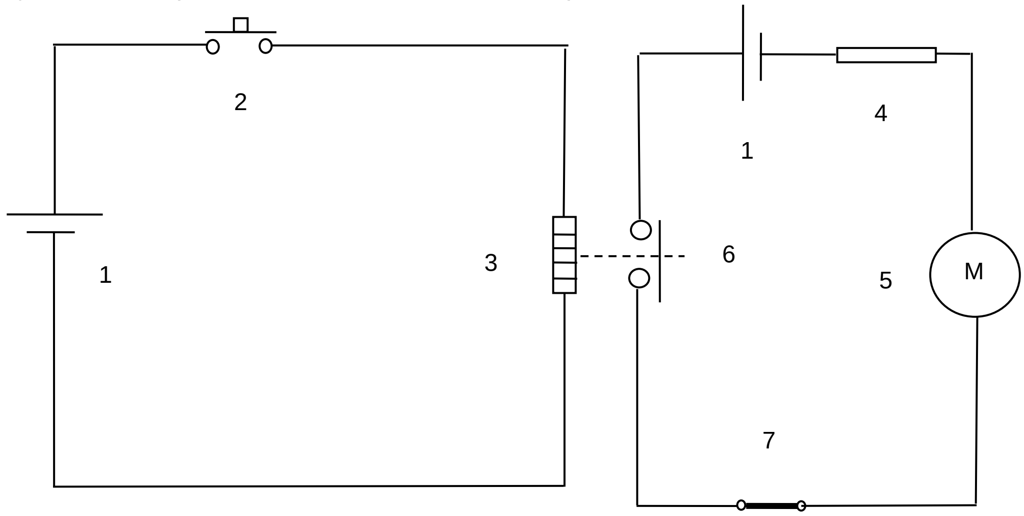


Fig.1. - The equipment
(1 – Battery; 2 – BP Button; 3 – Coil; 4 – Fuse; 5 – Engine; 6 – Relay; 7 – Wire.)

The presentation of the equipment

The system represents the start circuit of a direct current electric motor by pressing the start button 1. The automatic function is start and function for a short period of time of the M motor.

When the button 1 is pressed, coil 3 is supplied and it closes the relay 6 and this way the engine is supplied. The area of the wire 7 is under the action of external factors which can cause overheating and damage of the wire.

Hypothesis:

- The energy source is reliable.

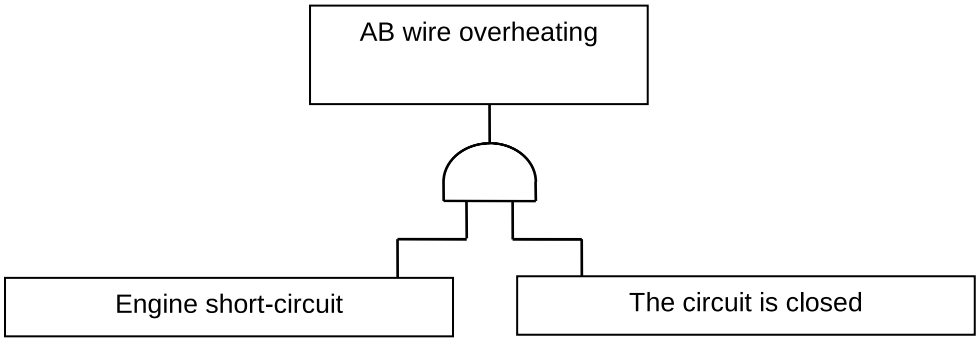
- The engine is made for functioning a short period of time. In case this period is exceeded, a short circuit appears. In case of a short circuit, the relay contacts are out of order and remain in the closed position.

2) The analysis of the system using AdD method

The undesirable event that we chose is overheating the AB wire, because the wire crosses an area with inflammable vapours that can ignite.

The undesirable event can occur only because of a high current in the second circuit, the circuit staying closed. The cause of the high current is a motor short circuit. This is considered the only source that can produce high current in the circuit.

It results:



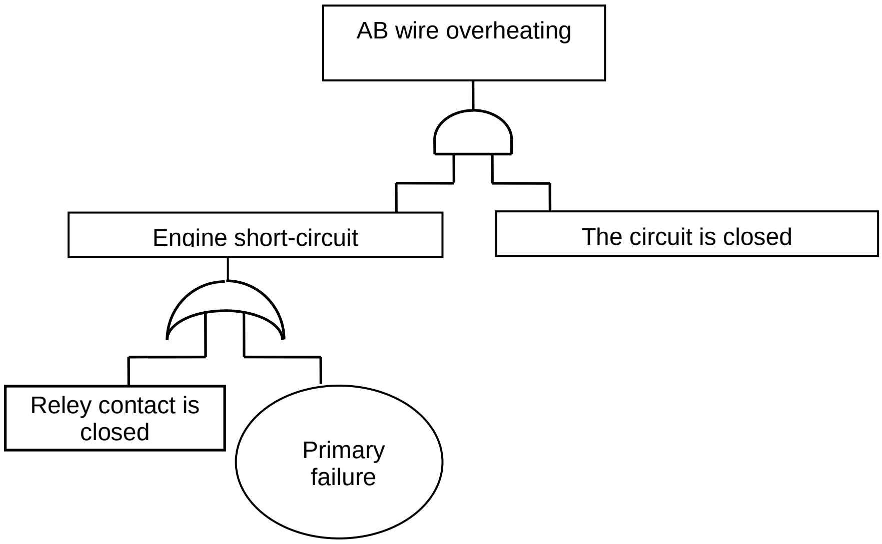
Intermediary events of immediately inferior level are:

- Engine short-circuit which is a component failure;
- Circuit 2 remains closed which is a system failure.

The causes that can produce an engine short-circuit are:

- primary failure – engine failure because of the aging so, a basic event;
- indirect failure because of the fact that the relay contacts remained stuck so, the engine has functioned longer and a short-circuit has occurred;
- there cannot be a command failure (*Chevalier Jean Marie*).

It results:

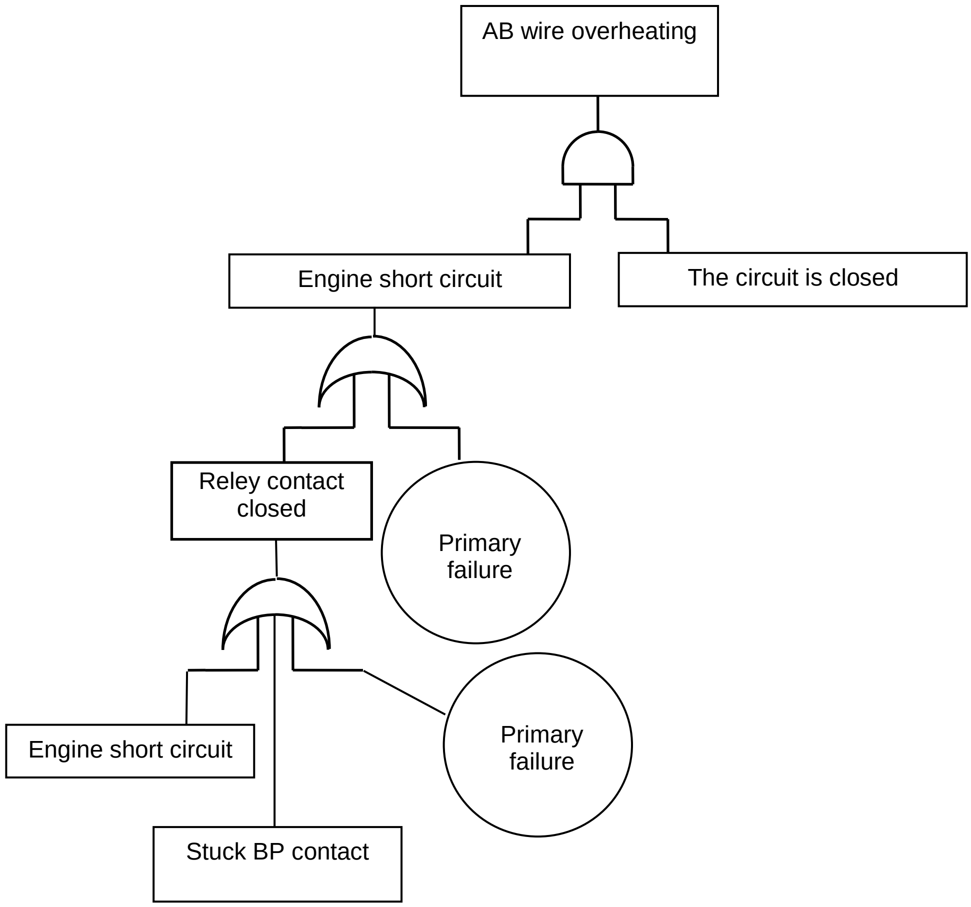


The development of the event: «contact is stuck» represents a relay failure. The causes may be:

- primary failure – the contacts are stuck because a mechanic failure, in this case we have a basic event;

- indirect failure – the contact is stuck in case a high current went through so in case of motor short circuit;
- command failure – the contact is stuck because the BP button remained stuck when it was pressed.

It results:

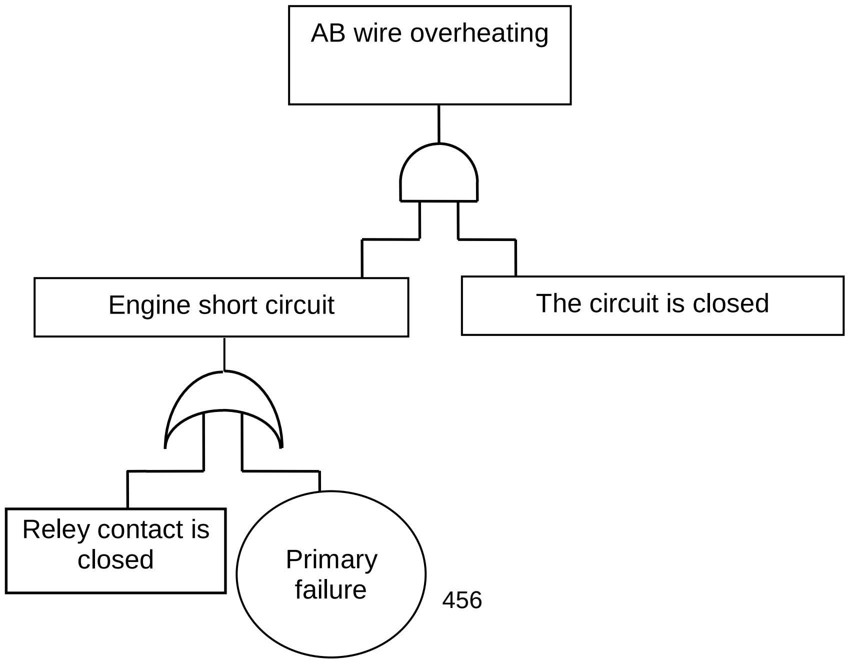


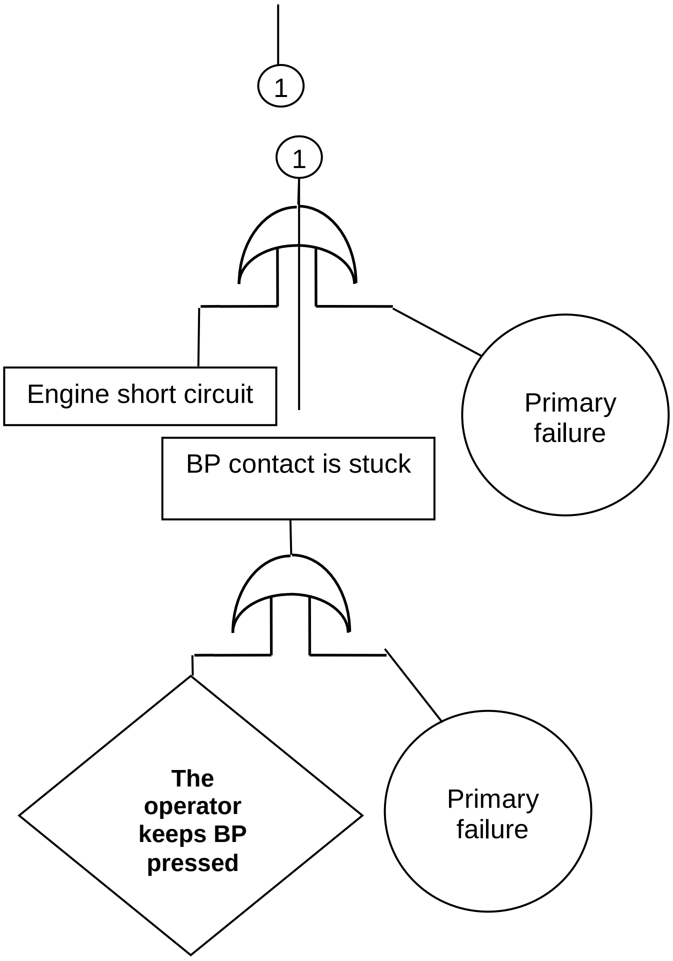
It can be noticed that the engine short-circuit is the cause and the consequence as part of the axle so it must be suppressed as cause, occurring after the cause that produced it.

BP button failure is caused by:

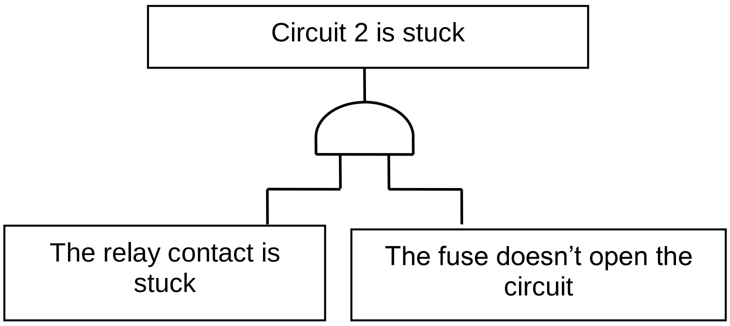
- primary failure – mechanic failure, so a basic event;
- indirect failure – it is not the case;
- command failure – the button remains stuck because of the operator, so there is a human error. It is a basic event.

It results:



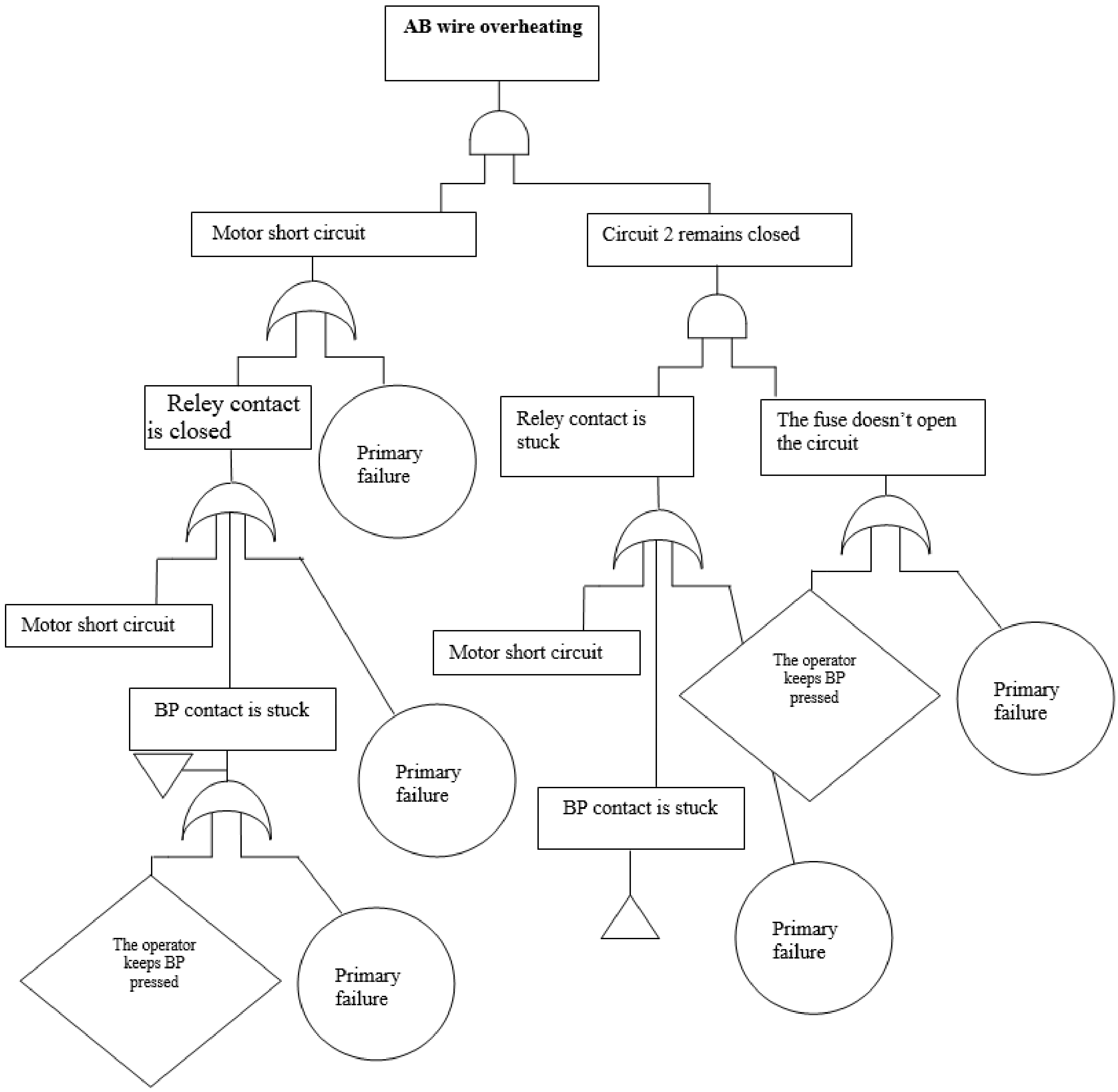


Let's take another intermediary event: «The second circuit remained closed»



The fuse doesn't open the circuit:
- primary failure – because of the fuse – basic element;
- indirect failure – doesn't exist;
- command failure – the operator had over scaled the fuse, so it is operator's failure.

Event "contact stuck" has been already developed.
It results:



CONCLUSIONS

The failure axles are used in designing in two ways.

In the preliminary calculation stage we start from the critic failure the probability of which is specified through imposed-reliability conditions and step by step we establish the components' failure probability.

In the checking stage of the project, the calculation starts in reverse order, from the failure probabilities D_{ijk} established through designing and the probability of the system failure is determined according to a specified algorithm. The calculation can be made automatically by using an expert program. [4]

For usage, the failure axel is very helpful for quick diagnose of the failure states or bad functioning of the systems. Also, by automated means, can be diagnosed the total or derived failures. In this case, the objective is not to determine the failures probabilities; it is necessary to take into account all failure types, including the secondary ones of causal type.

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MATHEMATICAL MODEL TO FORECAST ELECTRIC ENERGY CONSUMPTION / *MODEL MATEMATIC PENTRU PROGNOZA CONSUMULUI DE ENERGIE ELECTRICĂ*

Assoc. Prof. Ec. Vlăduţ O.*, Lect. PhD. Eng. Mihai P., Lect. PhD. Eng. Duţu M.F., Lect. PhD. Eng. Duţu I.-C., PhD. Stud. Eng.Vlăduţ D.-I., Eng. Popescu C.
University Politechnica of Bucharest
E-mail: oanavladut2016@gmail.com

Keywords: *mathematical model, forecast, electric energy, consumption, additive model.*

ABSTRACT

The main purpose of this paper is to present the elaboration methodology of some forecasts in the energy consumption area, using some mathematical models. Consumption forecasts represent the fundamental analysis elements in the elaboration or modification of some decisions in different stages of the electric energy supply management service. Therefore, we need to make some consumption forecasts on short and medium term, as precise as possible, in order to contract, on the competitive market, optimal quantities and implicitly to reduce the costs of electric energy acquisition.

REZUMAT

Scopul principal al acestei lucrări este de a prezenta metodologia de elaborare a unor prognoze în domeniul consumului de energie, folosind câteva modele matematice. Prognozele de consum constituie elemente fundamentale de analiză pentru elaborarea sau modificarea unor decizii în diferite etape ale managementului serviciului de furnizare a energiei electrice. În acest sens, se impune întocmirea unor prognoze de consum pe termen scurt si mediu cât mai exacte, prin aceasta urmărindu-se contractarea pe piaţa concurenţială a unor cantităţi optime şi implicit reducerea costurilor legate de achiziţia de energie electrică.

INTRODUCTION

The forecast for the electric energy consumption is the scientific activity having as main purpose the forecast for the energy consumption based on calculations analysis and based on the interpretation of different data in order to obtain a more precise concordance between the estimated consumption and the one effectively realized.

We can see that a series of parameters (reasons) with random character leads to the energy consumption: climate, demographic, economic factors and also other factors.

The elaboration methodology of a forecast study for energy consumption has few main steps:

- collecting, selecting and analysing the initial data;
- establishing the mathematical model for the consumption;
- analysing the variable obtained for the forecast and establishing the final decision.

1. Components of the energy consumption mathematical model

Consumption curve represents the energy fluctuation in time (or we can take into consideration another parameter) and it can be split in several components. The forecast experience of the energy consumption shows four main components which determine the consumption curve *(W)* (fig.1):

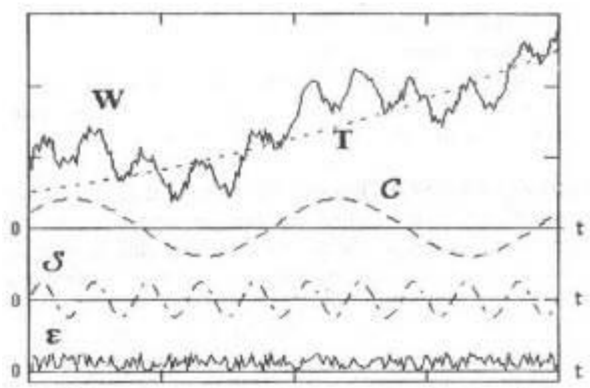

Fig.1 - The components for the mathematical model of the energy consumption curve

1. the trend (T) represents the consumption main compound.
2. the cyclic component (C) shows the fluctuant causes like the request-supply correlation for a period of more than a year.
3. the seasonal component (S) is caused by certain parameters which present seasonal fluctuations (especially climate elements). This component has a few months variation period and a similar shape for all years.
4. the random component (ε) is due to perchance causes that have been previously specified.

As a conclusion, the energy consumption results, totalling the elements that have been specified above, are:

$$W(t)= T(t)+C(t)+S(t)+\varepsilon(t) \qquad (1)$$

MATERIAL AND METHOD

The extrapolative methods principle

The direct forecast methods are supposing the assumption that the causes, the factors and the trends which established the energy consumption in the past are also maintaining in the future, without appearing any dramatic and sudden changes during the forecast that will affect the consumption evolution.

This assumption justifies the energy consumptions evolution trend extrapolation from the past for the future period and brings the forecast problem to the analysis of the energy consumption variation from the past to the future.

The analysed forecast methods suppose establishing a mathematical model with one or more variable functions (generally a single variable, time) that fairly estimates the trend in the last period. The estimation of the functions coefficients is made by solving an equations system where the coefficients are calculating means for the energy consumptions in the last period.

The estimation for the model components

It is considered a value set y_t of a chronological series.

Mathematical model can be made using an additive one:

$$y_t = T_t + C_t + S_t + R_t \qquad (2)$$

We consider the additive model:

$$y_t = T_t * C_t * S_t * R_t \qquad (3)$$

where:

T_t represents the trend (continuous component),

C_t represents the cyclical component,

S_t represents the seasonal components,

R_t represents the component due to random variations.

The additive model can be obtained in logarithmical way.

a) The trend T_t is determined by using linear model:

b)

$$y_t = b_0 + b_1 * t + \varepsilon_t \qquad (4)$$

where finding the parameters b_0, b_1 is made by using the matrix method.

The following matrixes are noted:

$$X = \begin{pmatrix} 1 & x_1 \\ 1 & x_2 \\ \dots & \dots \\ 1 & x_n \end{pmatrix}, Y = \begin{pmatrix} y_1 \\ y_2 \\ \dots \\ y_n \end{pmatrix}, \ B = \begin{pmatrix} \hat{b}_0 \\ \hat{b}_1 \end{pmatrix} \Rightarrow B=(X'X)^{-1}(X'Y) \qquad (5)$$

=> $\hat{b}_0$ and $\hat{b}_1$ parameters which determine the regressive right line: $y_t = \hat{b}_0 + \hat{b}_1 \cdot x_t$.

The advantage of this method is that it can be applied successfully in case of multiple regressive and non- regressive right lines.

b) The cyclical component C_t is obtained by using the additive model $y_t= T_t*C_t*S_t*R_t$

Graphical method supposes that:

1. the trend is established (regressive right line);
2. for each period of time the trend value is evaluated by calculations $\hat{y}_t$;
3. the percentage of the trend is $\frac{y_t}{\hat{y}_t}*100$. It is graphically represented, the points $\left(t, \frac{y_t}{\hat{y}_t}*100\right)$, it=1,.., n and the line 100%. If we see a cyclic phenomenon, we can consider the cycle with the length T.

The development methods in Fourier series

We have the following steps: In the simple cases, y_t can be represented using the mathematical formula: $y_t = \alpha + \beta \cdot \sin\frac{2\pi t}{T} + \gamma \cdot \cos\frac{2\pi t}{T} + \varepsilon_t$, T=cycle period, $(\varepsilon_t)_t$ is the random component.

If T is known and n (number of observations) is a T multiple: n = m*T, than m is the complete cycle number involved in our analysis. The unknown parameters α, β, γ are calculated using the method of least squares. So we can obtain the calculations:

$$\hat{\alpha} = \frac{1}{n}\sum_{i=1}^{n} y_t = \frac{1}{T}\sum_{u=1}^{T}\bar{z}_u, \hat{\beta} = \frac{1}{T}\sum_{u=1}^{T}\bar{z}_u \cdot \sin\left(\frac{2\pi u}{T}\right), \hat{\gamma} = \frac{1}{T}\sum_{u=1}^{T}\bar{z}_u \cdot \cos\left(\frac{2\pi u}{T}\right) \quad (6)$$

where $\bar{z}_u = \frac{1}{m}\sum_{v=0}^{m-1} y_{u+vT}, u = 1,2,...,T$. With T estimated in this way, are graphically represented the points (t, $\hat{y}_t$),t=1,2,..,n $\hat{y}_t = \hat{\alpha} + \hat{\beta} \cdot \sin\frac{2\pi t}{T} + \hat{\gamma} \cdot \cos\frac{2\pi t}{T}$.

c) The seasonal component S_t

The seasonal parameter is used to compare periodical fluctuations on short term between seasons (in our paper: months). The method showed below is applied for the additive model: $y_t= T_t *C_t *S_t *R_t$ and assuming that there isn't a cyclic effect:

We calculate MA(T); the parameter of the time series y/MA is determined; we calculate the mean for each month; we calculate the sum of these means and thus we'll obtain the seasonal parameters.

d) The forecast

The forecast can be obtained by smoothing. We will consider the exponential smoothing using the formula:

$$s_1 = y_1; s_t = \alpha \cdot y_t + (1-\alpha) \cdot s_{t-1}, t \ge 2, \alpha \in (0,1) \quad (7)$$

$$s_2 = \alpha \cdot y_2 + (1-\alpha) \cdot y_1 \quad (8)$$

$$s_3 = \alpha \cdot y_3 + (1-\alpha) \cdot y_2 = \alpha \cdot y_3 + \alpha(1-\alpha) \cdot y_2 + (1-\alpha)^2 \cdot y_1 = \alpha\left(y_3 + (1-\alpha) \cdot y_2 + (1-\alpha)^2 y_1\right) \quad (9)$$

$$s_t = \alpha\left(y_t + (1-\alpha) \cdot y_{t-1} + (1-\alpha)^2 y_{t-2} + ...\right), t \ge 2 \quad (10)$$

.

RESULTS

It is considered a data base (1992 data) which represents the electric energy consumption from University Politehnica of Bucharest during 2016. The registrations from the data base represent a real data base on energy consumptions which allows to locate, with a certain trust level, the consumptions on intervals obtained by proportional division principle. The safety of the forecasts is directly proportional with the number of the available registrations and with their precision, and the data are renewed daily.

The data estimation and the forecast in a time series are made using the modelling methods which have been discussed above. We have elaborated them using Matlab, the mathematical model for the forecast of the electric energy consumption.

For making an energy consumption forecast on short term we used Matlab, performing the following steps:

1. Creation of a data base;
2. We will make the calculations for the geometrical trend and we will see that they are concordant with the graphical method;

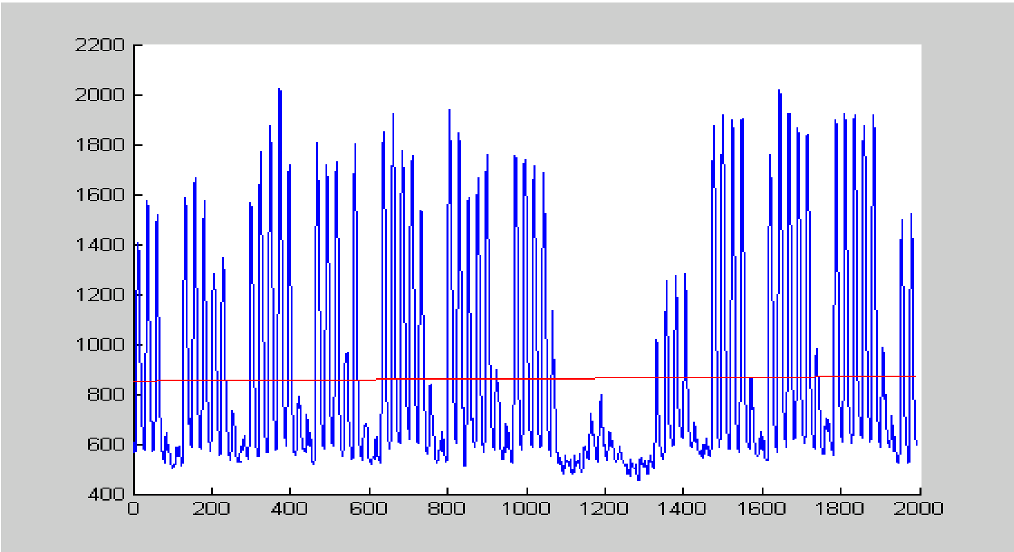

Fig 2 - The evolution in time of the energy consumption

3. We've made the calculations to determine the cyclical component and this is shown below;

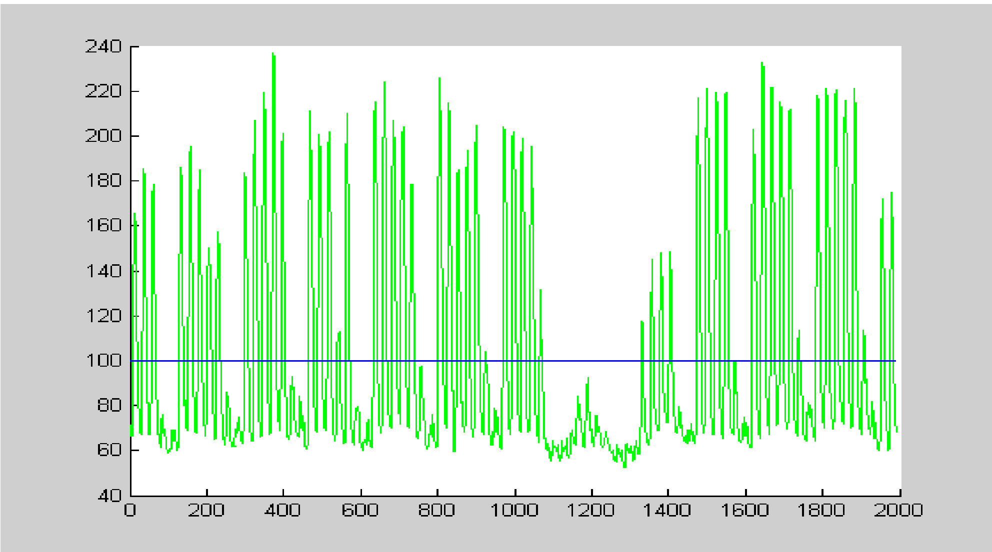

Fig.3 - The estimative result 100 * y/y to determine the cyclical effect

4. We've made the calculations for the seasonal effect and we have obtained the graph:

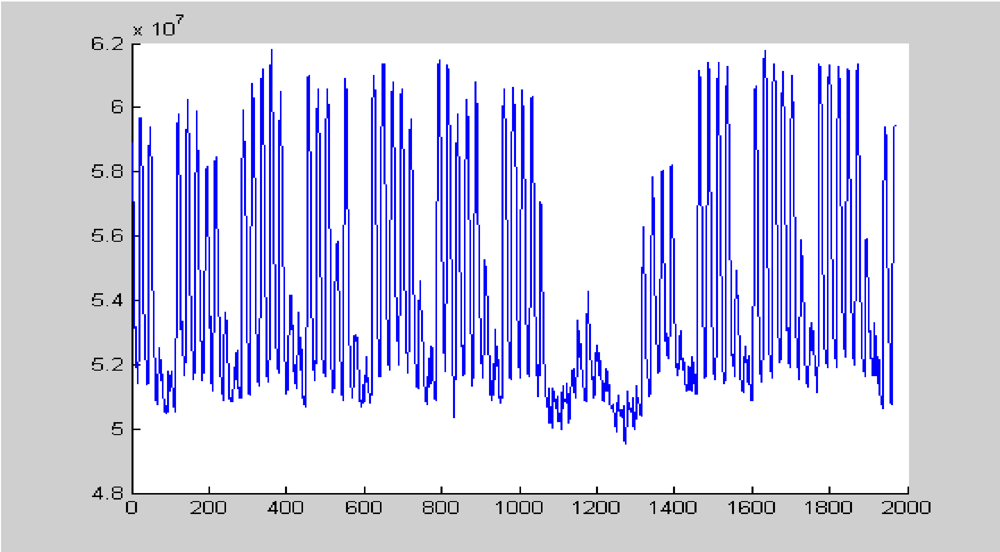

Fig.4 - The produced energy evolution in time, after removing the seasonal effect

5. The forecast for the following year was made using the exponential straightening and we obtained the graph.

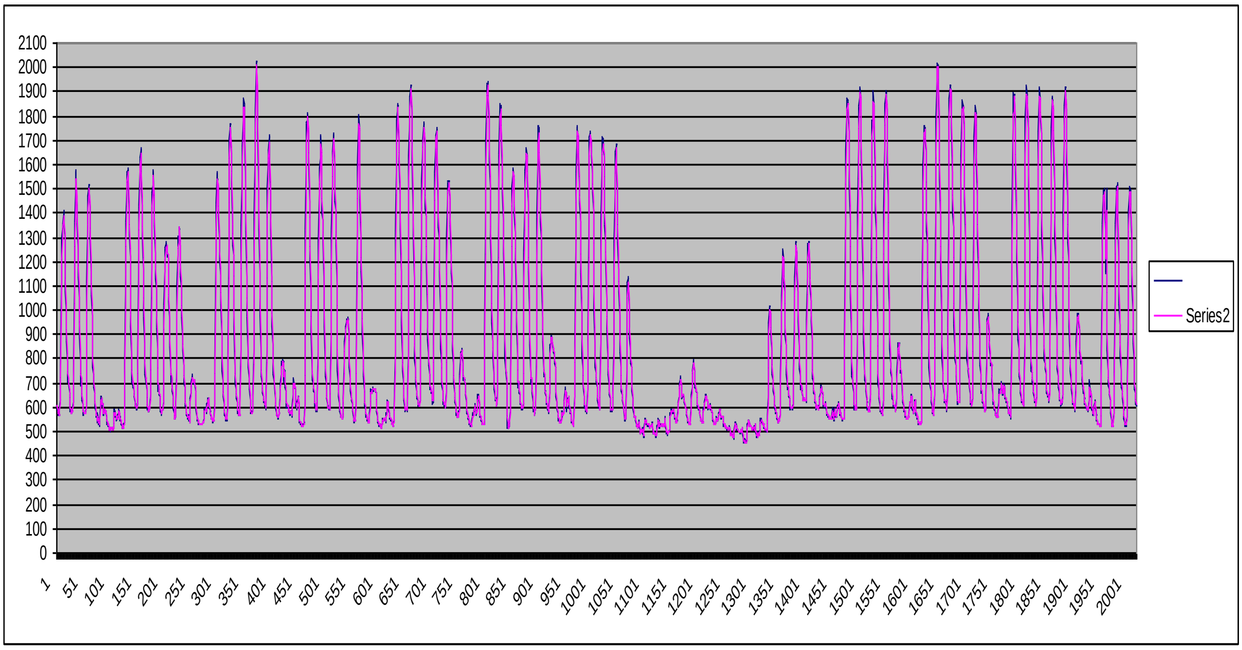

Fig.5 - Estimative forecast of the energy consumption for the following year

CONCLUSIONS

Consumption forecasts represent the fundamental analysis elements in the elaboration or modification of some decisions in different stages of the electric energy supply management service. Therefore, we need to make some consumption forecasts on short and medium term, as precise as possible, in order to contract, on the competitive market, optimal quantities and implicitly to reduce the costs of electric energy acquisition.

Using a recursive approximation procedure gave us some good results, even if there were large variations, for developing a model which takes into account the previous data. According to the graphs, the forecast shows that the energy consumption in 2016 at University Politehnica of Bucharest is almost the same with the one realized in 2015.

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CHARACTERIZATION AND EVALUATION OF SLUDGE FROM WASTE WATER TREATMENT PLANTS BURGAS, MEDEN RUDNIK, TSAREVO, KITEN AND OBZOR
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ХАРАКТЕРИСТИКА И ОЦЕНКА НА УТАЙКИ ОТ ПРЕЧИСТВАТЕЛНИТЕ СТАНЦИИ ЗА ОТПАДЪЧНИВОДИ /ПСОВ/ КЪМ „В И К“ГР.БУРГАС, МЕДЕН РУДНИК, ЦАРЕВО, КИТЕН И ОБЗОР

Prof. Marinova S.[1)],Prof. Kathijotes N.[2)], Assoc.Prof. Petrova V.[1)],Assoc.Prof. Zlatareva E.[1)]
[1]Institute of Soil Science Agrotechnology and Plant Protection"N. Poushkarov"-
Sofia 1080, 7 Shosse Bankya str, Bulgaria
[2] University of Nicosia
Tel. 00359879537371; E-mail: svetla_mar@abv.bg

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ABSTRACT

A study for characterization and assessment of sewage sludge from Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor Waste Water Treatment Plants was conducted as required by law. The analysis was made in accredited laboratories, using European and national methods. It was found, that the sludge is a biomass-rich with macro and micro elements and can be used in agriculture. Clostridium perfringens values are above the maximum set out in the legislation. The sludge contains no viable eggs of nematode type. We recommend sludge to stabilize and be decontaminated prior to its use in agricultural practice. This may be achieved by standing overs for 12-14 months, without the introduction of new lots. It can be used treatment with lime, biolayf, or other products, that will accelerate the processes of mineralization and disinfection of sludge and reduce the residence time prior to recovery. In the region of Burgas, the Municipality has sufficient arable land, where it can recommend the use of sludge as fertilizer. Moreover, there are opportunities for use as a means of rehabilitation of damaged areas, landfills and others.

РЕЗЮМЕ

През последните години се изградиха и влязоха в експлоатация голям брой станции за изкуствено биологично пречистване на битови, промишлени и селскостопански води. При биологичното пречистване се получават големи количества утайки. Утайките представляват органичен резерв, във връзка с недостига на органични източници в нашата страна и съдържащите се в тях органична маса, макро и микроелементи.

Оползотворяването на утайките е свързано със съблюдаване на определени изисквания, като наличие на тежки метали, органични замърсители, санитарно-показателни микроорганизми, които при високи концентрации могат да предизвикат вредно влияние върху почвата, подпочвените води, растенията и животните.

Целта на изследването е, да се направи характеристика и оценка на утайки от ПСОВ Бургас, Меден Рудник, Царево и Обзор като се изследват за агрохимични, химични, санитарно-микробиологични показатели и съдържание на органични замърсители, съгласно изискванията на законодателството.

INTRODUCTION

During the same time a large number of wastewater treatment plants (WWTP) were built and put in operation. As result from the biological purification, sludge and purified water are obtained (Marinova, S., 2002; Marinova, S., 2008). The big quantities of sludge accumulated after waste water processing became a storage problem and polluted the environment. On the other hand, the lack of organic fertilizers in our country requires seeking for alternatives. It has been shown by many scientific studies that waste water sludge is biomass rich in nutrients, macro and microelements, and is an organic reserve which can be utilized in agriculture.

Currently, in Bulgaria, there are 80 urban wastewater treatment plants / WWTP in operation, which produce large amounts of sludge. Pig farms operate many of the industrial wastewater treatment plants too. A small portion of industrial enterprises have established local treatment facilities which treated their waste waters before being discharged into urban sewage. So we cannot locate industries which dispose their untreated effluents directly into the urban wastewater treatment plants. Thus effluents from the urban stations are defined as mixed faecal-domestic and industrial waters.

The sewage sludge utilization is relates to abidance with certain requirements, such as the presence of heavy metals, organic pollutants, sanitary-indicative microorganisms which in high concentrations can cause harmful effects on soil, groundwater, plants and animals (*Marinova, S. 2002; Government decry 2011*).

The aim of this study is to evaluate the sludge from WWTPs in Burgas, Meden Rudnik, Tsarevo, Kiten and Obzorfor agrochemical, chemical, sanitary and microbiological parameters and organic pollutants, so as to assess their quality and recovery potential.

MATERIAL AND METHOD

Sludge investigations from the WWTP were carried out in accordance with EU requirements and regulations for the use of sludge in agriculture 14.12.2004, amended in 2016. These standard supply indicators to be followed in relation to chemical, agrochemical, sanitary and hygienic characteristics of the sludge and the allowable content of organic pollutants. There are also limit concentrations related to / PDK / heavy metals, organic pollutants and microorganisms, which need to be compared to obtained results. Sludge evaluations were carried out in accredited laboratories (*Marinova, S. 2015; Government decry 2011*).

RESULTS

Agrochemical and chemical composition of sludge

The WWTP sludge undergoes different stages of treatment which aim to stabilize the organic matter, reducing their volume, improve sanitary-epidemiological composition and removal from the plant area. Sludge greatly varies in characteristics. Variation of different indicators is quite wide and depends on many factors. Of greatest variation are characteristics of waste water at inflow, chemical and biological conditions through the ongoing processes and more. The results of chemical and agrochemical characteristics of the investigated sludge samples from WWTPs in Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor are shown in Table.1.In the table are listed and the methods by which are defined individual indicators *(Government decry 2011*).

Data shows that the measured values of dry matter varied between 92.62% and 97.41%. This means that sediments can be transported and spread by mobile means as manure (*Marinova, S. 2001*). Of great importance in using sludge in agriculture is its content in nitrogen. It was found that the content of ammoniac nitrogen is higher in the sludge, which has a lower content of absolutely dry mater. By increasing the amount of dry matter, ammonia nitrogen decreases. This can be explained with loss of ammonia nitrogen during the storage of sludge and scattering the field. In order for organic nitrogen to be utilized, it must pass in to ammonia form, and with further nitrification to nitrate. This depends mostly on the characteristics of the sludge. Mineralization of organic matter is carried out more rapidly in aerobic conditions rather than under anaerobic.

The total nitrogen is between 1.40% and 4.99% on a dry matter basis. The content of total nitrogen is sufficient to meet the needs of the plants of nitrogen. There is not only the total nitrogen content, but the amount of ammoniacal nitrogen, which is located in the sludge and may be lost during storage and spreading. In order to reduce nitrogen losses, it is appropriate after dispersal of sludge on soil surface to be carried out plowing, disking, or culturing, to allow the imported nitrogen enters into contact with the ground absorptive complex, wherein the losses minimized.

During biological treatment of wastewater, sludge is enriched with phosphorus. Phosphorous plays an important role in the growth of plants. From this perspective, sludge will be important for regulating plant nutrients. Research in this field reported values of total P_20_5 is from 0.95% to 2.87%.

The potassium content is low. This low content of potassium is due to increased solubility of potassium salts, which during the formation of sludge remain in the liquid fraction. The values established for potassium are from 0.14% to 0.26%.

Calcium and magnesium content has different impact on the soil properties. Calcium affects the plants and soil structure which leads to a change in response to environmental dynamics in the absorption of various elements. Calcium values reach to 4.15% in sludge from Obzor-Biala.

Magnesium also affects the plants in their physiological role. Captions of this element are easily assimilated by plants.

The use of sludge as fertilizer implies investigation of the presence the presence of heavy metal content above the limit concentration is a limiting factor for optimal fertilizer rate of sludge. Many of these elements in the minimum quantities required for the development of plants, but in higher concentrations were toxic to plants, soil, water, animals and humans.

Table 1

Chemical and agrochemical characteristics of the sludge from Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor WWTPs

Indicator	Burgas	Meden Rudni	Pomorie	Obzor-Biala	Kiten	Tsarevo
pH /H_20/	5.70	12.37	5.32	5.20	5.31	5.10
Dry matter %	97.97	97.35	97.07	98.39	97.82	96.50
Organic carbon%	15.77	12.97	9.25	12.08	15.42	18.80
Total content on the dry matter base %:						
N	3.52	4.34	4.92	3.21	3.55	4.17
P	1.72	1.86	1.48	2.21	2.38	1.60
K	0.17	0.21	0.36	0.21	0.13	0.20
Ca	4.02	13.17	3.90	3.41	3.34	2.46
Mg	0.82	0.45	0.98	0.51	0.52	0.64
Hydrogen amount on the dry matter base %:						
$N\text{-}NH_{4\ mg/kg}$	514.7	354.2	555.5	532.5	512.1	744.0
N-NO$_{3mg/kg}$	1.6	19.53	444.3	369.3	221.4	210.8
$P_{\%}$	0.16	0.12	0.10	0.087	0.057	0.11
$K_{\%}$	0.116	0.072	0.21	0.10	0.053	0.130
$S\text{-}SO_4$	4272	3090	18.68	3411	49.72	1004

Table 2

Contents of heavy metal in the sludge from Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor WWTPs

Heavy metal mg/kg	Burgas	Meden Rudni	Pomorie	Obzor-Biala	Kiten	Tsarevo	MAC BG standards	MAC EU standards
As	11.2	<10	<10,0	<10	<10	<10	25	-
Cd	3.3	1.7	1.5	1.7	1.0	1.8	30	40
Cr	69.5	42.3	62.0	47.9	34.5	50.8	500	-
Ni	34.9	19.4	36.8	23.3	24.3	32.0	350	400
Cu	226.7	82.0	179.8	131.6	302.9	198.8	1600	1750
Zn	1833.0	744.3	580.5	1523	1118.0	1610	3000	4000
Pb	66.4	19.2	38.1	20.8	37.8	36.1	800	1200
Hg	<1	<1	<1,0	<1	<1	<1	16	25

Data for heavy metals content in studied sewage sludge are shown in Table 2.They are compared to MAC heavy metals listed in the Ordinance for the use of sludge in agriculture, and the European standards. Values are established here are below MAC standards for heavy metals in sludge. This indicates that there is no limit for using these sludge's in the agricultural practices. We have to establish the source of this heavy metal, probably contained in the waste water input or due to improper sample taken for analysis.

Content of persistent organic pollutants

Requirements of the Ordinance for the use of WWTP sludge in agriculture poses as prerequisite the study of possible persistent organic pollutants such as polycyclic aromatic hydrocarbons / PAH and polychlorinated biphenyls / PCBs (*Marinova, S. 2002; Government decry 2011*).

Once in soil, organic contaminants can be absorbed by the solid phase to remain in the soil solution or be subjected to transformation. Some of them can migrate in depth profile or be exported with runoff.

Table 3

Comparative characteristics of organic pollutants in sewage sludge in mg / kg / average / polycyclic aromatic hydrocarbons

Indicator WWTP	Burgas	Meden Rudni	Pomorie	Obzor-Biala	Kiten	Tsarevo
Naphthalene	<0.00018	0.00018	0.00084	<0.00018	0.00190	<0.00018
Acenaphtene	0.00340	0.00018	<0.00018ж	<0.00018	0.00473	<0.00018
Acenaphthylene	0.00257	0.00170	0.00138	<0.00016	<0.00016	<0.00016
Fluorine	0.00659	0.00020	0.00365	<0.00020	0.00085	<0.00020
Fenantren	<0.00021	0.00021	<0.00021	<0.00021	0.00091	<0.00021
Antracen	0.00660	0.00025	0.00876	<0.00025	0.01051	<0.00025
Fluoranthene	0.03887	0.00024	<0.00024	<0.00024	0.09802	<0.00024
Piren	0.00201	0.00962	0.00186	<0.00026	0.00052	<0.00026
SumBenzo/a/ntrasen	0.03287	0.00054	0.00793	<0.00054	0.02023	<0.00054
Hrizen	0.08025	0.00053	<0.00052	<0.00053	0.01710	<0.00053
Benzo/b/phoureten	<0.00105	0.00103	<0.00103	<0.00103	0.16230	<0.00103
Benzo/к/Phuoreten	0.15134	0.00113	0.00811	<0.00113	0.03420	<0.00113
Benzo /a/ piren	0.04660	0.00096	0.02413	<0.00096	0.07191	<0.00096
Indeno /1,2,3-cd/ Piren	0.01430	<0.00164	0.03155	<0.00164	0.11889	<0.00164
Dibenzo /a, h/ antracen	0.44354	<0.00254	<0.00252	<0.00254	0.09951	<0.00254
Benzo /g h i/ piren	0.17371	0.18368	0.01997	<0.00121	<0.00120	<0.00121
PAV$_{16}$total mg/кg	**1.00266**	**0.19500**	**0.10818**	**0.00563**	**0.64159**	**0.00563**
MAC	**6.5**	**6.5**	**6.5**	**6.5**	**6.5**	**6.5**

PCBs

Indicator	Burgas	Meden Rudni	Pomorie	Obzor-Biala	Kiten	Tsarevo
PCBs 28	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs 52	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs 101	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs 138	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs 153	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs 180	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total PCBs$_6$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
MAC	**1**	**1**	**1**	**1**	**1**	**1**

Test results of dehydrated sludge are shown in Table 3. Data shows that levels of polycyclic aromatic hydrocarbons / PAH and polychlorinated biphenyls / PCBs are below the MAC, as compared with the MAC in the Ordinance and does not constitute a limiting factor in the use of sludge in agriculture.

Microbiological characteristics

The results of microbiological and parasitological examinations are shown in Table. 4. Data shows that the intestinal pathogen from *spp.Salmonella* is not isolated. Despite the fact that all members of *coliforms* are generally associated with faeces contamination, the ratio between genera and species included in this group, under certain conditions varies considerably. E-coli are established in fresh faeces contamination. As the self-cleaning progresses, microbial ratio shifts to other species of coliforms - families *Enterobacteriaceae, Citrobacter* and *Clostridium*. Increased is the content of enterococci too, which are used as indicators of recent faecal contamination. Unlike E-coli, they do not multiply in the presence of organic matter. In the studied sediments are not found E. coli - indicators of faecal contamination and Sulphide-reducing *Clostridia* in values above MAC. So each used sanitary-microbiological indicators reflect a certain point source pollution and self-cleaning.

No viable eggs of Helminths and protozoa were found in the study sample table 4.A number of studies conducted at the ISSAPP "N. Poushkarov" jointly with Centre for Hygiene and Public Health Protection show that after staying of sludge in drying field, progressively reduce sanitary microbiological indicators including E. coli, Enterococci and Clostridia Sulphide-reducing clostridia, and consistent change E. coli Citrate positive other forms. They characterize the intensity of the process of self-purification to 15 months, after which time sludge is not dangerous in epidemiological aspect (Marinova, S.2002; Marinova, S. 2008).

Evaluation of the research results and comparison with European and National regulations

Studies sewage sludge Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor WWTPs show that:

- Investigated samples of sludge meet the requirements of the Ordinance for the use of sludge in agriculture and the European standards in terms of content of heavy metals.

- Values of organic pollutants - PAH, PCB and MAC pose no danger for using sludge in agricultural practice.

- Sanitary parasitological indicators show that they occur naturally in sludge decontamination and microbiological parameters studied were higher than recommended. No viable *Helmints* eggs and *Protozoa* were found in examined sludge samples.

Table 4

Microbiological assessment of sludge from Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor WWTPs

N	Indicator WWTP	Salmonella sp.	Coli forms	Escher. coliTitar	Entherococ us	Clostr. Perfin gens	Viable Helmints eggs
1	**Burgas**	Not isolated	Above 1	Above 1	Above 1	Above 1	not found
2	**Meden Rudnic**	Not isolated	Above 1	Above 1	Above 1	Above 1	not found
3.	**Pomorie**	Not isolated	Above 1	Above 1	Above 1	Above 1	not found
4.	**Obzor-Biala**	Not isolated	Above 1	Above 1	Above 1	Above 1	not found
5.	**Kiten**	Not isolated	Above 1	Above 1	Above 1	Above 1	not found
6.	**Tsarevo**	Not isolated	Above 1	Above 1	Above 1	Above 1	not found
Requirement		Not allowed in 20 g	Above 1	Above 1	Above 1	Above 1	1 on 1 kg of dry matter

CONCLUSIONS

Sludge obtained during the biological treatment of wastewater in Burgas, Meden Rudnik, Tsarevo, Kiten and Obzor WWTPs s are biomass rich in macro and micronutrients.

The values of the heavy metals are below MAC in accordance with the legislation. Sludge must be stabilized and decontaminated prior to its use in agricultural practice. This may be achieved by standing the sludge-over's for 12-14 months without the introduction of new lots. It can be used treatment with lime, Biolayf or other products that will accelerate the processes of mineralization and disinfection of sludge and reduce the residence time before its utilization.

In the region of Bourgas, the Municipality has sufficient arable land, where it can recommend the use of sludge as fertilizer. Moreover, there are opportunities for use as a means of recultivation of damaged areas, landfills and others.

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DETERMINING THE EFFECT OF DIGESTATE RECEIVED FROM BIOGAS PRODUCTION AND IMPACT ON YIELD AND QUALITY OF CROP PRODUCTION / *ОЦЕНКА НА БИОШЛАМ ПОЛУЧЕН ПРИ ПРОИЗВОДСТВОТО НА БИОГАЗ И ВЛИЯНИЕТО МУ ВЪРХУ ДОБИВА И КАЧЕСТВОТО НА ПРОДУКЦИЯТА*

Assoc.Prof. Zlatareva E., Assoc.Prof. Petrova V., Ass. Prof. Kolchakov V., Prof. Marinova S.
Institute of Soil Science Agrotechnology and Plant Protection"N. Poushkarov"-
Sofia 1080, 7 Shosse Bankya str, Bulgaria
Tel. 00359879537371; E-mail: svetla_mar@abv.bg

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ABSTRACT

The shortage of electricity in Bulgaria requires demand for renewable energy sources. Interest in the production of biogas from organic waste has intensified in recent years. Anaerobic fermentation during biogas production is associated with obtaining the digestate. Several studies have found that digestate is rich in micro and macro nutrients and can be used as an organic reserve in agricultural practice.

The aim of this study is to determine the effect of digestate on yield and quality of crop production at the ratio of raw materials the input of biogas installation - pig manure and markets waste 70:30. The indicator culture is lettuce. The studies were carried out on two soil types. Different percentage of digestate was tested in comparison with untreated soils as controls.

РЕЗЮМЕ

Недостигът на електроенергия в България изисква търсенето на възобновяеми енергийни източници. През последните години се засилва интереса към производството на биогаз от органични отпадъци. По време на анаеробната ферментация при производството на биогаз се получава биошлам като вторичен продукт. Въз основа на проучвания е установено, че биошламът е богат на микро и макро елементи и може да се използва като органичен резерв в селскостопанската практика.

Целта на това проучване е да се определи ефекта на употребата на биошлам върху добива и качеството на селскостопанските култури. Началните суровини подадени на входа на експериментална инсталация за производство на биогаз е свински тор и отпадъци от пазарите в съотношение 70:30. Индикаторната култура е марулята. Изследванията са проведени върху два почвени типа. Тествани са различно процентно съотношение на биошлама спрямо теглото на почвата и нетретирана почви, като контроли.

INTRODUCTION

The shortage of electricity in Bulgaria requires renewable energy sources. In recent years there has been increased interest in biogas production from organic waste (*Zaharinov, 2011*). Currently, potential raw materials for biogas production are underutilized. Their improper treatment or deposition leads to pollution of the environment. In our country, there are still no installations for biogas production.

Anaerobic fermentation (AF) is a microbiological process of organic matter decomposition in the absence of oxygen and is commonly found in many natural environments (*Galabova et al., 2003*). Nowadays, AF is used mainly for the production of biogas in airtight tanks-reactor, usually called bioreactors (*Schink, 2001*). Wide range of microorganisms is involved in the anaerobic process as main end products are biogas and digestate. Biogas is a combustible gas containing methane, carbon dioxide and small amounts of other gases as well as small amount of other elements (*Simeonov, 2012; Zaharinov, 2013; Rychtera et al., 1983*).

During anaerobic fermentation for biogas production is obtained secondary biomass also known as digestate. This requires seeking of its realization. Several studies have found that digestate is rich in micro and macro nutrients and can be used as an organic reserve in agricultural practice (*Shaffer et al., 2001; Marinova et al., 2012; Baykov, et al., 2007*).

The interest of farmers associated with utilization of digestate is related to the shortage of organic sources in our country, imbalance of organic matter in Bulgarian soils and the availability of large quantities of organic waste nationwide.

The aim of this study is to establish the effect of digestate for use in agricultural practice and its impact on yield and quality of crop production at the ratio of the raw materials into biogas pilot plant - pig manure and markets waste 70:30.

MATERIAL AND METHODS

- **Conducting the vegetation experiment**

Testing different variations and identification of the most suitable soil for plants require to conduct vegetation experiments. These studies will establish the most appropriate and economic norms for utilization in field conditions (*Demirbas, 2006*).

Vegetation experiments were conducted using digestate from model installation for biogas production with raw material comprising pig manure: wastes from market in ratio 70%: 30%. The experiments are laid out on two soil types: fluvisols from the area of Kubratovo and vertisols from Bojurishte.

The following variants were tested: control - clean soil, control - soil with mineral fertilization and variants with 5%, 15%, 25% and 35% of digestate by soil weight.

The variants with mineral fertilization are included to compare the used digestate, which is organic matter (gradually mineralized) and mineral fertilization (easily assimilated form plants).

The lettuce (*Variety Gentilini*) was planted as a test crop. For establishment of content of macro and micro nutrients and cation exchange capacity digestate and soil types were analysed before experiment. Crop development is documented by photographs.

- **Determination of the yield and analysis of crop production and soil**

Post-harvest crop yield was recorded and the information was subjected to mathematical and statistical analysis.

The plant production is analysed for basic content of macro and micro nutrients and some heavy metals by standard methods used in ISSAPP, "N. Poushkarov".

- Total nitrogen - Kjeldahl,
- Microelements - method of Hess with atomic-absorption spectrophotometer.
- Ammonium and nitrate nitrogen – colorimetrically.
- Mobile forms of phosphorus - colorimetrically by a modification of the method of P. Ivanov.
- Mobile forms of potassium – with a flame photometer.
- Total content of heavy metals - aqua regia method.
- Mobile forms of microelements (heavy metals)-EDTA-method.
- pH (H_2O, KCl) - potentiometrically.
- Mechanical composition - pipette method with dispersant - sodium pyrophosphate, in Kaczynski.
- Hygroscopic humidity - a thermostatically-weight method.
- Soluble salts - weight method.
- Electrical conductivity – conductometrically.

RESULTS AND DISCUSSION

- **Characterization and evaluation of digestate used in vegetation experiments.**

Agrochemical and chemical characteristics of digestate obtained from 70% pig manure: 30% fruit and vegetable waste is shown in table 1.

The data show that digestate is rich in macro and microelements and can be used in agricultural practices to improve soil properties and crops yield.

The content of the common forms of nutrients - nitrogen, phosphorus and potassium are respectively 10.80%; 7.67% and 9.02% in absolute dry matter. Based on the dry matter content, reported in digestate (1%) the real values of total nitrogen were 0.11%; 0.08% total phosphorus and 0.099% total potassium. The pH activity is neutral- 7.62.

Table 1

Chemical and agrochemical characteristics of digestate from vegetative experiments

Elements	70:30 pig manure: markets waste	Elements	70:30 pig manure: markets waste
pH –H_2O	7.62	Mobile P %	0.54
Moisture %	98.9	Mobile K %	1.25
Dry residue %	1.1	S (as SO_4) %	0.1
Organic C %	24.88	As mg/kg	< 5.0
Total P_2O_5 %	7.67	Cd mg/kg	< 1.0
Total N %	10.8	Cr mg/kg	13
Total K_2O %	9.02	Ni mg/kg	26
Total CaO %	7.6	Cu mg/kg	411
Total MgO %	2.89	Zn mg/kg	1409
Mobile N–NH_4 %	5.48	Pb mg/kg	8
Mobile N–NO_3 %	0.53	Hg mg/kg	<1

The content of heavy metals (table 1) shows that values are under maximum allowable concentration (MAC) and digestate is not hazard for use in agriculture.

The data on chemical composition and physicochemical properties of digestate shows that it can be a source of important plant nutrients such as nitrogen, phosphorus, potassium, magnesium, calcium, iron, sodium, etc.

- **Characterization and evaluation of experimental soil types**

- **Agrochemical physical-chemical characteristics of fluvisol from Kubratovo.**

Data from agrochemical analysis show that the soil is very well supplied with mobile phosphorus (23.2 mg P_2O_5/100g soil) well preserved with mobile potassium (27,4 mg K_2O/100g soil) and mineral nitrogen in dominant ammonium form.

Conductivity is low and amount of soluble salts is also very low. The total amount of heavy metals in the soil is below MAC (table 2).

Table 2

Chemical analysis of vertisol and fluvisol of the vegetation experiments

Elements	Vertisols	Fluvisol	Elements	Vertisols	Fluvisol
pH –H_2O	6.1	5,5	Exchange Mg mg/100g	108	57
pH – KCl	-	5,5	Conductivity mS/cm	0.042	0.077
Total N %	0.12	0,21	Water soluble salts g/100g	0.013	0.024
Total Ca%	-	0,14	As mg/100g	<1	< 1
Total Mg %	-	0,58	Cd mg/100g	<1	< 1
Total Fe %	2.77	3,51	Cu mg/100g	185	210
Total P %	-	0,14	Pb mg/100g	2	42
N – NH_4 mg/kg	8.2	11,8	Ni mg/100g	22	18
N –NO_3 mg/kg	5.8	7,1	Zn mg/100g	1170	132
Mobile P_2O_5 mg/100g	0.22	23,2	Cr mg/100g	7	11
Mobile K_2O mg/100g	36.9	27,4	Humus %	3.36	-
Exchange Ca mg/100g	696	430			

A physicochemical characterization of soils, used in vegetation experiments was also made. Data on Fluvisols is presented in Table 3. According to the constitution bases, when the bases are <Tca (T 8.2%) and pH <6 the soil is podzolic. According to the buffer systems the soil is medium acid and the ion exchange capacity (T 8.2 = 35 g soil meqv. /100) define it as medium colloidal. The predominant clay minerals determine soil as montmorillonite-illite (81.43% TCA = 8.2 T) with evolution to illite-montmorillonite (base = 80.29%).

Table 3

Cation exchange capacity and base saturation in studied fluvisol

Materials	**pH/ H_2O**	**$T_{8,2}$**	**T_{CA}**	**T_A**	**Exch. $H_{8,2}$**	**Exch. Al+H**	**Exch. Ca**	**Exch. Mg**
		meqv/ 100 g.						
Soil	5.5	35.0	28.5	6.5	6.9	0.4	24.0	3.9

T_{CA}	**T_A**	**Exch. $H_{8,2}$**	**Exch. Al**	**Exch. Ca**	**Exch. Mg**	**base saturation %**
% $T_{8,2}$						
81.43	18.57	19.71	1.43	68.57	10.86	80.29

Physical and mechanical properties of Fluvisol (Table.4) show that fraction <0, 001 dominates.

Table 4

Mechanical composition of Fluvisol from the vegetation experiments

Variants	**Particle size (mm)**							
	Amount > 1	1 – 0.025	0.25 – 0.05	0.05 – 0.01	0.01 – 0.005	0.005 – 0.001	<0.001	Amount < 0.01
Soil	0.0	16.7	19.73	13.72	15.04	6.71	28.10	49.85

- **Agrochemical and physical-chemical characteristics of Vertisols in the region of Bojurishte.**

Soil from Bojurishte region - Sofia that is provided for vegetation experiment is, classified as Smolnitsa according to the Bulgarian Soil Classification, which correspond to vertisol in the World Reference Base for Soil Resources (*IUSS Working Group WRB, 2006*).

Data from agrochemical analysis of the soil shows that it is very well supplied with mobile potassium-36, 92 mg K_2O / 100 g soil, and very low, almost poor in the plants absorbable phosphorus- 0, 22 mg P_2O_5 /100 g soil.

Mineral nitrogen is in predominance of ammonium form. The amount of soluble salts is very small due to the low conductivity. The total amount of heavy metals is below the limit (table 2).

Data for physical and chemical characteristics of the soil is presented in Table 5. The ranges of variation of the magnitude of cation sorption capacity ($T_{8,2}$) and the average percentage of strong (T_{CA}) and weak (T_A) acidoid is determined using the Ganev and Arsova method.

Table 5

Cation exchange capacity and base saturation in studied vertisol

Materials	**pH/ H_2O**	**$T_{8,2}$**	**T_{CA}**	**T_A**	**Exch. $H_{8,2}$**	**Exch. Al+H**	**Exch. Ca**	**Exch. Mg**
		meqv/ 100 g.						
Soil	6.1	50.7	43.86	6.9	3.9	0.0	34.7	9.04

T_{CA}	**T_A**	**Exch. $H_{8,2}$**	**Exch. Al**	**Exch. Ca**	**Exch. Mg**	**base saturation %**
% $T_{8,2}$						
86.39	13.61	7.69	0.0	72.39	17.89	92.31

Constitution bases soil (A horizon) with pH = 6.1, bases = T_{CA} confirms that the soil is leached. According to the acid and buffer systems, vertisol is a weak acid (A horizon). Colloidal reactivity ($T_{8.2}$ = 44, meqv/100g) shows that the soil is poorly colloid. The prevalent clay mineralogy (T_{CA} = 43.86 meqv/100g) determine soil as montmorillonite-illite.

It was also determined the mechanical composition of the vertisol. The results are presented in table 6. The data shows that dominated participation have a size fraction less than 0.001 (finest fraction).

Table 6

Mechanical composition of vertisols for vegetation experiments

Variants	Particle size (mm)							
	Amount > 1	1–0.25	0.25–0.05	0.05–0.01	0.01–0.005	0.005–0.001	<0.001	Amount < 0.01
Soil	0.0	1.8	9.8	13.0	11.5	8.8	53.3	73.6

- Development of plants during vegetation

As we noted above, vegetation experiments are conducted with digestate from biogas production in pilot installation with raw materials in ratio 70% pig manure: 30% vegetable waste. *(Simeonov et al, 2012*).

Vegetation experiments are set on 31 October 2011 on already mentioned two soil types (Fluvisols and Vertisols). Sowing of lettuce was carried out. Plants germinated normally on 10 November 2011. 20 days later lettuce was thinned. Daily watering of plants, according to the field capacity (FC) was fulfilled. 46 days after sowing the plants, different variants were photographed on both soil types.

Lettuce

- **Yield and chemical analysis of lettuce plant production**

Vegetation experiments show that lettuce develops normally on both soil types. The obtained data from lettuce yield on fluvisol (fig.1) and leaching vertisol (fig. 2) show that quantity of biomass is higher on the first soil type for all variants.

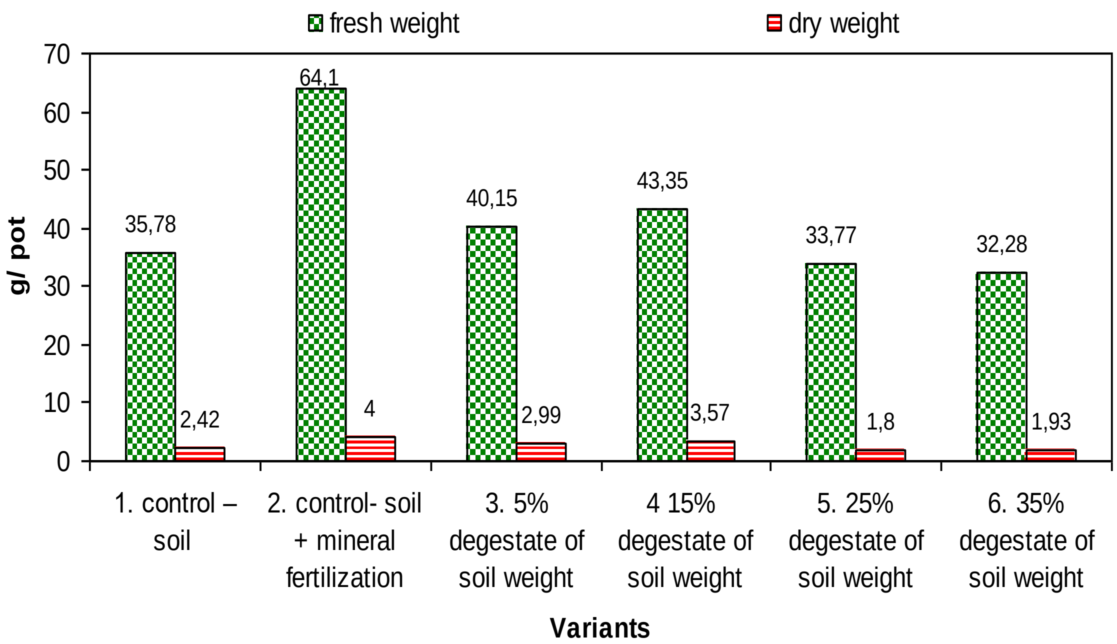

Fig.1 - Yield of lettuce from fluvisol on experiments with digestate

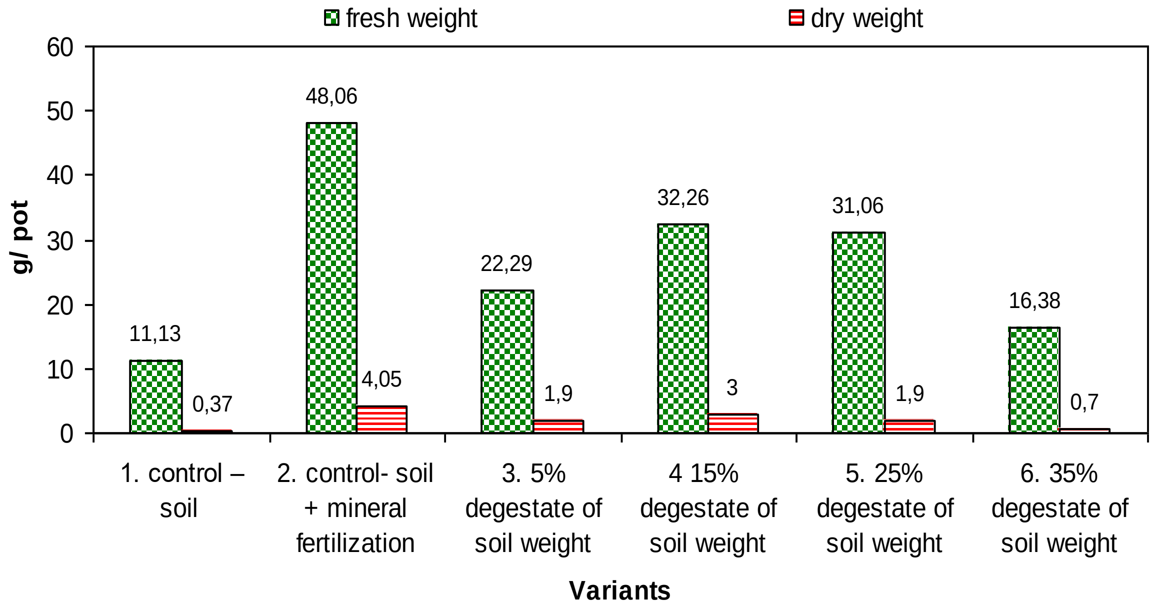

Fig. 2 - Yield of lettuce from vertisol on experiments with digestate

The high value of lettuce yield on Fluvisol is probably due to the very good soil preservation with N, P and K. The trend in yield by increasing the amount of digestate for both soil types is similar. The best lettuce developing is observed in variants with mineral fertilization and the yield is highest. Biomass of lettuce in control variant (clean soil) remains low compared to other variants and it is similar in both soil types. For variants with digestate the largest biomass was measured in variants with 15% digestate compared to control variant.

High doses of digestate have suppressive effects on plant development and yield probably due to excessive high levels of digestible nitrogen, phosphorus and potassium. Higher doses of digestate obtain the soil compaction, which affects the optimal development of lettuce root system. On the other hand digestate values higher than 15% are not environmentally friendly and cost effective. The highest yield of lettuce in both soils was obtained with mineral fertilization variants – 4g / pot in Fluvisol and 4.05 g / pot - Vertisols. The differences between each variant are greater than less permissible difference (LPD) 0.1%.

In digestate variants, the maximum of yield is in 15% digestate by weight of soil. The difference between yields from variants of fluvisol is statistically proven (LPD 1%), and the vertisols - in (LPD 0.1%). There is a tendency to reduce yield at further increasing the amount of introduces digestate (with LPD 0, 1%).

After lettuce harvesting some analyses for content of basic macro and microelements and heavy metals were made. The results of chemical analysis of plant production are presented in table 7 and table 8.

Table 7

Chemical characteristic of plant production by lettuce grown on Fluvisol

Variants	N %	P %	K%	**Ca %**	**Mg %**	**Zn mg/kg**	**Cu mg/kg**	**Mn mg/kg**	**Fe mg/kg**
1. Control	1.40	0.46	6.80	1.22	0.32	46	10	78	800
2. Soil+NPK	2.20	0.72	7.40	1.53	0.42	53	11	95	1200
3. 5% digestate	1.20	0.49	7.40	1.19	0.31	39	11	92	1650
4. 15% digestate	1.30	0.46	6.40	1.44	0.45	42	6	98	1050
5. 25% digestate	2.30	0.45	8.60	1.43	0.38	50	10	48	1000
6. 35% digestate	2.40	0.43	9.00	1.50	0.40	51	13	63	1400

Table 8

Chemical characteristic of plant production by lettuce grown on Vertisols

Variants	N%	P %	K%	**Ca %**	**Mg %**	**Zn mg/kg**	**Cu mg/kg**	**Mn mg/kg**	**Fe mg/kg**
1. Control	0.83	0.18	5.80	1.00	0.25	35	7	65	850
2. Soil+NPK	1.40	0.43	7.50	1.18	0.28	41	9	67	950
3. 5% digestate	1.20	0.25	6.00	0.92	0.23	36	7	71	900
4. 15% digestate	1.40	0.18	6.80	0.84	0.30	48	11	103	2000
5. 25% digestate	1.20	0.27	8.40	1.07	0.39	54	10	104	2500
6. 35% digestate	1.40	0.26	7.50	2.40	0.47	66	13	120	2300

The content of total nitrogen in plants varies between 1.40% and 2.40% on fluvisol and from 0.83% to 1.40% on vertisols. These values are comparable with data from studies of *Mitova and Marinova, (2012*) with enriched vermiculite on the same soil types and the same variety of lettuce. In fluvisol with increasing digestate amount, the phosphorus in plants is not changed, potassium increased slightly, while calcium and magnesium is varying (table 7).

Vertisols for the content of all nutrients expressed no clear trend with increasing amount of digestate, the concentrations in different variants slight vary (table 8).

Analyses for content of microelements Cu, Zn and Mn in plant production show that they are in optimal range for the species.

The iron content in plant tissues at the end of the study have high values in Vertisols (from 850 to 2400 mg / kg), and from 800 to 1400 mg / kg in Fluvisol. Regardless of increased amounts of iron visible depression in lettuce is not noticeable.

- Chemical and agrochemical characteristic of Fluvisol from Kubratovo after lettuce harvesting.

Agrochemical analysis of soil, after harvest lettuce show that increasing of digestate amount significantly leads to increased absorbable phosphorus for plants (table 9).

Table 9

Agrochemical characteristic of Fluvisol with variant post-harvest vegetation experiments with lettuce

Variants	**pH H_2O**	**Mineral nitrogen mg/kg**		**P_2O_5 mg/100g**	**K_2O mg/100g**
		NH_4,	**NO_3**		
1. Control	5.8	66.70	16.80	23.20	28.40
2. Soil+NPK	5.3	62.10	44.70	76.60	39.20
3. 5% digestate	5.8	66.70	28.40	26.70	32.90
4. 15% digestate	5.9	60.90	38.90	32.30	34.00
5. 25% digestate	5.9	70.20	43.50	42.10	43.20
6. 35% digestate	6.0	52.80	45.80	50.30	45.20

Higher level of absorbed phosphorus supplied has the variant with 35% added digestate, which causes a decrease in yield. The degree of movable potassium increases with increasing the digestate amount in variants. In 35% digestate the potassium content reaches 45.2 mg K_2O / 100 g soil and it shows very high degree of supply with this nutrient.

The amount of mineral nitrogen was also increased with increasing dose of digestate. This is at the expense of a large increase of nitrogen from 16.83 mg / kg N-NO_3 var.1 up to 45.8 mg / kg N-NO_3 for var.6. The change of ammonia form of mineral nitrogen is weak and variable, but generally mineral nitrogen has very high values (table 9).

Table 10

Assessment salinity of Fluvisol from vegetation experiments with lettuce with different variants of digestate

Variants	Conductivity mS/cm	Water soluble salts g/100g
1. Control	**0.098**	**0.030**
2. Soil+NPK	**0.308**	**0.100**
3. 5% digestate	**0.084**	**0.027**
4. 15% digestate	**0.098**	**0.031**
5. 25% digestate	**0.116**	**0.037**
6. 35% digestate	**0.135**	**0.043**

After harvesting the lettuce analyses of conductivity and presence of soluble salts in variants, show increasing amount of added compost gradually increasing conductivity and the amount of water-soluble salts, but they are within the limits of not salty soils. The highest values have variant 2, with incorporated mineral N, P, K fertilizers (table 10).

- Chemical and agrochemical characteristic of vertisols in the region of Bojurishte after lettuce harvesting.

Studies on agrochemical characteristics of soil after harvesting the lettuce found that increasing of digestate dose leads to smoothly increasing of absorbable phosphorus for plants. The highest dose of digestate is P_2O_5/100 14.16 mg g soil (table 11).

In variant with 35% digestate is achieved moderate supply of absorbable phosphorus. The degree of movable potassium in vertisols is very good. In the variants with the highest amount of digestate content reaches 10, 1 mg K_2O / 100 g soil and it can lead to depression in yield.

As noted above the amount of mineral nitrogen in non-treated soil is high with prevalence of the ammonia form. Significantly increasing of the digestate dose leads to increasing the amount of nitrate form of mineral nitrogen (table 11).

Table 11

Agrochemical characteristics of Vertisols after lettuce harvesting

Variants	**pH H_2O**	**Mineral nitrogen mg/kg**		**P_2O_5 mg/100g**	**K_2O mg/100g**
		NH_4	**NO_3**		
1. Control	6.1	49.3	13.3	0.75	45.0
2. Soil+NPK	5.6	101.5	124.7	66.13	105.0
3. 5% digestate	6.1	63.2	33.1	3.13	46.0
4 15% digestate	6.0	58.6	55.1	6.38	51.0
5. 25% digestate	5.9	71.3	80.6	11.63	59.0
6. 35% digestate	6.1	53.9	94.5	14.16	101.1

Analyses were conducted for the electrical conductivity and the presence of soluble salts on all variants after lettuce harvesting. It is found that with increasing amount of imported digestate slightly increases conductivity and quantity of water-soluble salts, but this does not lead to salinisation (table. 12). The highest values have both indicators, measured for variants with chemical fertilization (table 12).

Table 12

Evaluation of Vertisols salinity after lettuce harvesting

Variants	**pH H_2O**	Conductivity mS/cm	Water soluble salts g/100g
1. Control	6.1	**0.042**	**0.013**
2. Soil+NPK	5.6	**0.406**	**0.130**
3. 5% digestate	6.1	**0.084**	**0.027**
4. 15% digestate	6.0	**0.098**	**0.031**
5. 25% digestate	5.9	**0.116**	**0.037**
6. 35% digestate	6.1	**0.135**	**0.043**

CONCLUSIONS

In the conducted experiments and the obtained results it was found that:

1. Agrochemical and chemical characteristics define digestate as a biomass rich in macro and micronutrients that can be used in agriculture for increasing soil fertility. The content of heavy metals in initial digestate is below maximum allowable concentration and soil is not burdened with these elements.
2. A positive effect of digestate utilization was established in vegetation experiments on the yield and quality of crop production. The results of lettuce at increasing doses of biomass indicates that plants have the best development and quality options with 15% digestate with 70% pig manure.
3. The results for total nitrogen, phosphorus, potassium, calcium, magnesium and microelements copper, zinc and manganese in plant production of lettuce are within the normal range for the species. The values of iron content are higher in lettuce grown on vertisols.
4. It is found that increasing of digestate dose significantly increased plants absorbable phosphorus and potassium in both soil types. The quantity of mineral nitrogen (nitrate form) also increases. The amount of soluble salts in the soil increases slightly, but there is no danger of salinization. The content of heavy metals in initial digestate is under the limits and soils are not burdened with these pollutants.

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INNOVATIVE TECHNOLOGY FOR DEGRADED SLOPE LANDS AFFORESTATION TO ESTABLISH GREEN INFRASTRUCTURE
/
TEHNOLOGIE INOVATIVA DE IMPADURIRE A TERENURILOR DEGRADATE IN PANTA IN VEDEREA INSTALARII INFRASTRUCTURII VERZI

Ph.D. Eng. Visan A.L.*[1)], Eng. Bogdanof G.C.[1)], Eng. Milea D. [1)], Phd. Student eng.agr. Mircea C.
[1)] INMA Bucharest, Romania
E-mail: alexandrion1982@yahoo.com

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ABSTRACT

The current afforestation technologies of degraded lands with a high difficulty degree, such as slope terrains, are of worldwide interest in the context of climate changes, superior capitalisation of renewable natural resources and rehabilitation of high degree calamity areas. From this point of view it was considered necessary to develop several afforestation innovative technologies for degraded slope lands in order to make specific innovative technical equipment which can be effectively combined, so as to allow its adaptation according to the needs of the ecological implementation system. This technology aims to fulfil several national and European major objectives, by developing the dedicated technological means for establishing the green infrastructures in: degraded areas or abandoned lands, ecological reconstruction of forest fund, protection forest belts establishment, as well as greening the technologies from the forestry field.

REZUMAT

Tehnologiile de împădurire a terenurilor degradate cu grad ridicat de dificultate, precum terenurile în pantă, la ora actuală, prezintă un mare interes la nivel mondial în contextul schimbărilor climatice, valorificării superioare a resurselor naturale regenerabile şi reabilitarea zonelor cu risc ridicat de calamitate. Din acest punct de vedere s-a considerat că este necesar dezvoltarea unor tehnologii inovative de împădurire a terenurilor degradate în pantă în vederea dezvoltării unor echipamente tehnologice inovative specifice care pot fi combinate eficient, astfel incat sa ofere posibilitatea adaptării lor în funcţie de cerinţele sistemului ecologic de implementare. Această tehnologie urmăreşte îndeplinirea unor obiective majore de interes naţional şi european, prin dezvoltarea mijloacelor tehnoogice dedicate instalarii infrastructuri verzi în: zone cu terenuri degradate sau abandonate, reconstrucţia ecologică a fondului forestier, înfiinţarea de perdele forestiere de protecţie, precum şi ecologizarea tehnologiilor din domeniul silviculturii.

INTRODUCTION

The impact of degraded lands afforestation technologies

In mass-media, in the last period, there is a general interest concerning environment, respectively green spaces and protection of forest fund, by promoting greening activities and afforestation. That comes from high degree of pollution from large cities and the lack of green infrastructure, ecological disasters and the risks that we are exposed to by powerful people in the rush for easy and illegal income.

A prompt reaction comes from environmental organisations, which drew attention that only during last year were illegally exploited trees that could be loaded in 100 train carriages. These statements are also confirmed by the representative of the Forestry Direction of Maramures County, “At the end of 2015, 7502 cubic meters of wood material were illegally taken and for the 2016 first three months we are talking about an illegally cut volume of 451 cubic meters”. [5]

Real figures could be much higher, because officials also take into account as “forest” the places where is forestry vegetation, namely seedlings only a few centimetres tall, as in Fig. 1, but as deforestations have been put down over half of million hectares. The total area covered by forest could rather be around 5 million hectares, fig. 2, representing only 20% of Romania’s surface, and the ecological disaster, according to some journalists “is caused by private forests owners who have triggered the slaughter of Romanian forests”. [6]

The coordinator of WWF forestry programs, Radu Vlad has confirmed, that there is a tight correlation between the illegal cuts red code and the floods red code, but also that *"Not accidentally, the degradation of forests and illegal cuts are considered a threat to national security". [6]*

Therefore, the biggest dangers that Romania forests are confronted with are the destructions generated by uncontrolled cuts from wild mountain areas, both state and private forest property, which are poorly managed, that has a negative impact on environmental quality and disastrous consequences for medium and long term.

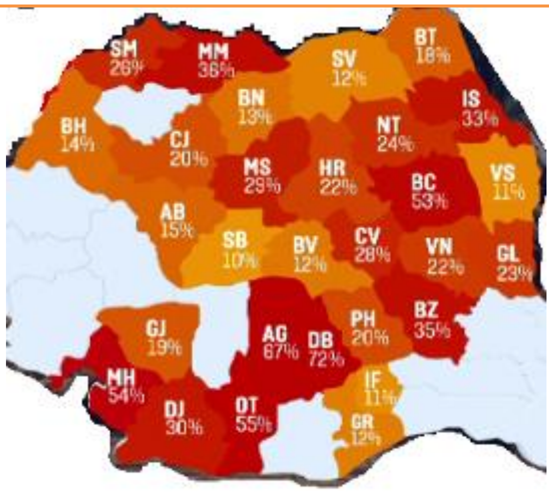

Fig. 1 Map of risk areas and illegal deforestation.[5]

Fig. 2 Romanian forest fund situation in 2013. [6]

Having in view that the percentage of forests distribution is higher in mountain areas, Fig. 3, these are the areas that are prone to ecological disasters due to the lack of green infrastructure and poor management.

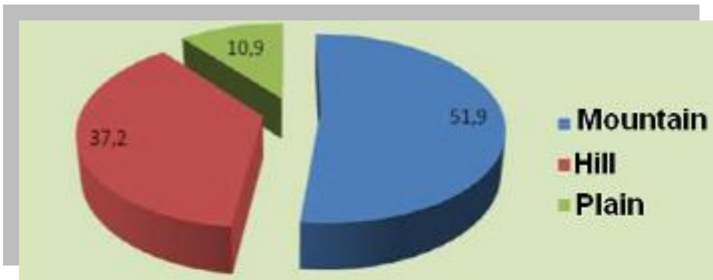

Fig. 3 - Forest fund distribution depending on landforms [5]

Simultaneously with mass harvesting / wood cutting, on state property forestry lands are annually carried out artificial regeneration works, thus the necessity of afforestation technologies dedicated for mountain and hill areas is appropriate and must be accordance with soil and seeding material type. [2]

Given the fact that the European and national strategies finance large infrastructure projects for historically polluted sites and abandoned degraded lands that have as specific objectives the regional development of unfavourable areas and decreasing the ecological disasters risks. That is way the afforestation technology of degraded slope lands can be successfully implemented within these projects, which can be proposed both by institutions and profile organisations, but also by private forest owners.

MATERIAL AND METHOD

Current state of development regarding the afforestation technologies of degraded lands

Internationally, afforestation technologies are really found in and are implemented mostly in hill areas where the soil is not degraded. In the majority of cases, these consist in semi-mechanized individual equipment specific for each operation (soil processing, levelling, drilling, covering, etc.) which can be adequate and fitted on small size tractors and motocultivators. The most versatile and newest model that can be easily situated to these types of works is the GT series developed by MultiOne S.R.L. Company, fig. 4 and 5. To effectuate the planting dwellings, also can be used vertical drills carried by the operator, equipment which can be successfully used when the planting process is achieved on light soils, fig. 7, 8 and 9.

Fig.4 - GT series fitted with drilling equipment [8]

Fig.5 - GT series fitted with drilling equipment [9]

Fig. 6 - DA300E – HITACHI [10]

Fig. 7 - TR 1551 - EFCO [11]

Fig. 8 - BBA520 – MAKITA [12]

For slope degraded lands, this type of equipment is globally missing, because the working conditions are difficult (the soil structure is uneven and can have a high degree of instability), the required equipment power is high and their gauge is restricted.

In Romania, the afforestation of degraded slope lands is performed manually, using a lot of work force over a long period of time. Therefore, INMA has developed an afforestation innovative technology for degraded slope lands, in order to increase the mechanisation degree of the afforestation process, by developing experimental models adequate for heavy working conditions, so that rehabilitation works to be developed complying to national regulations so that saplings to be planted in the optimal period.

Usually, the degraded lands are subjected to terracing works, because they are usually unstable to landslides or other forms of mass gravitational displacements. [3]

Depending on the surface and technology enforced, the soil works consist in: ***entire surface works*** (scraping and grinding of the untilled soil, subsoiling, harrowing and tillage); ***partial works*** in strips or bands (in plain regions), in strips or bands (in hill regions) and **in grates** (in mountain region, on rough lands). [1]

Figure 9 shows the afforestation innovative technology dedicated to degraded slope lands and the technical works order to prepare terraces lands in order to plant saplings, in which can be use tractors and motocultivators for propulsion. When is needed to increase adherence, these can be equipped either with agricultural wheels or tracks, especially in cases where soils are unstable or heavily eroded. In the case of motocultivators, the adherence can be increase by attaching metallic wheels with crampons. Small size tractors, as TP 20 manufactured by Miercurea-Ciuc tractor factory, can be fitted with twin (paired) wheels, fact that leads to a four-foot way increase and afforestation terraces deterioration that are achieved in counter-slope.

The first equipment from this technology, has the purpose to process the soil, thus ensuring the optimal conditions for saplings development (air, water, soil), but also the preparation of terrace surfaces in order to achieve the counter-slopes specific to geo-climatic conditions. [3]

The milling equipment can be used, before and after the levelling process, especially when soils are hard to process and when the angle of the counter-slope in big (over 15 º). [13]

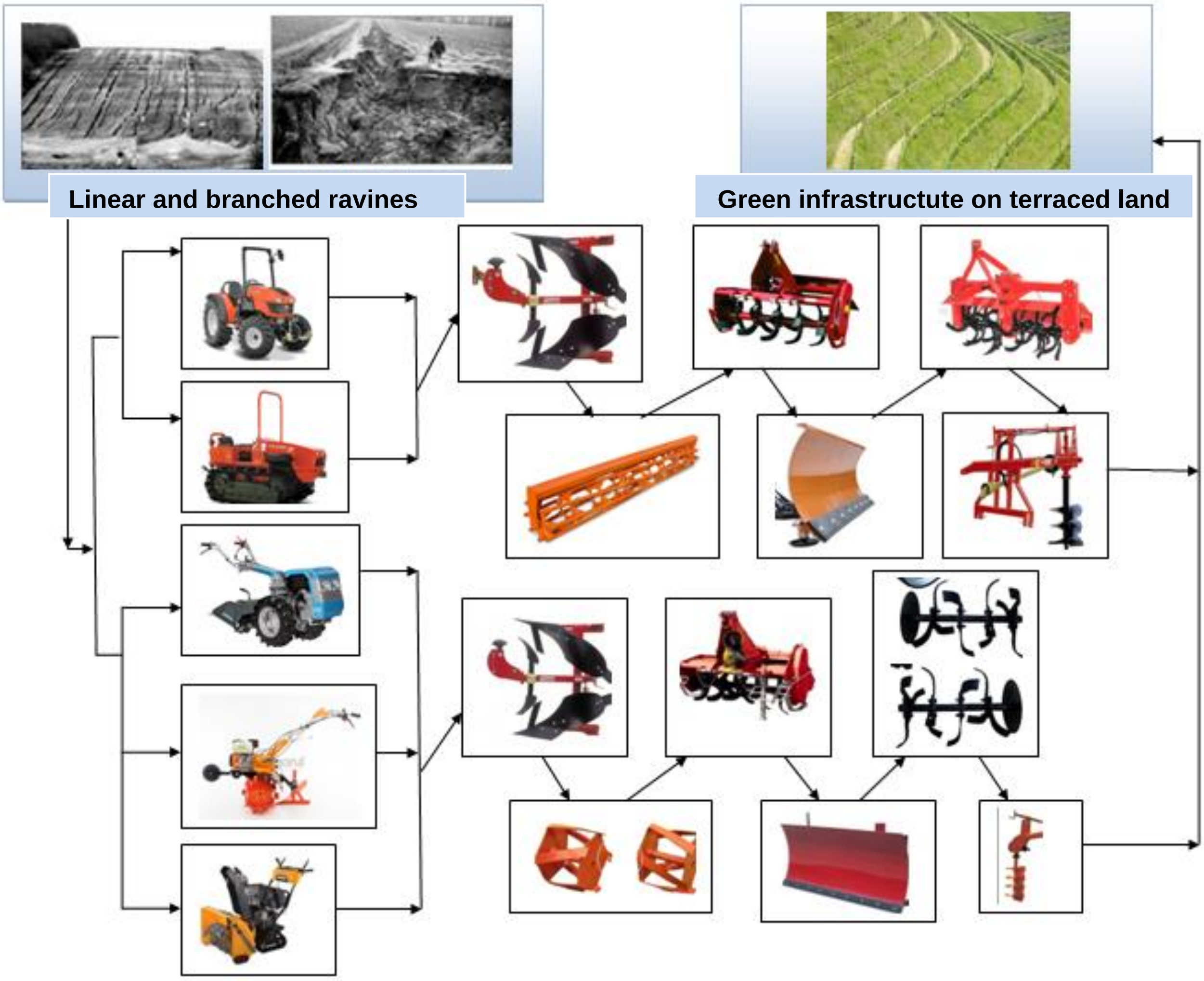

Fig.9 - Innovative technology for the afforestation of degraded slope lands [3]

From technical point of view, the drilling equipment is provided with dedicated augers, especially designed for various kinds of degraded soil. The most representative augers models are made by McMillen and Skid Steer, the most experienced company from this field. In the next paragraph, the most appropriate models are presented (Table 1).

Table1. Most used dedicated augers used by drilling equipment for degraded soil. [14, 15]

HDC auger.	HDF auger	HDR auger	HTF auger	Eterra Cast Bits auger

A model dedicated for light and moderate soils are HDF. Nevertheless, the HDC model is designed for hard working conditions (compact soil, clay soil, asphalt, frozen soil and fractured rock). It is made from cast steel and it has double hardened coils (on the outside edge) that are ended with chisels for depth. The boring tip is "fishtail" shaped. The HDR auger has a single hardened coil (on the outside edge) that is ended with steel tines shaped bullet, the distance to the active element is 75" and a 2 "hexagonal boring tip with 4" length. The HTF auger model has been especially created to plant trees and shrubs.

The Eterra Cast Bits auger, made by Skid Steer Company, has a working domain between 4" and 36" and it is equipped with removable chisels, in order to work with degraded lands as: land with rocks, boulders, lava, or mixing zones with concrete or broken solid rock into large pieces.

When used power machineries and equipment with low ground clearance, it is necessary to use versatile augers with short coils, who works sequentially on reduced depths. From this category is presented the Eterra Cast Bits auger, which is provided by the supplier with an extension shaft such that it can be adapted higher ground clearance to equipment and to increase the working field.

RESULTS

Considerations regarding using innovative technologies for the afforestation of degraded slope lands

The use of existent agricultural equipment within an afforestation technology according to a logical sequence must be correlated with the requirements for processing the soil and for establishing green infrastructure.

Land terracing works are part of the series of works with land and agro-forestry development character within the territory systematization, for land stabilization in accordance with the factors that could cause this process in time. [4] From a scientific point of view, it was proven the efficiency to make terraces 0.6 to 1.5 m wide, alternated with grass strips accomplished by mechanized technologies. [2]

If the slope land is organized in terraces, it encourages water infiltration in the soil in loose strips of land in the areas of the terrace, this way ensuring an additional pluvial water supply for the saplings planted there. The terraces can be dimensioned depending on: the water volume that comes from precipitations; the terrace air flow, the number of saplings planted, as well as the terrace platform counter-slope, which can be accomplished of 70 - 80 cm wide, placed at a distance of approximately 2 m from the symmetry axis of terraces. The volume of water that can be retained by them is scientifically proven and the indicated values are: for a 10% (9 ^{o}) terrace counter-slope it can collect approximately 17 l/m^2 and for 15% (13.5 ^{o}) counter-slope, 25/m^2. [4]

Regarding those technical considerations, a study on the use of this innovative technology depending on the particularities of the degraded slope land is presented. The efficiency of works executed on slope lands higher than 15^{o} is superior because the moisture deficit can be prevented by using this technology, especially in the case of excessively eroded mountain slopes.

For this reason, a study was necessary regarding the opportunity of using small size tractors or motocultivators, when they are used on the terraces counter-slopes achieved on the degraded soil at 15^{o}, respectively 25^{o}.

For the levelling operation the motocultivator can be used as power source, because the forwarding resistance forces are considerably reduced compared to the tractor. If the operation of levelling the counter-slopes of terraces is analysed from the technological point of view, it is observed that for a terrace up to 15^{o} counter-slope, there are no notable operating problems, see fig. 10, and for a counter-slope between 15 – 25^{o}, the levelling process is made in multiple passes (because the volume of dislocated and displaced land is considerably increased), as it is presented in fig. 12.

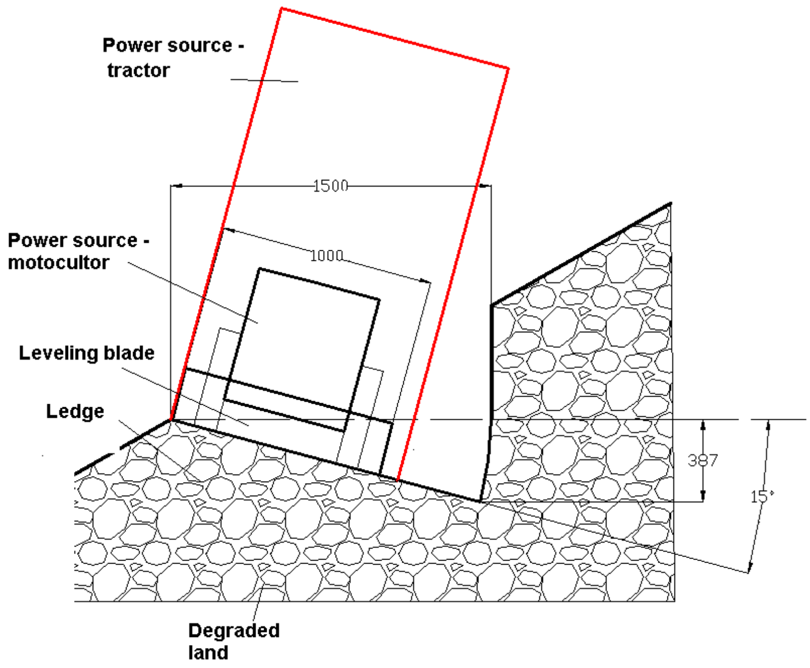

Fig. 10 - Equipment for levelling the terrace in a 15 º counter-slope

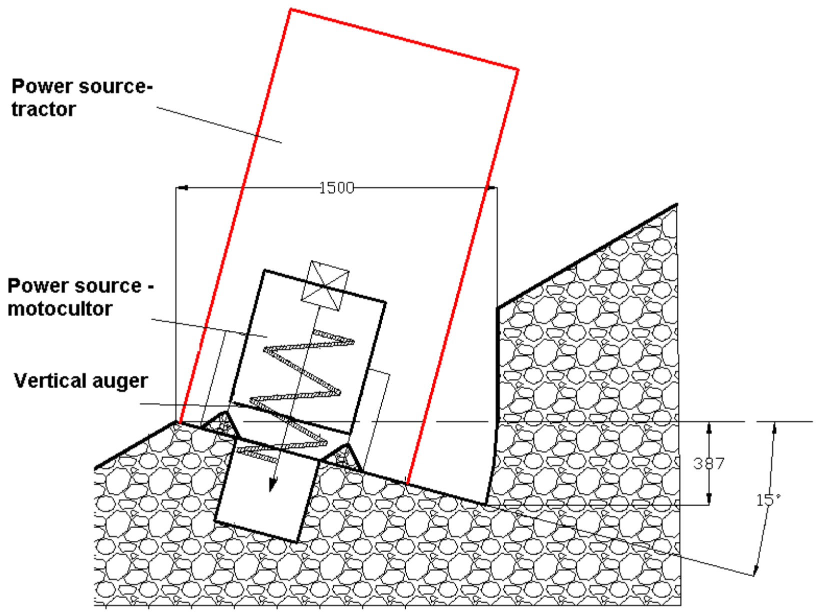

Fig.11 - Equipment for the achievement of planting sockets for terraces in a 15º counter-slope.

Once the counter-slope is achieved, the energy source follows its profile and, for this reason, it is necessary that the drilling equipment that achieves planting dwellings to be set on inclination equal to the achieved counter-slope (case in which the terrace has a counter-slope angle higher than 15 º), fact that leads to plant the seedling material on vertical direction, see figures 11 and 13. In order to fulfil those conditions, it is required that drilling equipment have a positioning system so the planting dwellings to be easily orientated in accordance with counter-slope angle. Thus the optimal growth conditions of the planted seedlings with or without earth ballot are created.

In the process of achieving planting dwellings using appropriated augers, at the end of the operation, around the dwellings, appears an earth torus (brink) that can be subsequently used for covering the root system, Fig. 11. When the dwelling is achieved on a maximum counter-slope of 25 º, there is the possibility for the earth brink extracted to slide downstream, fig.13. This situation should be avoided to prevent the bonding effect in the saplings vicinity.

On the basis of these observations, it can be concluded that, the equipment for achieving sockets is indicated to move on counter-slopes of max. 15°, so that the inclination angle does not have a negative effect on the development of sapling and in stabilizing lands thus afforested.

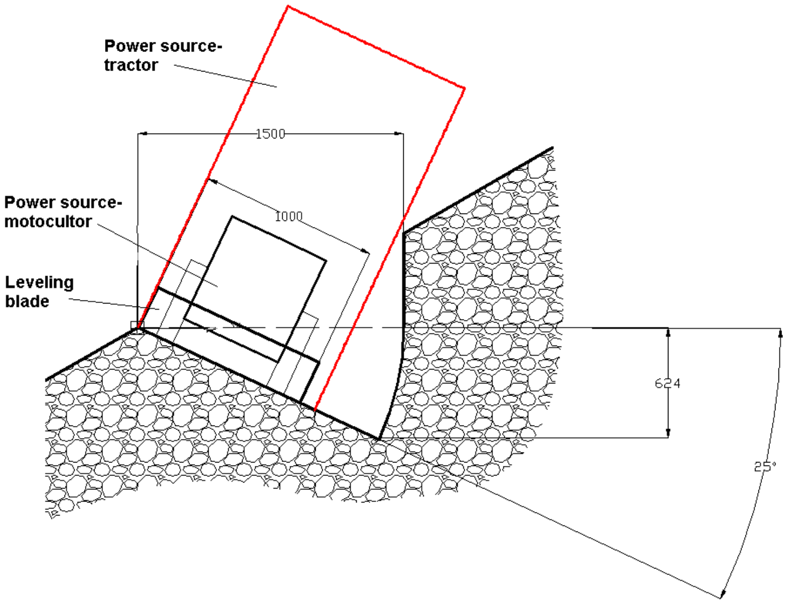

Fig.12 - Equipment for levelling the terrace in a 25 ° counter-slope

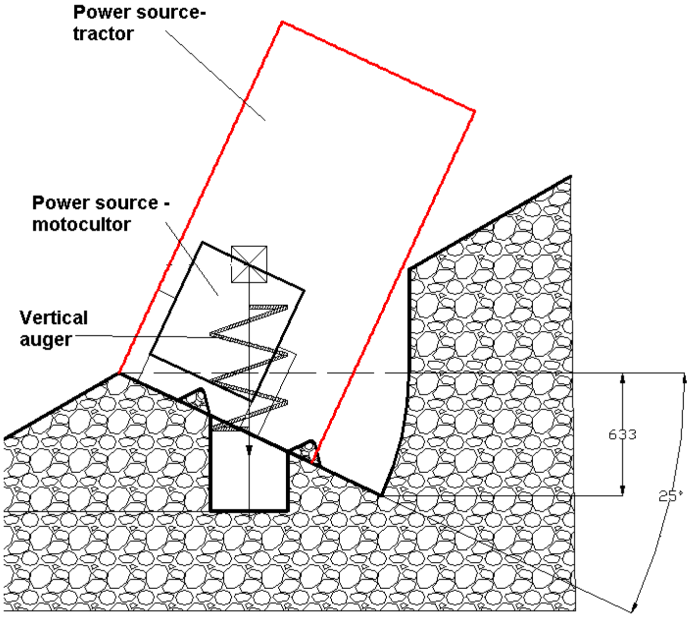

Fig.13 - Equipment for the achievement of planting sockets for terraces in a 25° counter-slope

General considerations: in respect to the two operating manners, with tractor respectively with motocultivator, we can state that: the size of a tractor is bigger than that of motocultivator; the power developed by the tractor is higher than the one of motocultivator; the motocultivator can be fitted with maximum two independent PTOs, for the most performing models; tractors have a PTO for mechanical, hydraulic and pneumatic drives; the manoeuvrability of a motocultivator is higher, but the operator can be placed in difficult working situations, especially when the soil is very degraded and unstable, the tractor can have more automation systems than a motocultivator.

For working counter-slopes bigger than 25°, it is not indicated to use tractors as power source because more risks appear during operation:

- The risk to deteriorate the angle of the terrace achieved on degraded lands due to the possibility for the resistance structure of the tractor to get in contact with the terrace and generate landslides, situation shown in figures 12 and 13;

- The risk of working accidents and equipment deterioration in the situation where the soil is unstable (high moisture or sandy soil) and under the action a higher weight.

CONCLUSIONS

Reviewing the “strengths” of our country, we can state that it is opportune to develop the innovative technology for the afforestation of degraded slope lands in order to install infrastructure according to European directives regarding remediation and reconditioning of the environment conditions, national development and research strategies. National statistics show a general tendency for deforestation in mountain areas, the possibility to produce superior quality seedling material in producing units, vast experience in RDI activities in the field of fruit growing/forestry of research institutes, in programs dedicated to these directions, as well as encouraging and sustaining activities of stopping, remedying and ameliorating degraded slope lands, for preventing disasters and the disappearance of areas with indigenous flora and fauna, as well as promoting innovative technologies for the afforestation of degraded slope lands that comply with national and European development policies.

ACKNOWLEDGEMENT

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STUDIES AND RESEARCHES ON LETTUCE GROWTH IN AQUAPONIC CULTURES / STUDII ŞI CERCETĂRI ASUPRA CREŞTERII ŞI DEZVOLTĂRII SALATEI VERZI ÎN CULTURI ACVAPONICE

77

PhD. Stud. Eng. Laza E-A.*, PhD. Stud. Eng. Andrei S.
INMA Bucharest – Branch Timisoara / Romania
Tel: 0741122570: E-mail: eveline_anda@yahoo.com

Keywords: *aquaponic, hydroponic, nutrients.*

ABSTRACT

The paper aims to study the main issues regarding the productivity and efficiency of fish breeding and plant cultivation in aquaponic systems. Aquaponics is defined as a combination of aquaculture and hydroponic systems, in which waste water rich in nutrients from aquaculture system is introduced in a hydroponic system. Plants absorb nutrients from waste water thus improving and purifying water from acvacole system, this method providing an ecological and sustainable system. Aquaponics is a symbiosis of: aquaculture (fish breeding in closed systems) and hydroponics (growing plants in water without using soil), considered by many experts agriculture of the future. Vegetables, lettuce, special herbs (spinach, chives, basil and watercress) have low to medium nutrient needs and are well adapted to aquaponic systems.

REZUMAT

Lucrarea de faţă are ca scop studierea principalelor aspecte privind rentabilizarea şi eficientizarea creşterii peştilor şi a cultivării plantelor în sisteme acvaponice. Acvaponia este definită ca fiind o combinaţie între acvacultură şi sistemele hidroponice, prin care apa reziduală bogată în nutrienţi din sistemul de acvacultură este introdusă într-un sistem hidroponic. Plantele absorb nutrienţi din apa reziduală şi astfel îmbunătăţesc sau purifică apa din sistemul acvacol, aceasta metodă oferă un sistem ecologic şi durabil. Acvaponia este o combinaţie simbiotică între: acvacultură (creşterea peştilor în sisteme închise) şi hidroponie (creşterea plantelor pe apă, fără a utiliza solul), fiind considerată de mulţi specialişti agricultura viitorului. Verdeţurile, salata verde, ierburi speciale, (spanac, arpagic, busuioc şi năsturel) au cerinţe scăzute spre medii pentru nutrienţi şi sunt bine adaptate la sistemele acvaponice.

INTRODUCTION

Aquaponics is an intensive production system where several cultures are produced with reduced inputs of water and fertilizers and it is very suitable for small agricultural producers targeting local markets and agritourism opportunities.

Aquaponic systems are more complex than the systems designed only for growing plants or fish breeding, because optimum conditions for each group of active organisms participating in the production process - plants, fish and nitrifying bacteria are not identical.

For practicing efficient Aquaponics increased attention is necessary regarding consumer demands, food security and economic efficiency, through continuous development of new technologies.

Aquaculture, as well as hydroponics, has already become agri-food sectors with the fastest growth worldwide, representing an important potential for supplying the world population with aquaponic products, namely vegetables and fruits, healthy and of high quality. Their combination is still at the beginning, being subject of research to innovative development of many specialized institutes (*Martan E., 2008; Şumălan R., 2009*).

In aquaponic systems a variety of plants can be grown such as: any type of lettuce, Chinese cabbage, parsley, basil, thyme, mint, lemon balm, chives, rosemary, beet, rucola, watercress and various tropical plants. Fruit plants (tomatoes, peppers, cucumbers, beans, peas, marrows) have high nutrient demands, that is why they need systems well loaded with nutrients and very stable. Plants that are used for their fruit (tomatoes, peppers, cucumbers) have a higher nutritional demand and perform better in a well-supplied and stable aquaponic system. Greenhouse tomato varieties are better adapted to conditions of low-light and high humidity in greenhouses than the land varieties (*Hughey T.W. 2005*). A component of the aquaponic system is aquaculture, which supposes the existence of fish and one or more fish breeding basins. In their basins, the fish get fresh water and food in order to grow. As a result of fish feeding, the water in the basin will contain excrements and food remains, water which in turn is treated with specific bacteria which turns waste into nutrients for plants, favouring their natural and ecological growth.

The fact that nutrients in the water are consumed by vegetable "layers" makes the water become usable again for fish, so it is pumped or directed by free flowing back to the fish basin and the recirculation process continues.

Waste water from fish basins, directed through pipes, irrigates the plants placed above another basin, with their roots in the water, on a bed of gravel (or other materials), then returns to the fish basin in a continuous flow. In hydroponic cultures, plants are seeded either on floating artificial substrates or in sterile, porous, high water permeability substrate.

This way plants receive nutrients and fish water is naturally filtered. Fish effluents contain nitrates and bacteria that favour vegetables natural and organic growth (*Blidariu F., 2013; Cristea F. Et al., 2011*).

In fish basins, ammonia exists in two forms, which together are called total ammoniacal nitrogen (*Francis-Floyd, R. Et al., 2012*). The nitrification process is the two-step biological oxidation of ammonia to nitrate. The process is carried out by autotrophic bacteria that use ammonia and nitrites as a growth substrate to generate energy for the cellular activity and reproduction (*Blidariu F., 2013; Cristea F. Et al., 2011*).

The efficiency of the nitrification process depends on the oxygen concentration, temperature, biomass retention time, alkalinity and pH. Nitrifying bacteria are strictly aerobic, they can nitrify only in the presence of dissolved oxygen (DO).

Biological denitrification process is the conversion of nitrates to gaseous nitrogen in the absence of oxygen. This process is carried out by a part of heterotrophic bacteria, called denitrifying heterotrophic bacteria, having the ability to use nitrates and nitrites as electron acceptor in organic matter oxidation process.

The efficiency of the denitrification process is affected by the absence of dissolved oxygen, the presence of a suitable and active population of denitrifying bacteria, pH, temperature, nutrients and redox potential (*Martan E., 2008; Şumălan R., 2009*).

MATERIAL AND METHOD

The hydroponic subsystem has the following main components:

– two hydroponic basins, placed on two metal supports. The water coming from acvacole subsystem, supplies, in parallel, each of the two basins, being introduced at one of their ends and then removed at the opposite end;

– Floating supports for plants, made of expanded polystyrene, presenting holes where the lettuce seedlings are planted;

– Devices for regulating water level in hydroponic basins;

– Taps for regulating water flow rate in hydroponic basins;

– plant lighting panels, placed over the hydroponic basins, so that the distance to plants is adjustable, have the role to ensure the light necessary for photosynthesis.

Connecting the hydroponic system to the aquaponic one is made using fittings and fixtures so that water supply for hydroponic basins can be ensured either through the outlet pipe or the supply pipe of the biological filter. Water removal from hydroponic basins will be made through the supply pipe of the mechanical filter.

Determining water quality, in different phases of the technological process, will be made by taking periodical samples and their analysis in laboratory.

The denitrifying installation from aquaponic cultures that will be used during the experiment has the following main characteristics:

- Type of culture .... aquaponic
- Fish species bred in recirculating acvacole systems (RAS).............sturgeons and pike-perch
- Hydroponic culture vegetables ....lettuce
- Hydroponic culture surface……...... ……….8 m2
- Culture density (lettuce) …………..12...14 piece/m2
- Average water need for lettuce growing 1,5 m3/day
- Lighting type ..…………….........….. LED lamps
- Energy source ..……………..….. photovoltaic panels.

Quality evaluation from the chemical point of view was made on lettuce (*Lactuca sativa)* within the first research experiment.

The quality of the two repetitions production was evaluated compared to the production of the control culture grew conventionally, under natural conditions.

The chemical analysis was made on 5 plants of each repetition and on 5 plants of the control culture. The plants selected for chemical laboratory analysis were among those with marketing potential, which have a maximum degree of development regarding the quantitative characteristics and respected as closely as possible the phenotypic characteristics of the variety grown. There have also been evaluated the root parts of plants.

Root chemical evaluation was made on total amount of roots. Three root samples were taken:

sample 1 – the roots of the 5 plants chemically assessed from repetition 1,
sample 2 - the roots of the 5 plants chemically assessed from repetition 2,
sample 3 - the roots of the 5 plants chemically assessed from control culture.

This chemical analysis focused on the amount of ammonia (NH_4^+), nitrate (NO_3^-) and phosphorus as phosphorus pentoxide (P_2O_5) in plants, respectively in roots.

Determining the amount of ammonia (NH_4^+), nitrate (NO_3^-) and phosphorus as phosphorus pentoxide (P_2O_5) in plants was made in acetic acid extract (*Cristea F. Et al., 2012*).

RESULTS

Basic descriptive statistical indexes for chemical variables studied in the case of lettuce from aquaponic module and lettuce conventionally grown under natural conditions are presented in the following table where:

NH_4R_1 – Ammonia level from repetition 1 (mg/kg fresh product);
NO_3R_1 – Nitrate level from repetition 1 (mg/kg fresh product);
$P_2O_5R_1$ – Phosphorus pentoxide level from repetition 1 (mg/kg fresh product);
NH_4R_2 – Ammonia level from repetition 2 (mg/kg fresh product);
NO_3R_2 – Nitrate level from repetition 2 (mg/kg fresh product);
$P_2O_5R_2$ – Phosphorus pentoxide level from repetition 2 (mg/kg fresh product);
NH_4M – Ammonia level from control culture (mg/kg fresh product);
NO_3M – Nitrate level from control culture (mg/kg fresh product);
P_2O_5M – Phosphorus pentoxide level from control culture (mg/kg fresh product).

Table 1

Basic descriptive statistical indexes for chemical variables studied in the case of lettuce from aquaponic module and lettuce conventionally grown under natural conditions

		X	Min	Max	S	S^2	CV%	S_X
Rep. no.1	NH_4R_1	1.77	1.55	2.00	0.24	0.05	10.98	0.10
	NO_3R_1	811.69	776.25	865.89	34.59	1228.43	4.15	15.10
	$P_2O_5R_1$	349.12	321.65	378.90	27.59	761.56	7.91	12.32
Rep. no.2	NH_4R_2	1.70	1.41	2.10	0.29	0.12	16.49	0.09
	NO_3R_2	810.79	740.95	896.00	63.91	4082.17	7.97	29.50
	$P_2O_5R_2$	374.32	356.00	410.11	17.38	301.69	4.68	7.78
Control Version	NH_4M	2.12	1.90	2.65	0.28	0.08	11.29	0.15
	NO_3M	111.75	89.66	137.90	16.66	246.31	15.14	5.56
	P_2O_5M	206.23	184.23	239.03	19.10	329.76	9.78	9.10

Basic descriptive statistical indexes for variables studied in the case of lettuce from aquaponic module and lettuce conventionally grown under natural conditions where:

$GradR_1$ – Root mass from repetition 1 (g);
$GrfrR_1$ – Leaf rosette mass from repetition 1;
$NrfrR_1$ – Number of leaves per plant from repetition 1;
$GradR_2$ – Root mass from repetition 2 (g);
$GrfrR_2$ – Leaf rosette mass from repetition 2;
$NrfrR_2$ – Number of leaves per plant from repetition 2;
GradM – Root mass from control culture (g);
GrfrM – Leaf rosette mass from control culture;
NrfrM – Number of leaves per plant from control culture.

Table 2

Basic descriptive statistical indexes for variables studied in the case of lettuce from aquaponic module and lettuce conventionally grown under natural conditions

		X	Min	Max	S	S^2	CV%	S_X
Rep.no. 1	$GradR_1$	4,09	2,89	6,12	1,42	1,99	29,56	0,73
	$GrfrR_1$	35,21	20,30	55,38	15,10	199,80	29,95	6,41
	$NrfrR_1$	17,66	13,00	25,01	4,55	21,30	25,70	2,06
Rep.no. 2	$GradR_2$	6,65	4,10	12,74	3,59	12,59	43,53	1,68
	$GrfrR_2$	51,07	36,62	74,78	14,47	218,71	28,39	6,56
	$NrfrR_2$	22,03	17,00	29,10	4,38	19,60	19,91	1,99
Control Version	GradM	4,09	2,80	6,35	1,34	1,87	29,83	0,65
	GrfrM	34,58	25,33	50,25	10,30	105,99	29,87	4,68
	NrfrM	11,62	8,00	15,10	2,75	7,35	20,93	1,18

CONCLUSIONS

Modern Aquaponics, a branch still at the beginning, which combines aquaculture with hydroponics, judiciously applied, can sum up the benefits, and even more, can mutually neutralize some major problems of the two, such as the use as nutrients, by plants, of noxious products fish generated.

For operating a fish aquaponic breeding system in a recirculating acvacole system and hydroponic plant production, it is essential to maintain an optimal quality of recycled water. This is achieved, mainly, through efficient filtration, treatment and denitrification of waste water.

Regarding the assessment of the chemical characteristics of lettuce obtained in aquaponic module and conventional technology under natural conditions, it has been observed that there are differences between NH_4^+ levels identified in plant rosettes in repetition 1 and repetition 2 and but they are not significant. There are significant differences between the NH_4^+ level found in plant rosettes from repetition 1 and the NH_4^+ level from control culture. There are also significant differences between the NH_4^+ level found in plant rosettes from repetition 2 and the NH_4^+ level from control culture.

P_2O_5 levels identified in plant rosettes from repetition 1 and 2 are different, but not significant.

In respect to the assessment of organoleptic characteristics of lettuce obtained in aquaponic module and conventional technology under natural conditions it was found that plants obtained in aquaponic module were not so appreciated in terms of taste, plant health, odour and colour. In conclusion, the conventional production plants are valued more by consumers compared to the plants produced in aquaponic module.

In conclusion, although the level of nitrate is significantly lower in control culture than in aquaponic productions, they do not exceed the maximum limit admitted for human consumption.

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SYNTHESIS OF SELF-CENTRING GRIPPERS / *SINTEZA MECANISMELOR DE PREHENSIUNE AUTOCENTRANTE*

Moise V., Tabără I., Dudici C.L., Bănică E., Rotaru Al., Boureci Gh. A., Stroe I.
University Politehnica of Bucharest,
E-mail: victor.moise@yahoo.com

Keywords: *gripper, synthesis, self-centring, robots*

ABSTRACT

The manipulation of cylindrical and spherical shape parts and semi-manufactures by using robots, to move them from a working place to another, requires certain conditions to the gripper which must be self-centring, to avoid the deterioration of the robots. In this paper is done the synthesis of some self-centring grippers, by amplification with simple modular groups, usually RRR dyads. The grippers are considered to be with rigid fingers and with movable catching point.

REZUMAT

Manipularea pieselor şi semifabricatelor cilindrice şi de formă sferică folosind roboţi pentru a le muta dintr-un spaţiu de lucru la altul necesită anumite condiţii pentru elementul de prindere, care trebuie să fie auto-centrabil, pentru a evita deteriorarea roboţilor. În această lucrare se face sinteza unor elemente de prindere cu auto-centrare, prin amplificarea cu grupuri modulare simple, de obicei diade RRR. Elementele de prindere sunt considerate a fi cu degete rigide şi cu punctul de capturare mobil.

INTRODUCTION

Manipulators and industrial robots can manipulate the pieces and blanks of different shapes. In the case of parts or blanks of cylindrical or spherical shape, the gripping mechanism it is necessary to be self-centring, to avoid the damage of the robot.

In this paper, we will refer only to mechanisms for gripping with fingers stiff.

Movements of fingers belonging to gripping mechanisms can be pure rotation, pure translation or planar complex motion.

As a result of this, the gripping centre of parts having cylindrical or spherical shape parts is movable, depending on the diameter of the parts and of the kinematic dimensions of the gripper.

Figure 1 shows the kinematic scheme of the mechanisms gripping fingers presented in two different positions. The two fingers are articulated at points A and C and they have prismatic jaws.

The fingers are symmetric related to axis OX and accomplish the angles φ_1, respectively φ_2 with the positive direction of the axis *OX*. The diameters of the two cylindrical parts are *D*1 and *D*2.

The error between the positions of the two centres of the parts is:

$$\Delta L = XO2 - XO1 \tag{1}$$

where:

$$XO1 = R\cos\varphi_1 + BO1\sin\varphi_1$$
$$XO2 = R\cos\varphi_2 + BO1\sin\varphi_2 \tag{2}$$

$$BO1 = a + D1/2/\cos\alpha$$
$$BO2 = a + D2/2/\cos\alpha \tag{3}$$

$$\sin\varphi_1 = \frac{-R.\cdot e + BO1\sqrt{BO1^2 + R^2 - e^2}}{BO1^2 + R^2}$$
$$\cos\varphi_1 = \frac{BO1\cdot e + R\sqrt{BO1^2 + R^2 - e^2}}{BO1^2 + R^2} \tag{4}$$

$$\sin\varphi_2 = \frac{-R.\cdot e + BO2\sqrt{BO2^2 + R^2 - e^2}}{BO2^2 + R^2}$$
$$\cos\varphi_2 = \frac{BO2\cdot e + R\sqrt{BO2^2 + R^2 - e^2}}{BO2^2 + R^2} \qquad (5)$$

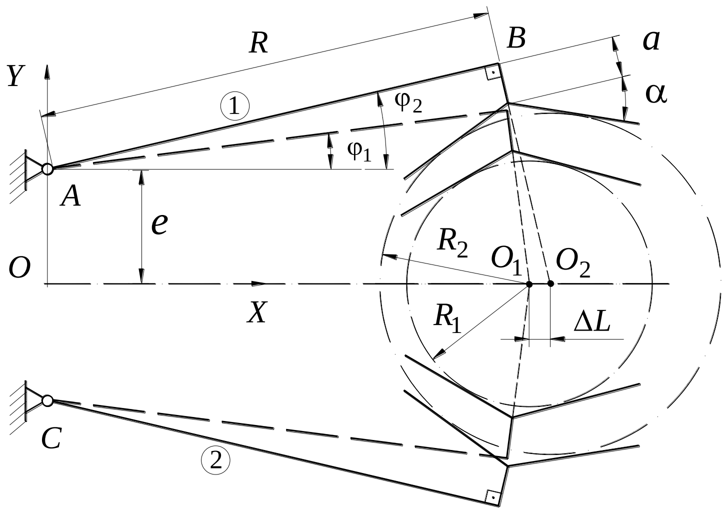

Fig. 1 - Highlighting centres of the cylindrical parts

In the literature related to this field is to be remarked the achievement of various self-centring mechanisms in several ways, namely:

- by kinematic synthesis of the entire mechanism taking into account the self-centring (*Dudiţă, Fl., Stareţu,I.; Konstantinov, M. Et al., Kovacs,Fr., Cojocaru,G. Simionescu, I. Et al*.);
- by the synthesis of cams for actuating jaws in order to fulfil the condition of centring (*Huang Qingsen*);
- by shaping the caching jaws of gripping mechanism, so that the gripping centre to remain fixed (*Simionescu, I. et al.*).

MATERIAL AND METHOD

In the present paper it is accomplished the synthesis of self-centring gripping mechanisms, by amplifying the gripper with movable self-centring catching mechanism with simple modular groups, typically RRR dyads.

In Figure 2.a, it is shown the kinematic scheme of a gripper with bars and lower pairs and having the movable gripping centre, and Figure 2.b presents its schematic multipolar diagram.

Considering the multipolar scheme, it results that the gripper contains, besides the base group Z(0), a “motohexada” with lower pair.

The mechanism gripping shown in Figure 2 can be transformed into a self-centring gripper, like the one presented in Figure 3, by amplifying it with two dyads RRR, which are designed to guide the nippers of the fingers, so that the catching centre to remain fixed for a certain range of diameters of parts to be caught between his fingers.

Determination of elements dimensions contained in the modular groups involves two steps, namely:
a) establishing the old mechanism kinematic parameters for a given number of diameters to be gripped, considering point P has been fixed;
b) synthesis of the new mechanism from the self-centring conditions.

The synthesis equations are determined by using the contour *CDEFPC*. By projecting the vector equation:

$$OT' + \overline{T'T} + \overline{TD} + \overline{DE} = \overline{OP} + \overline{FP} + \overline{FE} \qquad (6)$$

on the axes of the coordinates system it results the system presented below:

$$\begin{cases} S_i + b - XP + DE\cos\varphi_{3i} + EF\sin(\varphi_{4i} + \alpha - \beta) - \\ \qquad\qquad\qquad - FP\cos\varphi_{4i} - XP = 0; \\ d + DE\sin\varphi_{3i} - EF\cos(\varphi_{4i} + \alpha - \beta) - FP\sin\varphi_{4i} = 0; \\ i = \overline{1, p}, \end{cases} \tag{7}$$

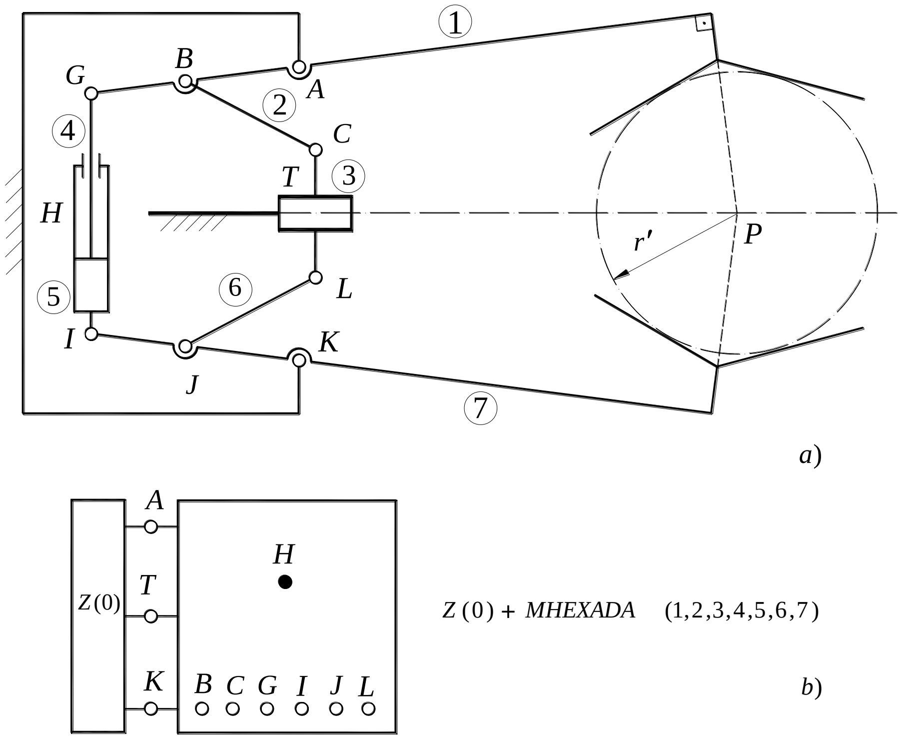

Fig.2. - Gripper with movable gripping centre depending on the diameter of the gripping parts
a) kinematic scheme, b) multipolar scheme

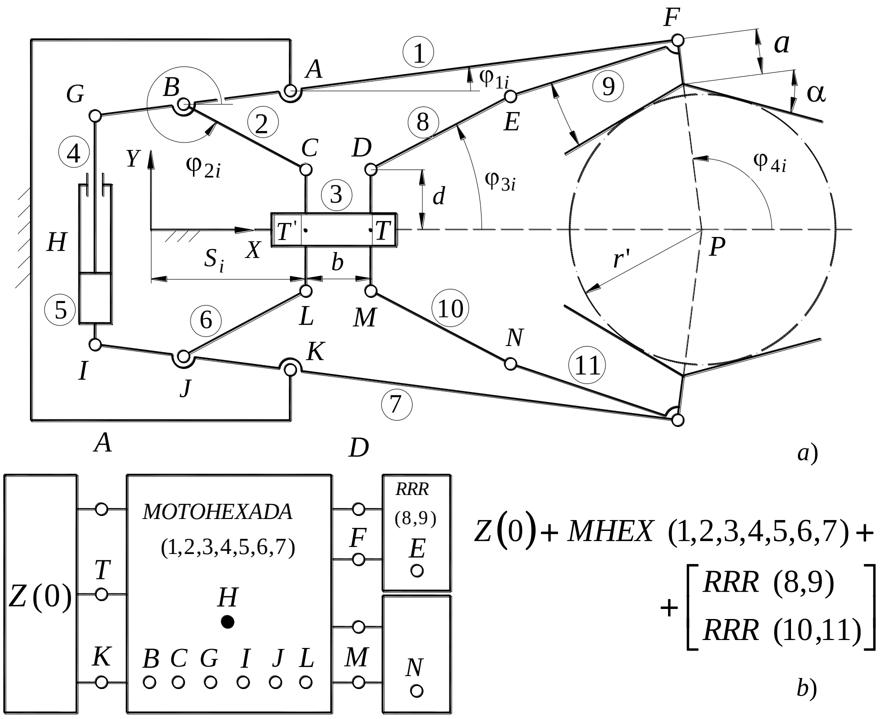

Fig.3. - Self-centring gripper with bars
a) kinematic scheme: b) multipolar scheme

In the above system ***p*** represents the number of positions for which the gripping is exact.

It was obtained a system of non-linear equations which has the unknown: *b*, *d*, *DE*, *EF*, β, φ_{3i}, $i=\overline{1,p}$ Starting from the condition of compatibility: 2*p* = 5+*p*, it results *p* = 5, so there are 5 possible solutions for which the gripping is done accurately.

The accomplished system of non-linear equations it is solved by using an adequate numerical method [5] (Newton-Raphson, gradient etc.). The number of system equations can be reduced from 10 equations to 5 equations by eliminating the angle φ_{3i}. In this way is achieved a system of non-linear equations which have the unknowns: *b*, *d*, *DE*, *EF*, β namely:

$$\begin{cases} b11+2b1[EF\sin(\varphi_{4i}+\alpha-\beta)-FP\cos\varphi_{4i}]- \\ \quad -2d[EF\cos(\varphi_{4i}+\alpha-\beta)+FP\sin\varphi_{4i}] \\ \quad -2EF.FP\sin(\alpha-\beta)=0; \\ i=\overline{1,p}, \end{cases} \tag{8}$$

where: $b11=b1^2-DE^2+EF^2+FP^2+d^2$,

$b1=b+S_i-XP$.

In figure 4 is presented the kinematic scheme a) and multipolar scheme b), of a self-centring gripper fulfilled from a gripping mechanism with moveable centre and composed from a motor tetrad with bars and gears, amplified with two dyads RRR.

The system of equations used for the synthesis of the mechanism is:

$$\begin{cases} XE+EF\cos(\varphi_{1i}+\gamma)-FG\cos\varphi_{2i}+HP\cos\varphi_{3i}- \\ \qquad -HG\sin(\varphi_{3i}+\alpha-\beta)+XP=0; \\ YE+EF\sin(\varphi_{1i}+\gamma)+FG\sin\varphi_{2i}-HP\sin\varphi_{3i}- \\ \qquad -HG\cos(\varphi_{3i}+\alpha-\beta)-YP=0; \\ i=\overline{1,p}, \end{cases} \tag{9}$$

where: *HP = a+D/2/cosa.*

The unknowns of non-linear equations of obtained system are: EF, FG, HG, β, γ φ_{21}, $i=\overline{1,p}$.

Taking into account the condition of compatibility it results the solution p = 5. The variable dimensions φ_{2i}, φ_{3i} are determined previous to synthesis by taking into account the kinematic analysis of the initial mechanism. By eliminating the angle φ_{2i} the nonlinear system is reduced from 10 to 5 nonlinear equations as follows:

$$\begin{cases} b22+2EF(HP\cos(\varphi_{1i}+\varphi_{3i}+\gamma)- \\ -HG\sin(\varphi_{1i}+\varphi_{3i}+\alpha-\beta+\gamma)+XP\cos(\varphi_{1i}+\gamma)- \\ -YP\sin(\varphi_{1i}+\gamma))-2HP(HG\sin(\alpha-\beta)- \\ -XP\cos\varphi_{3i}-YP\sin\varphi_{3i})-2HG(XP\sin(\varphi_{3i}+\alpha-\beta)- \\ -YP\cos(\varphi_{3i}+\alpha-\beta))=0; \\ i=\overline{1,p}, \end{cases} \tag{10}$$

where: *b22=EF²-FG²+HP²+HG²+XP²+YP²*

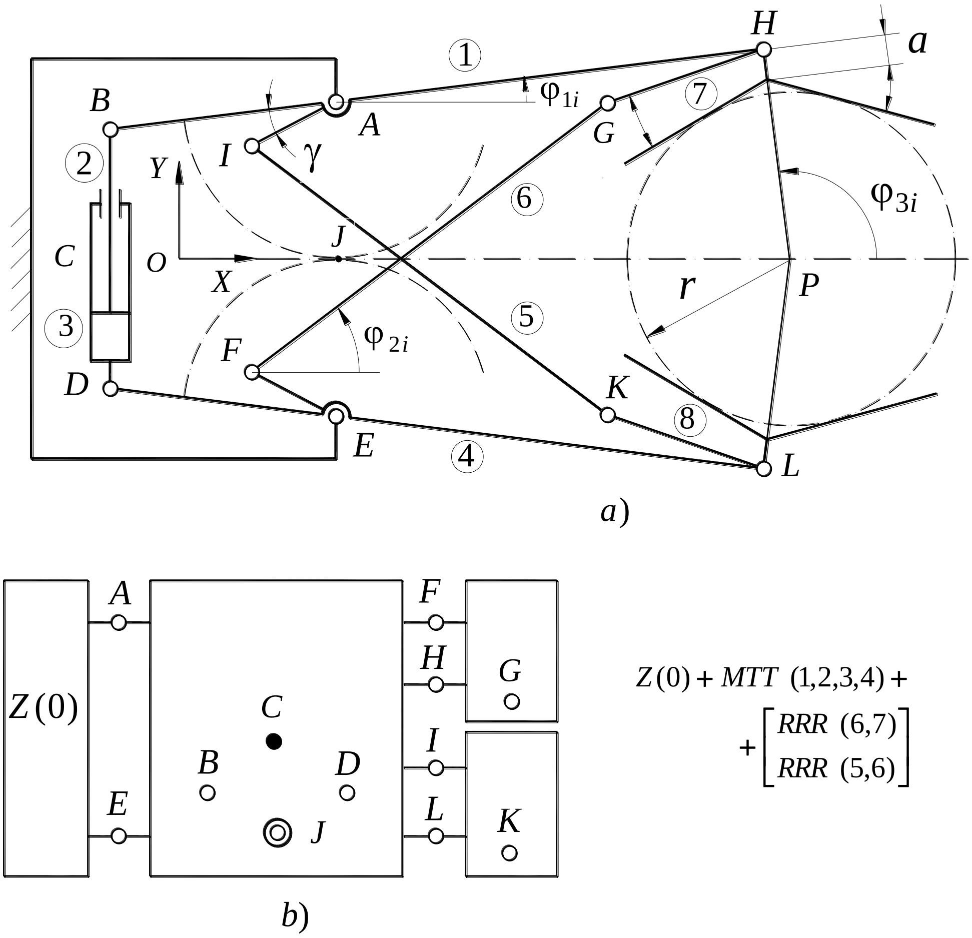

Fig.4. - **Self-centring gripper with bars and gears**

a) kinematic scheme: b) multipolar scheme

RESULTS

To convert the gripper with the movable catching centre depending of the diameter of the caught parts into a self-centring a gripping mechanism were considered:

- The diameter range of the griped parts between 0.040 and 0.08 m.
  - α = 0.5235987 radians;
  - *a* = 0.010 m;
  - *XP* = 0.165 m
  - *XA* = 0.065 m;
  - *YA* = 0.040 m;
  - *AB* = 0.030 m;
  - *BC* = 0.050 m;
  - *AF* = 0.102 m;
  - *CT'* = 0.010 m.

By analysing the mechanism shown in figure 2 the resulted angles are φ_{1i}, φ_{2i} as well as the variable parameter in the prismatic pair T.

By solving the system of linear equations, afferent to the mechanism considered for synthesis, it results:

- *b* = -0.32082 m;
- *d* = 0.09999 m;
- *DE* = 0.11667 m;
- *EF* = 0.11336 m;
- β= -0.0001095 radians.

The results below represents the links dimensions of RRR attached dyad, as well as the connection elements with the initial mechanism.

CONCLUSIONS

The synthesis method presented allows an easy adaptation of some self-centring grippers with movable catching centre, by amplification with simple modular groups, usually RRR dyads.

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EXPERIMENTAL DETERMINATION OF POWER CONSUMPTION FOR MIXING SOLID-LIQUID SYSTEMS
/
DETERMINAREA EXPERIMENTALĂ A PUTERII CONSUMATE PENTRU AMESTECAREA SISTEMELOR SOLID-LICHID

Lect. PhD. Eng. Ungureanu N.*[1)], PhD. Eng. Vlăduţ V.[2)], Lect. PhD. Eng. Dincă M.[1)], Lect. PhD. Eng. Muşuroi G.[1)], Assist. PhD. Stud. Eng. Zăbavă B.Şt.[1)]
[1)]University Politehnica of Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
[2)]INMA Bucharest
Tel: 0724086492; E-mail: nicoletaung@yahoo.com

Keywords: *biomass, anaerobic digestion, stirrer, baffle, power consumption*

ABSTRACT

The paper presents the experimental results regarding the influence of solid-liquid mixture concentration and stirrer type on mechanical power consumption, aiming to determine the optimal mixing system for biomass in anaerobic digesters. As feedstock were used heterogeneous solid-liquid mixtures, composed of water and dry energy plant Miscanthus x giganteus, and also water and green grass chopped to sizes between 1 and 3 cm. For each tested mixture were used two concentrations (8.3% and 16.6%). Various configurations of stirrers were tested: impeller turbine, paddle and propeller, all being combined with baffles, and also without baffles in the mixing vessel. The lowest power consumption was obtained for the propeller stirrer.

REZUMAT

În lucrare sunt prezentate rezultatele experimentale privind influenţa concentraţiei amestecului solid-lichid şi a tipului de agitator asupra consumului de putere, în vederea stabilirii sistemului optim de amestecare a biomasei în digestoarele anaerobe. Ca materii prime s-au utilizat amestecuri eterogene solid-lichid, alcătuite din apă şi planta energetic Miscanthus x giganteus uscată, precum şi din apă şi iarbă verde tocată la dimensiuni cuprinse între 1 şi 3 cm. Pentru fiecare amestec testat s-au utilizat două concentraţii (8.3% and 16.6%). S-au testat diferite configuraţii de sisteme de amestecare: turbină impeller, palete şi elice, atât în combinaţie cu şicane, cât şi fără şicane în vasul amestecătorului. Cel mai mic consum de putere s-a obţinut pentru agitatorul cu elice.

INTRODUCTION

Anaerobic digestion is a well-established process for renewable energy production in which biomass (also referred as substrate or feedstock) is broken down and converted into biogas (a mixture of methane, carbon dioxide and traces of other gases) by microorganisms (*Montgomery and Bochmann, 2014; Prabhu et al., 2014*). The anaerobic digestion as a complex biological process is influenced by several environmental factors such as: temperature, pH, substrate composition, mixing, pressure, nutritive elements, inoculation and heavy metals (*Dincă et al., 2015*).

In anaerobic digesters, mixing aims to improve the contact between microorganisms and substrate, and to improve the ability of the active microbial biomass to obtain nutrients. Also, mixing prevents the formation of scum on top of the substrate in the digester (*Monnet F., 2003; Muzenda E., 2014*), thus allowing the normal evolution of gas bubbles (*A Chinese biogas manual, 2013*), creates homogeneity in fluids (*Boontian N., 2014*), prevents the development of concentration and temperature gradients within the digester (*Monnet F., 2003; Gomez et al., 2006*), ensures an even distribution of buffering alkalinity, and prevents the sedimentation of particulate material (*Karlssonet al.,* 2014).

Mixing is primarily needed for effective high-rate biogas production. However, excessive mixing can disrupt the microorganisms, reducing biogas production, and therefore slow mixing is preferred (*Monnet F., 2003*). Gentle mixing prevents methane producing organisms from being washed out by the liquid (*Muzenda E., 2014*). Another factor that influences biogas production is the particle size of biomass, as it was found that size reduction increases the bio-accessibility of the substrate (*Motte et al, 2014*). In case of co-digestion, different feedstock should be mixed before being introduced into the digester, to ensure a sufficient homogeneity. Important factors regarding the mixing operation are the velocity and turbulence fields in the digester.

Mixing of the digester content can be achieved continuously or intermittently, at different frequencies. It was found that low speed mixing allowed digesters to better absorb the disturbances of shock loadings, compared to digesters with high speed mixing (*Gomez et al., 2006*). The type of mixing is influenced by the reactor design, the type of substrate to be digested, the desired loading rate etc. (*Karlssonet al.,* 2014).

Mixing can be conducted by means of mechanical mixers, biogas recirculation and slurry recirculation, but mechanical mixers are considered the most efficient in terms of power consumption per mixed volume (*Moiceanu et al., 2015*). More than 54 % of the new biogas plants have installed slowly moving paddle stirrers in completely mixed digesters. About 9 % of all stirrers are slowly moving long-shaft stirrers and only 7 % are rapid velocity submersible-motor propeller stirrers. Over 50 % of the new biogas plants have only one mixer installed, but the tendency is towards digesters with two or three mixers (*Hopfner-Sixt et al., 2006*).

In anaerobic digestion, the efficiency of the mixing system design in relation to microorganism colonization, presence of dead zones and changes in viscosity / rheology is yet unclear and requires further attention (*Karlssonet al.,* 2014). The energy requirement for biomass mixing is highly dependent on solid loading: the higher the solid loading, the lowest the energy requirement (*Zhang et al, 2009*). Anaerobic digestion of solid state biomass generally occurs at solid concentrations higher than 15%, while liquid anaerobic digestion handles feedstock with solid concentrations between 0.5-15% (*Boontian N., 2014*). In this paper were tested mixtures with two concentrations, corresponding to both cases.

MATERIAL AND METHOD

In the experiments was tested the influence of solid-liquid mixture concentration and stirrer type on power consumption, in order to determine the optimal mixing system for biomass stirring in anaerobic digesters.

Experiments were conducted using the CEK Armfield equipment for fluids mixing (Fig. 1), provided with a vessel of 30 litres volume, in which is mounted a mixer on which may be fixed different types of stirrers. The equipment is fitted with a speed controller and an electronic tachometer that shows the speed of the mixer's shaft (in the range of 0-500 rpm). A dynamometer, mounted on a bridge, measures the torque using a force balance with direct reading. To increase the turbulence and mixing efficiency, a circular frame on which are mounted vertical baffles (or vortex breakers) can be introduced in the mixing vessel.

Fig. 1 – CEK Armfield stirrer for fluids, with the baffles mounted in the vessel

During the experiment, on the shaft of the mixer were attached three types of stirrers, which are used in practice for the mixing or dissolving of substances with low or medium viscosity: three-bladed propeller stirrer, impeller turbine stirrer, respectively rectangular paddle stirrer (Fig. 2).

Two types of biomass were tested: plant biomass: dry *Miscanthus x giganteus* and green grass. Coarse shredding of the biomass was performed using the VIKING GE 150 garden shredder. Then, the coarsely shredded biomass was introduced into the Grindomix GM 200 laboratory mill for one minute at 5000 rpm to achieve fine grinding, thereby to obtain biomass with particle sizes between 1 and 3 cm. The Kern EW-N/EG-N balance was used to weight 200 g, respectively 400 g of each type of biomass.

Fig. 2 - Types of stirrers used in the experiment: propeller, impeller turbine and blades

Fig. 3 - Viking GE 150 garden shredder, Grindomix GM 200 laboratory mill and Kern EW-N/EG-N balance used in the experiments

Thus, in the experimental research were tested various solid-liquid mixtures, with different concentrations and different configurations of the mixing system. In the mixing vessel were achieved the following concentrations of solid-liquid liquid systems, which can be further used as vegetable substrate:

- 200 g grinded dry *Miscanthus x giganteus* + 24 litres tap water (8.3 % concentration);
- 400 g grinded dry *Miscanthus x giganteus* + 24 litres tap water (16.6 % concentration);
- 200 g grinded green grass + 24 litres tap water (8.3 % concentration);
- 400 g grinded green grass + 24 litres tap water (16.6 % concentration).

Grinded solid biomass was first introduced into the mixing vessel and stirred at high speed for a good dampening. For the two types of biomass, the experiments with each of the three types of stirrers (propeller, impeller turbine and blades) were repeated, both with the baffles mounted in the mixing vessel, and in the absence of baffles.

In Figures 4 and 5 are presented some aspects from the mixing of the two types of biomass, both in the presence and in the absence of the baffles in the mixing vessel.

Fig. 4. – Mixing of *Miscanthus x giganteus* and water, without baffles (left) and with baffles (right)

Fig. 5. –Mixing of grass and water, without baffles (left) and with baffles (right)

For each experiment were used five steps of shaft speeds and speed value, n [rpm] was displayed by the tachometer. Each time, it was read the mass value [kg] recorded by the force balance of the dynamometer (with torque arm radius r = 0.11 m), then the force F [N] was determined as product of the value indicated by the force balance and gravity acceleration. For each test were calculated the torque, the angular speed and the mechanical power consumed for the rotation of each mixing system, as follows:

Torque (T) is given by the following equation:

$$T = F \cdot r \quad \text{[Nm]} \tag{1}$$

Angular speed (ω):

$$\omega = n \cdot \frac{2 \cdot \pi}{60} \text{ [rad/s]} \tag{2}$$

Mechanical power consumed for stirring (P) is given by the equation:

$$P = T \cdot \omega \quad \text{[W]} \tag{3}$$

RESULTS

Experimental data obtained during the mixing of 200 g of dry *Miscanthus x giganteus* and 24 litres of tap water, are presented in Table 1. It must be mentioned that, in the case of the propeller, results were obtained only when the baffles were used, because in their absence the stirrer could not rotate.

Table 1

Results obtained from mixing 200 g of dry *Miscanthus x giganteus* with 24 litres of tap water

n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]	n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]
Impeller stirrer with baffles					**Impeller stirrer without baffles**				
88	1.2753	0.1403	9.22	1.293	88	0.0490	0.0054	9.32	0.050
169	1.3734	0.1511	17.70	2.674	183	0.0981	0.0108	19.16	0.206
252	1.6677	0.1834	26.39	4.840	303	0.2452	0.2698	31.73	0.856
345	4.1202	0.4532	36.13	16.374	400	0.2943	0.0324	41.89	1.356
351	4.2183	0.4640	36.76	17.056	507	0.5395	0.0593	53.10	3.152
Paddle stirrer with baffles					**Paddle stirrer without baffles**				
76	2.0601	0.2266	7.96	1.803	78	0.981	0.1079	8.17	0.882
137	2.3053	0.2536	14.35	3.640	174	1.2262	0.1349	18.22	2.458
202	6.1312	0.6744	21.15	14.264	256	2.2563	0.2482	26.81	6.654
210	6.1803	0.6798	21.99	14.950	371	2.4525	0.2698	38.85	10.481
196	6.0822	0.6690	20.21	13.520	467	2.9921	0.3291	48.90	16.094
Propeller stirrer with baffles									
86	0.0098	1.08	9	0.019					
195	0.0196	2.16	20.42	0.044					
312	0.0294	3.24	32.67	0.106					
418	0.0392	4.32	43.77	0.189					
517	0.0490	5.40	54.14	0.292					

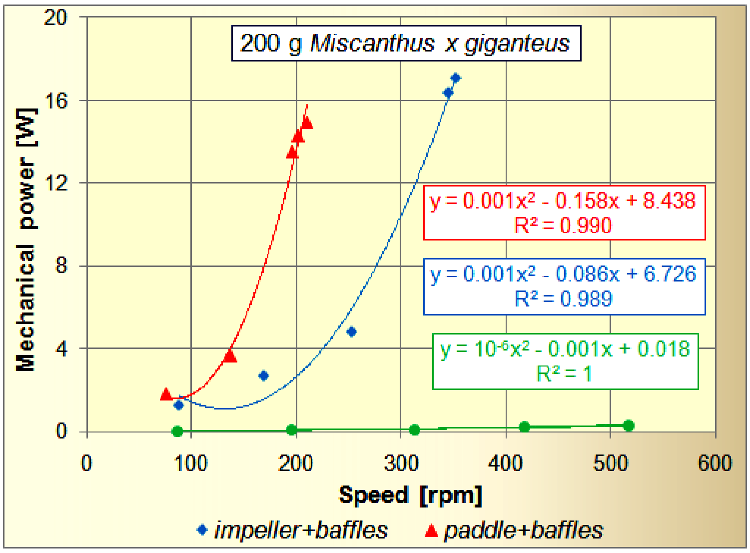

Fig. 6 – Variation of mechanical power with speed, for 200 g *Miscanthus x giganteus*, with baffles

Analysing Figure 6, it can be seen that by stirring the *Miscanthus x giganteus* mixture in concentration of 8.3%, with baffles in the mixing vessel, there is significant variation between the power consumed by the impeller and paddle stirrers, compared to the propeller. The power consumed by the propeller, for the range of speeds between 86 - 418 rpm, varies from 0.019 to 0.189 W, and in this case it was observed that mixing is not efficient in the vessel. This is due to the existence of baffles, which prevent the formation of currents. The best mixing was obtained when using the impeller stirrer. In all three situations, the trend for power consumption is an increasing one by polynomial distribution laws, and the correlation coefficient has very high values (R^2= 0.989 ÷1).

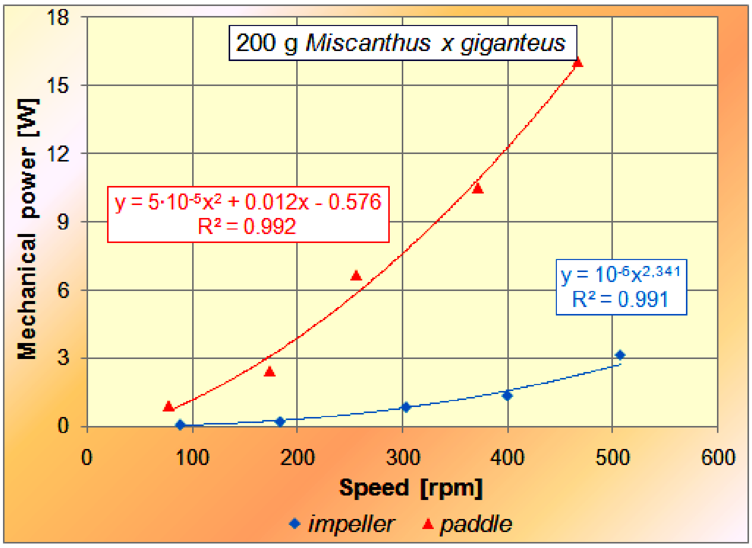

Fig. 7 – Variation of mechanical power with speed, for 200 g *Miscanthus x giganteus*, without baffles

In the absence of baffles (Figure 7), the power consumed by the impeller started from 0.05 W at a speed of 88 rpm and increased to 3.152 W at the speed of 507 rpm. Instead, the power consumed by the paddle stirrer varied after a power-law distribution, between 0.882-16.094 W, during the use of this stirrer being highlighted the highest turbulence in the vessel.

Experimental data obtained by the mixing of 400 g of dry *Miscanthus x giganteus* and 24 lifters of tap water (16.6% concentration), for the impeller and the paddle stirrer, with and without baffles in the mixing vessel, are presented in Table 2. In this case, while testing with the propeller the force balance indicated no change to the value of mixing force, which affected the measurements. Therefore, the values for the propeller could not be considered.

Table 2

Results obtained from mixing 400 g of dry *Miscanthus x giganteus* with 24 litres of tap water

n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]	n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]
Impeller stirrer with baffles					**Impeller stirrer without baffles**				
78	0.1864	0.0205	8.17	0.167	65	0.1471	0.0162	6.81	0.110
173	0.2943	0.0324	18.12	0.587	183	0.2158	0.0237	19.16	0.455
272	2.4525	0.2698	28.48	7.683	302	0.2943	0.0324	31.63	1.024
355	4.4145	0.4856	37.18	18.054	400	0.4022	0.0442	41.89	1.853
360	4.4635	0.4910	37.70	18.510	504	0.7848	0.0863	52.78	4.556
Paddle stirrer with baffles					**Paddle stirrer without baffles**				
71	0.2028	0.0223	7.44	0.166	79	0.2943	0.0324	8.27	0.268
140	2.7468	0.3021	14.66	4.430	169	0.7848	0.0863	17.70	1.528
193	6.1803	0.6798	20.21	13.739	217	1.4224	0.1565	22.72	3.555
212	5.8860	0.6475	22.20	14.374	368	2.5015	0.2751	38.54	10.605
254	5.6407	0.6205	26.60	16.505	464	3.1882	0.3507	48.59	17.041

Variations of mechanical power consumed for the mixing of *Miscanthus x giganteus* in concentration of 16.6%, for the four tested combinations of mixing systems, are presented in Figures 8 and 9.

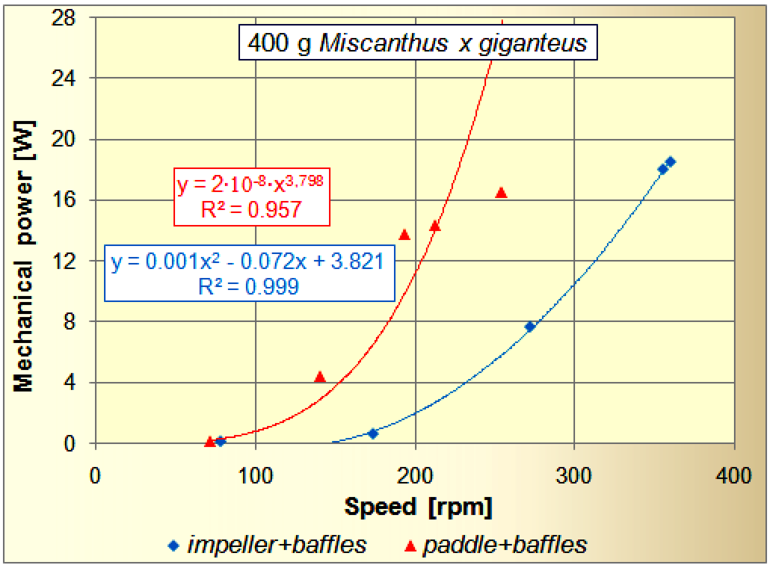

Fig. 8 - Variation of mechanical power with speed, for 400 g *Miscanthus x giganteus*, with baffles

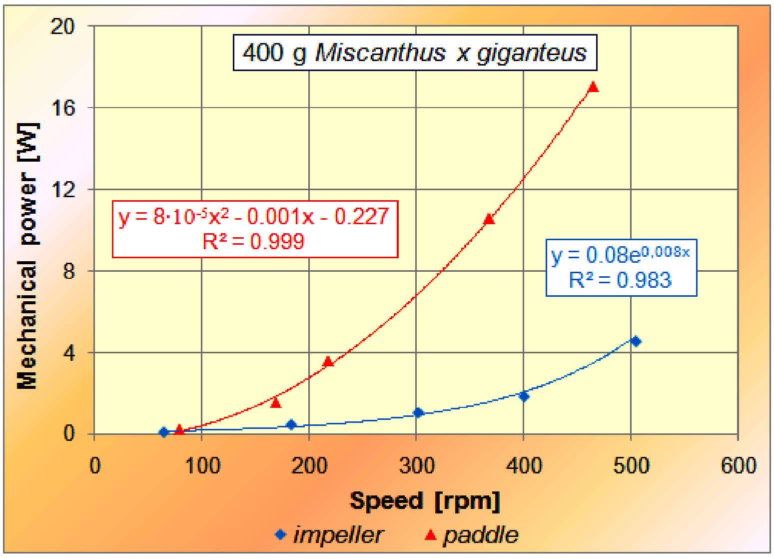

Fig. 9 - Variation of mechanical power with speed, for 400 g *Miscanthus x giganteus*, without baffles

For the mixture of *Miscanthus x giganteus* in concentration of 16.6%, by using of baffles in the vessel (Figure 8) were not recorded significant variations between the power consumed by the impeller stirrer (between 0.167 - 18.51 W) and the power consumed by the paddle stirrer (between 0.166 - 16.505 W). In contrast, from Figure 9 it is observed that in the absence of baffles, at maximum speed of the stirrer, the power consumed by the impeller is four times less than the power consumed by the paddle stirrer.

Experimental data obtained during the mixing of 200 g of green grass and 24 litres of tap water (8.3% concentration), for the three types of stirrers, both with and without baffles in the mixing vessel, are presented in Table 3.

Table 3

Results obtained from mixing 200 g of green grass with 24 litres of tap water

n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]	n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]
Impeller stirrer with baffles					**Impeller stirrer without baffles**				
75	0.0687	0.0076	7.85	0.059	80	0.1766	0.0194	8.38	0.163
166	0.5395	0.0593	17.38	1.031	178	0.2452	0.0270	18.64	0.503
268	0.7357	0.0809	28.06	2.271	300	0.3433	0.0378	31.42	1.187
318	2.2563	0.2482	33.30	8.265	398	0.4414	0.0486	41.68	2.024
329	2.0110	0.2212	34.45	7.621	505	0.5003	0.0550	52.88	2.910
Paddle stirrer with baffles					**Paddle stirrer without baffles**				
73	0.2648	0.0291	7.64	0.223	74	0.0588	0.0065	7.75	0.050
132	0.4905	0.0539	13.82	0.746	173	0.5886	0.0647	18.12	1.173
156	0.5493	0.0604	16.34	0.987	286	0.8338	0.0917	29.95	2.747
164	2.7468	0.3021	17.17	5.188	388	2.6487	0.2913	40.63	11.838
170	2.9920	0.3291	17.80	5.858	460	2.9430	0.3237	48.17	15.594
Propeller stirrer with baffles					**Propeller stirrer without baffles**				
81	0.0294	0.0032	8.48	0.027	70	0.0686	0.0075	7.33	0.055
207	0.0490	0.0054	21.68	0.117	188	0.0981	0.0108	19.69	0.213
329	0.2452	0.0270	34.45	0.929	321	0.2256	0.0248	33.62	0.834
411	0.2943	0.0324	43.04	1.393	426	0.2649	0.0291	44.61	1.300
502	0.4414	0.0486	52.57	2.552	525	0.4905	0.0539	54.98	2.966

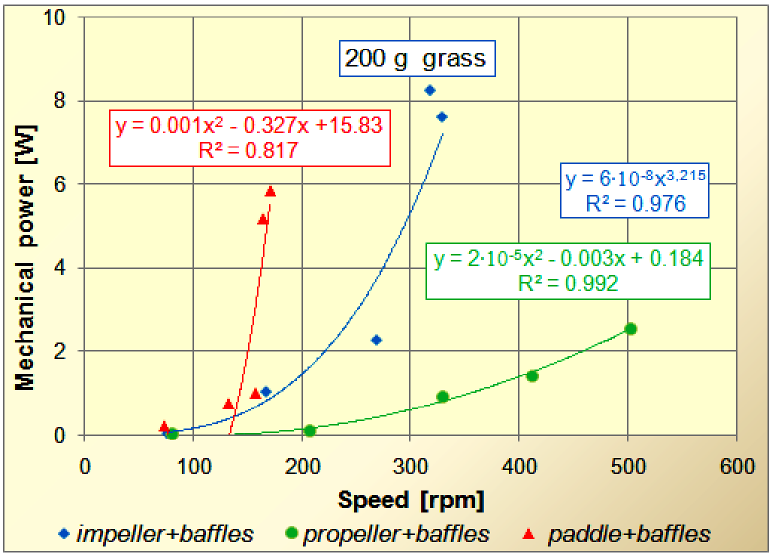

Fig. 10 - Variation of mechanical power with speed, for 200 g grass, with baffles

From the analysis of the data obtained from the stirring of grass mixture in concentration of 8.6% with baffles (Figure 10) the lowest power consumption was obtained for the propeller stirrer and the paddle stirrer, which have not achieved an efficient stirring of the mixture. By using the paddles, biomass particles tended to agglomerate around the stirrer's shaft, as evidenced by low differences between speed values at different speed steps (between 73 - 170 rpm). With the impeller stirrer was achieved the highest turbulence in the vessel, at the maximum speed of 329 rpm power consumption being 7.621 W.

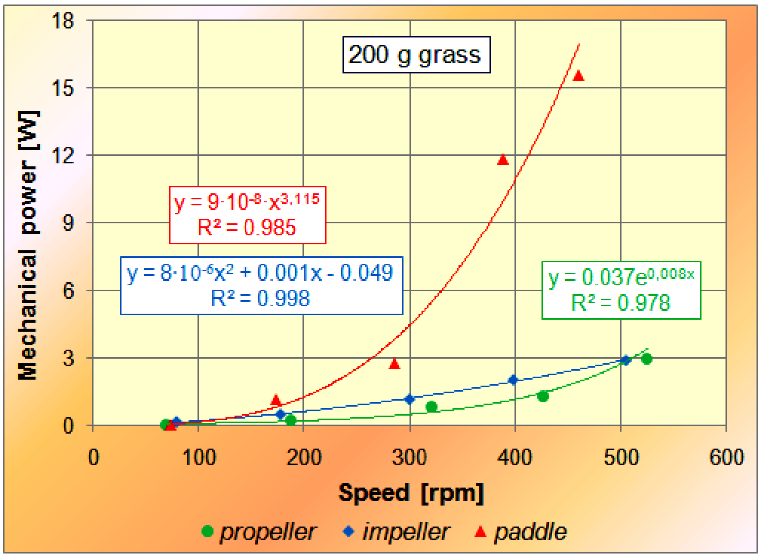

Fig. 11 - Variation of mechanical power with speed, for 200 g grass, without baffles

In the absence of baffles (Figure 11) were obtained similar variations of the power consumed by the impeller stirrer and the impeller stirrer, and this time the power consumed by the paddle stirrer was approximately five times greater than that consumed by the other two types of stirrers.

Experimental data obtained during the mixing of 400 g of green grass and 24 litres of tap water (16.6% concentration), for the three types of stirrers, with and without baffles in the mixing vessel, are presented in Table 4. Graphical representations of these data are presented in Figures 12 and 13.

Table 4

Results obtained from mixing 400 g of green grass with 24 litres of tap water

n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]	n [rpm]	F [N]	T [N·m]	ω [rad/s]	P [W]
Impeller stirrer with baffles					**Impeller stirrer without baffles**				
85	0.0981	0.0108	8.90	0.096	73	0.0588	0.0065	7.64	0.049
174	0.5493	0.0604	18.22	1.101	178	0.0981	0.0108	18.64	0.201
267	0.7848	0.0863	27.96	2.414	300	0.2943	0.0323	31.42	1.017
341	2.0110	0.2212	35.71	7.901	400	1.2262	0.1349	41.89	5.650
334	3.6787	0.4046	34.98	14.155	503	1.3243	0.1457	52.67	7.673
Paddle stirrer with baffles					**Paddle stirrer without baffles**				
28	0.0196	0.0022	2.93	0.006	81	0.1667	0.0183	8.48	0.155
107	0.0294	0.0032	11.21	0.036	154	0.5395	0.0593	16.13	0.957
132	0.0294	0.0032	13.82	0.044	271	0.7848	0.0863	28.38	2.450
182	0.0392	0.0043	19.06	0.082	369	1.4715	0.1618	38.64	6.254
171	0.0392	0.0043	17.91	0.077	457	1.9620	0.2158	47.86	10.329
Propeller stirrer with baffles					**Propeller stirrer without baffles**				
77	0.0588	0.0065	8.06	0.052	75	0.0196	0.0022	7.85	0.017
196	0.1765	0.0194	20.53	0.398	200	0.1962	0.0216	20.94	0.452
328	0.2452	0.0269	34.35	0.927	315	0.2551	0.0281	32.99	0.926
417	0.3139	0.0345	43.67	1.508	431	0.2747	0.0302	45.13	1.363
518	0.5395	0.0593	54.24	3.219	530	0.2943	0.0324	55.50	1.796

At the stirring of the grass mixture in concentrations of 16.6% in the presence of baffles (Figure 12), the mechanical power consumed by the three types of stirrers does not vary significantly. In this case, the biomass particles had the tendency to agglomerate around the paddle stirrer, with very small variations of the values recorded by the force balance and, consequently, of power consumption at different stirrer speeds.

For the three stirrers, power consumption varied by power - law distributions. For the impeller stirrer, power consumption started from 0.096 W and increased to 14.155 W, while for the propeller stirrer, power consumption varied between 0.052 – 3.219 W.

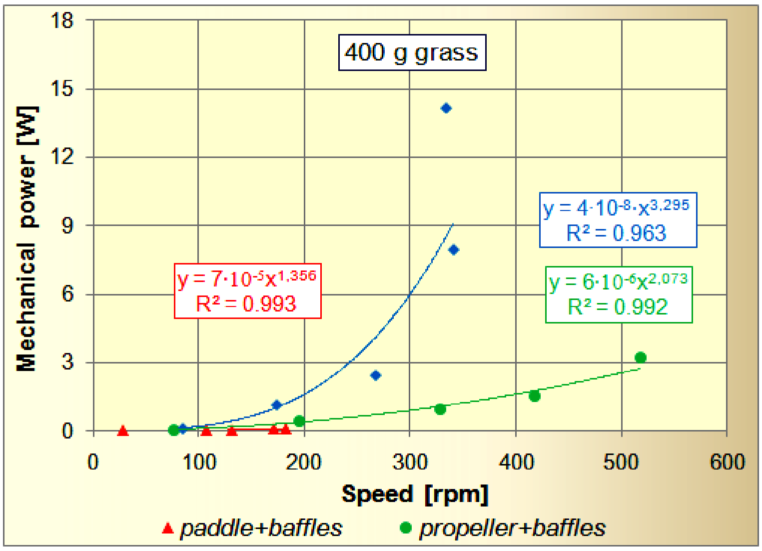

Fig. 12 - Variation of mechanical power with speed, for 400 g grass, with baffles

In the absence of baffles in the mixing vessel (Figure 13) for the propeller were recorded the lowest values of power consumption (between 0.017 – 1.796 W), compared to the impeller (between 0.049 – 7.673 W) and the paddle stirrer (between 0.155 – 10.329 W).

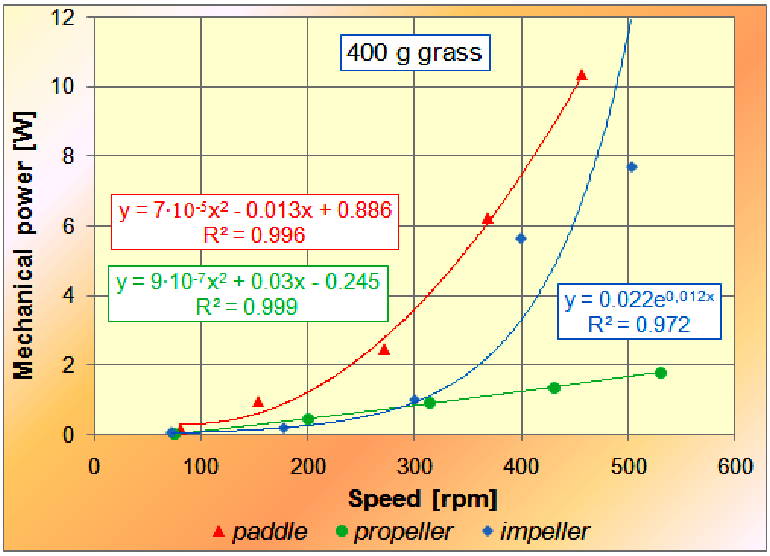

Fig. 13 - Variation of mechanical power with speed, for 400 g grass, without baffles

CONCLUSIONS

Mixing is a mechanical operation that improves the contact between the methanogenic bacteria and substrate, prevents the formation of scum on top of the substrate and allows the normal evolution of gas bubbles, thus increasing the yield of biogas.

For the mixture of *Miscanthus x giganteus*, for both concentration of 8.3% and 16.6%, the highest power consumption was obtained for the impeller stirrer with baffles (17.056 W, respectively 18.510 W).

For the mixture of grass in a concentration of 8.3%, the highest power consumption was recorded for the paddle stirrer without baffles (15.594 W) and at 16.6% concentration, the higher power consumption was obtained for the impeller stirrer with baffles (14.155 W).

For the same concentration of the two mixtures, power consumption was greater when the impeller stirrer and baffles were used, compared to the impeller stirrer without baffles. When using the paddle stirrer, the trend was reversed, namely power was higher in the absence of baffles in the mixing vessel.

Although the propeller stirrer has the lowest power consumption, it does not produce sufficient agitation in the vessel so, under these circumstances, its use is not appropriate for a proper mixing of the biomass.

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THE IMPORTANCE OF HUMAN EVALUATION IN SENSORY MARKETING APPROACH
/
IMPORTANŢA EVALUARII UMANE INTR-O ABORDARE A MARKETINGULUI SENZORIAL

Lect. Ph.D. Eng. AVRAMESCU A.-M.[1)], Lect. Ph.D. Eng. DOBRE C.-G.[2)]
[1)] University Polytechnic Bucharest, Faculty of Aerospace Engineering / Romania
[2)] University Polytechnic Bucharest, Faculty of Mechanical Engineering and Mechatronics / Romania
Tel: 0724594846; E-mail: avr_ana@yahoo.com

Keywords: *innovation strategies, consumers' behaviour, quality, sensory evaluation*

ABSTRACT

In innovation strategies, knowing consumers' behaviour, their mental representations, their reactions, their desires (whether expressed or not) is of great importance. Sensory evaluation plays a crucial role in creating and manufacturing new products, in determining the differences of the products, in optimizing, but also in the potential impact of a changing process upon the final quality of the product. The issue of human evaluation is addressed in the analysis of customer's needs. In this paper we propose a subjective assessment approach that is used in the domain of human evaluation assessment. The aim of this paper is to create a methodological framework.

REZUMAT

În cadrul strategiilor de inovare se acordă o mare importanţă cunoaşterii comportamentului consumatorului, a reprezentărilor sale mentale, a reacţiilor şi dorinţelor sale (exprimate sau nu). Evaluarea senzorială are un rol esenţial în crearea şi formularea de noi produse, în stabilirea diferenţelor dintre ele, în optimizare şi în ceea ce priveşte impactul potenţial a unui proces în schimbare asupra calităţii produsului. Problema evaluării umane este discutată în cadrul analizei nevoilor consumatorului. În lucrarea de faţă propunem o abordare a evaluării subiective folosite în domeniul comportamentului consumatorului. Scopul său este să pună bazele unor cadre metodologice.

INTRODUCTION

Sensory marketing is considered a shopping experience, the best way to promote your products. The advertising is not dead, but continuing to evolve along with the new technologies. Still, its basic principles are the same [4, 7, 8]. Everything goes down to that: knowing the brand, the consumers and their reactions. Sensory marketing could exist as long as product marketing is going to appeal to our senses. Unconsciously, we react immediately when we see things that we like and that catch our attention. New things will always have a great impact upon us [2, 4, 9, 21].

For a better understanding of the benefits that sensory marketing could bring to promotion we have to outline the differences of the two. First, traditional marketing is based mostly on functionality, on the product characteristics and benefits, on its performance. The consumer's reaction is a rational one, following the industrial development [1, 3, 5, 13, 16, 17, 20]. The customers are lured to pick their own product. The principles of sensory marketing are based on the marketing mix of the four P (Product, Price, Place, and Promotion) [10, 18]. These are the tools that a campaign uses and are essential in order to succeed. Sensory marketing, on the other hand, is based mostly on experiencing than using the product. In order for the consumer to have significant experiences, the marketing must evoke the consumer's feelings [11, 19]. Sensory marketing is about creating a brand and a brand image and also about establishing a close connection between consumer and product, leading to higher rates of consumption [6, 14]. In designing products, sensory marketing focuses on the five senses of the human being. The main strategy is to establish a deep emotional bond, beyond tangible, between the consumer and the product [12, 15, 19].

MATERIAL AND METHOD

Our purpose is to design a three volume ensemble for a pavilion. The design is conceived in order for the users to feel surprising sensations. Therefore, it is a means of promotion using sensory marketing. The pavilion could convey colour, shape, and tangibility for a number of ideas and emotions. It represents a platform that establishes the bond between the product (object, idea, program etc.) and the possible customer [1, 14, 18].

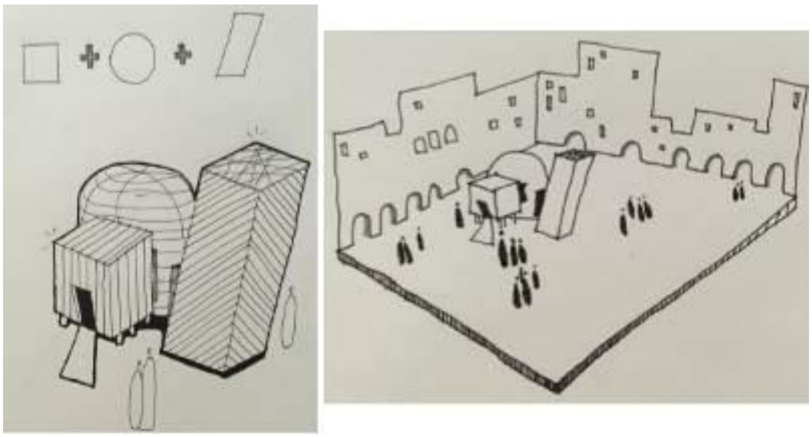

Fig.1 – Personal sketch

The pavilion has three separate volumes – a cube, a sphere and a reclined parallelepiped – connected through two hubs.

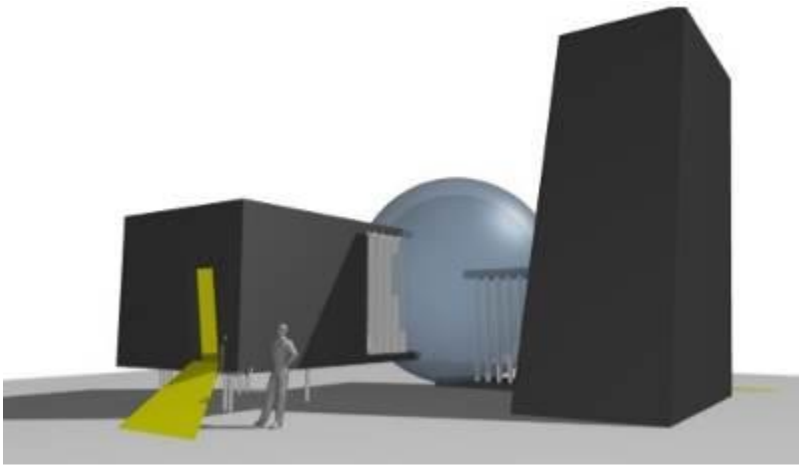

Fig.2 – The concept – suggestion of presentation

These three volumes are able to have different roles and aspects. They could be a basic support in order to convey the desired idea. The cube and the reclined volume are made from light wood and based on an easy detachable network of elements, easy to transport and assemble in any given place. The second volume, the sphere, is made of a very resistant rubber, having two concentric walls. Therefore, its resistance structure is inflatable and very easy to move and transport [14, 19, 21].

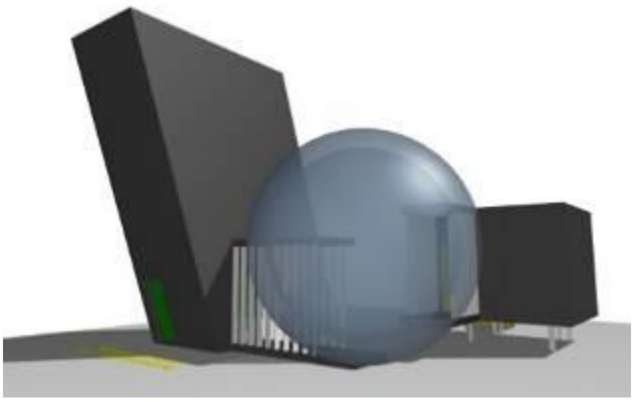

Fig.3 – Product design - Pavilion

The pavilion is designed to be placed in a central square (ex. University Square, Bucharest)

RESULTS

The cube is the first to enter via a ramp. The exterior is in black paint, the interior in yellow. The module will have attached an air conditioning unit that, no matter the weather outside, it will maintain a constant temperature of 40 degrees Celsius. The ambiance will be provided with the animal sounds of a savannah from an intelligent sound system.

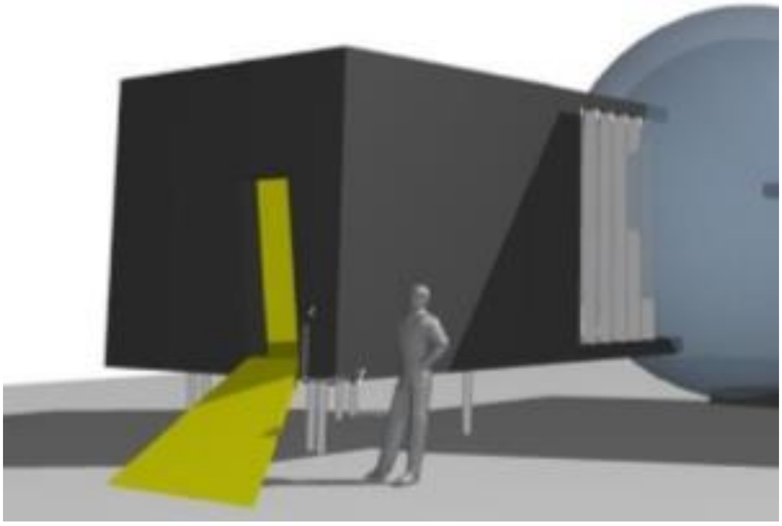

Fig.4 – Personal sketch – outside view of the cube

Fig.5 – Personal sketch – inside view of the cube

Over the yellow paint it will be applied a pattern to evoke the spots or streaks of a beast, conveying the experience of a savannah without actually seeing the animal or the landscape. The volume creates the ambiance in a minimalistic way, leaving the user to come up with his or hers own imagery.

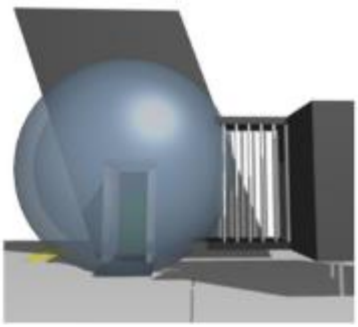

Fig.6 – The sphere – suggestion of presentation

One can enter the inflatable sphere following the indicated track from the cube. The scenery here is the sea. The seagulls' cries and the "breeze" suggested through the ventilation tubes, together with the round sensation of the spherical shape are making the user to long for the sea. Also, the sphere will have a light system to mimic the sunlight reflected in water. Of great importance is the floor, being very soft in order to convey the sensation of sand.

Fig.7 – Inside view of the sphere – suggestion of presentation

The third volume is also of wood with a special structure adapted to its shape. It is 7 meters tall and with an area of 3 x 3 meters. It is designed to be modular, fast and easy to assembling. Being so tall and having a relatively little area, combined with the reclined walls makes the viewer to look up. On the roof it is installed a luminary allowing the light to enter only in part because of its intricate design of metallic elements.

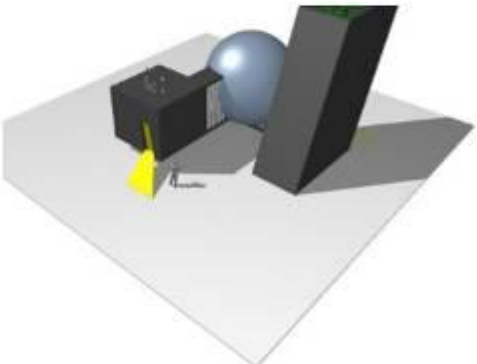

Fig.6 – Suggestion of presentation

The access is from the inflatable sphere, from total light to obscurity. We will have here a third hypostasis, that of a cool forest, where the light pierces only through the thick branches of the trees. The module shape, the lower temperature, the playful shadows, the colour and the texture of the interior, together with the forest specific sounds will create the right ambiance. The walls will be painted in dark green having the pattern of tall trees.

Fig.7 – The reclined volume – suggestion of presentation

In conclusion, the track follows the three sensory experiences of the three overall holyday destinations: an exotic adventure, by the sea and in a mountain forest. In fact, this platform is part of a tourism campaign – "Choose your destination". When inside, the user will be stimulated to make as many selfies as he or she can, using his or hers mobile phone or camera in order to download the pictures on the travel agency website as a way of participating to the agency's contest. The one with the most appreciation votes will win a trip to one of its dream destinations.

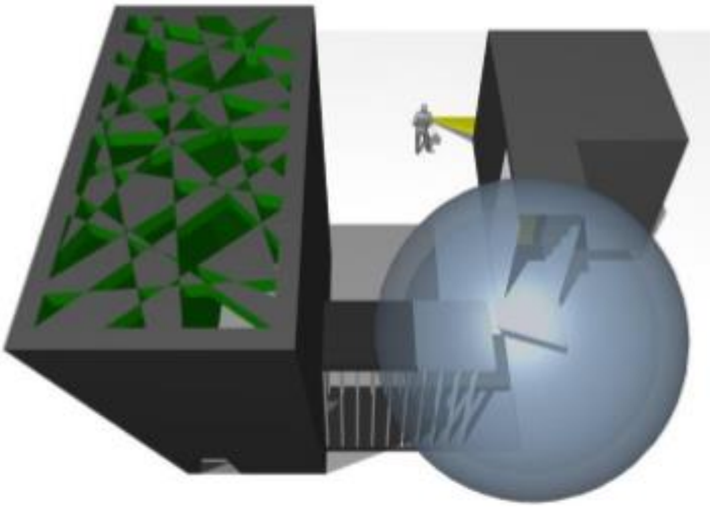

Fig.6 – View from above – suggestion of presentation

The project is a tool for the online promotion of the travel agency. The pavilion succeeds in creating a pleasant and unique experience for the user which he or she could also further share with friends. It is a way of gaining awareness for the agency. Its identity will be associated with the sensations and emotions experienced. Actually, the pavilion is meant to challenge the user to unleash his or hers already expressed desires of going on vacation.

CONCLUSIONS

Analysing the traditional marketing, we see that because of the market and product development there is a need to create a bond with the customers, a bond beyond the immediate sale of a product. The online and offline companies could develop sensory experiences for their customers. A good brand has a total impact upon the consumer if, along with the visual and hearing stimuli, there is an arousal of the other senses: tactile, smell, taste. Today, the marketing addresses especially the senses. Therefore, the big companies conceived different development strategies involving the human senses.

One of the great importances in innovation strategies is given to the knowledge of consumers' behaviour, their reactions, their mental representations, their desires expressed or not. Sensory evaluation plays a remarkable role in the creation and formulation of new products to determine differences between products, optimizations, but also the potential impact of changing process on the final quality of the product. The issue of human evaluation is addressed in the analysis of customer's needs.

Based on research, we noticed that advertising is highly affected by the technological advances, especially in communication. In a society overwhelmed with images and trying to influence its members we must know to make the distinction between the different needs, we must make conscious decisions, not only based on emotion and senses that could deceive us. But we cannot help but notice the great impact that sensory marketing has in this consumerism society based on sensations. It is developing with impressive force that is alarming when triggers the impulse to work more in order to buy more.

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RESEARCHES ON DETERMINING THE WEAR OF CHISEL-TYPE ACTIVE PARTS IN HEAVY SOILS
/
CERCETARI PRIVIND DETERMINAREA UZURII UNOR ORGANE ACTIVE TIP DALTA IN SOLURI GRELE

PhD. Eng. Vlăduţ V.[1], Prof. PhD. Eng. Biriş S.[2], Assoc. Prof. PhD. Eng. Bungescu S.[3], PhD. Eng. Marin E.[1], PhD. Sud. Eng. Persu C.[1], Eng. Grigore I.[1], Lect. PhD. Eng. Ungureanu N.[2], PhD. Sud. Eng. Gheorghe G.[1], PhD. Eng. Voicea I.[1], Assoc. Prof. PhD. Eng. Ilea R.[3], Lect. PhD. Eng. Hărmănescu M.[3], PhD. Stud. Eng. Cujbescu D.[1], Eng. Bolintineanu Gh.[1], Eng. Dumitru I.[4], Eng. Caba I.L.[5]
[1]INMA Bucharest / Romania; [2]P.U. Bucharest / Romania; [3]USAMVB Timişoara / Romania;
[4]Power Group International S.R.L. / Romania; [5]S.C. Munax S.R.L. / Romania
E-mail: valentin_vladut@yahoo.com

Keywords: *soil, part, wear, traction force, equipment*

ABSTRACT
This paper presents the results of experimental researches obtained using a conservative soil tillage – mixed type, after performing deep loosening, analysing the influence of friction (wear) between soil and the chisel-type active part.

REZUMAT
Lucrarea prezintă rezultatele cercetărilor experimentale obţinute cu un echipament de prelucrare conservativă a solului – tip combinator, după executarea operaţiei de afânare adâncă, analizându-se influenţa frecării (uzura) dintre sol şi organul activ tip daltă.

INTRODUCTION
Conservative soil tillage is an alternative solution to the classical soil tillage method by plowing, followed by harrowing or other operations leading to soil being properly grinded for seeding.

Taking into account the lack of rainfall in recent years and therefore a shortage of water in soil, the use of tillage methods that would not overturn the furrow and would maintain the amount of water in the soil, which is small enough anyway, has become a must.

Under these circumstances, the use of soil conservative tillage equipment, also performing grinding in a single pass, has become widespread, the mixed-type equipment having active parts of notched discs, chisel and leveller type.

Such soil tillage equipment in conservative system is made as a complex aggregate consisting of 4 modules having different active parts, mounted one after the other so that several operations are performed in a single pass finally leading to quality tillage of soil. For each of these modules the qualitative work indexes will be determined.

Module 1 consists of notched discs battery, mounted in front of the equipment on curved elastic supports (Fig. 1), performing a first soil grinding and crop residues chopping.

Fig. 1 - Notched discs battery mounted on elastic supports

Module 2 consists of two rows of chisel-type active parts, the front one (behind the disc battery) with distanced supports, the second one having its parts placed in line, (fig. 2), performing a deep tillage (breaking soil structure).

Fig. 2 - Chisel-type active parts

Module 3 consists in a battery of discs mounted two by two, in V shape (fig. 3), so that soil grinding and levelling following chisel-type active parts pass would be performed.

Fig. 3 - Battery of notched discs mounted in V shape, two by two (in the back)

Module 4 consists in a leveller (fig. 4), which is designed to ensure lumps (small size) grinding and soil levelling, so as to finally obtain well tilled soil, grinded and levelled for seeding.

Fig. 4 - Leveller

Chisel-type active parts undergo increased wear due to the shape that gets in contact with the soil directly.

MATERIAL AND METHOD

In the experiments an experimental model of technical equipment for soil conservative tillage – a mixed cultivator was used, designed to obtain a double working layer: one superficial, operating a mix of residues and soil (fig. 5), as well as a deeper layer, by scarifying action. It is of semi-mounted type and works in aggregate with 330-550 HP tractors.

The equipment is made of: chassis consisting of a central frame with tow hitch, two lateral frames, left and right, where are mounted working parts of chisel knife type, with extension, and a transport train; two front modules having mounted on them the operating elements of notched disc type, individually mounted on elastic supports in "C" shape; two back modules having mounted on them a levelling notched disc bar with adjusting tilting and a roller with steel rings and hydraulic installation for adjusting tow hitch height, vertical folding of lateral frames in transport position and frontal discs working depth.

Fig. 5 - Soil tillage equipment in conservative system

Chisel-type active part had been previously analysed using complete elements method (fig. 6 and 7), determining the hydrostatic pressure on the part surface.

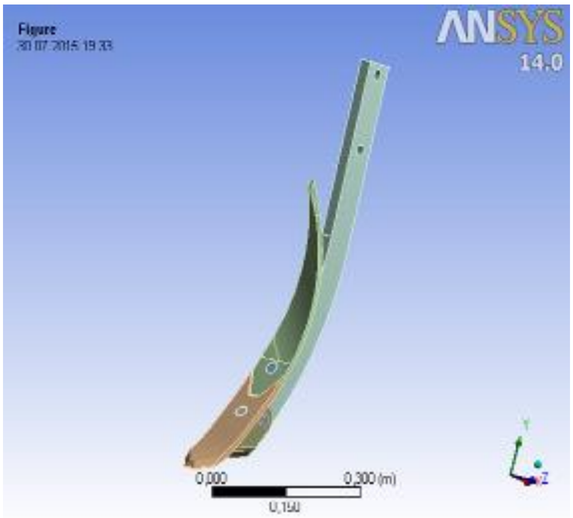

Fig. 6. Geometric model of analysed working part

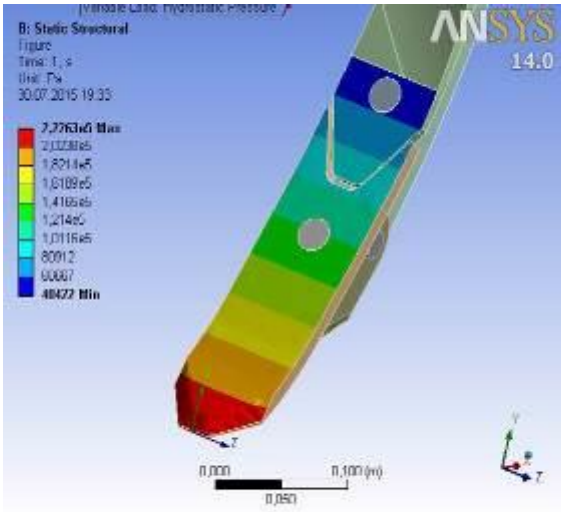

Fig. 7 - Hydrostatic pressure on part surface

The experiments for determining chisel-type active parts wear were carried out in Costeiu, Valea Lunga Romana village, Timis County, on 86 ha field (fig. 8). There, the wear of chisel-type active parts (the control ones on the equipment, respectively those hardened by different methods) was followed.

Fig. 8 - Field used for experiments

Experiments with the equipment for preparing the seedbed in conservative system were made on a scarified (after 20 years) field; the lumps resulted from the scarification process were very big and hard (fig. 9).

Fig. 9 - Soil tillage equipment in conservative system during experiments

RESULTS

For the chisel-type active part of the equipment the wear resulted from its friction with the soil (table 1) was followed, for the part mounted on the equipment (control), respectively for 4 variants of parts hardened through different methods, the final goal being to identify a method allowing to increase resistance to wear and thus to increase the life of chisel-type active parts.

Wear was established by measuring active part (chisel) weight before starting the experiments and after completing them, namely after the 86 ha field was tilled using the equipment.

Table 1

Wear of hardened active parts, after 86 ha field tillage
(Costeiu, Valea Lungă Romană village, Timiş County)

Type of chisels and hardening		Mass before working, [g]		Mass after working, [g]		Wear, [%]
1M	Chisels hardened by MAG method using SK ABRA MAX O flux cored wire as brazing filler	1656.92		1573.54		5,03222847
2M		1695.17		1604.72		5,33574804
1W	Chisels hardened by WIG method using tungsten carbide composite rods as brazing fillers	1610.43		1439.47		10,6157983
2W		1628.27		1427.30		12,3425476

1H	Chisels hardened by using BWG Abraguard 55 alloy tips and consolidated by welding adjacent areas (a buffer layer with E307(18/8/6) electrode and two layers of Postalloy 2832-SPL wire added upon)	1609.48		1435.60		10,8034893
2H		1628.99		1439.18		11,6520052
1E	Chisels hardened by electrode experimentally coated with tungsten carbide, of SUDOTIM AS brand.	1646.11		1420.67		13,6953181
2E		1633.37		1423.56		12,8452218
Control	Chisel of 30MnCrB5	1902.05		1748.08		8,09495019

CONCLUSIONS

The experimental researches were aimed at identifying a hardening solution for chisel-type active parts so that they can be used for a longer period of time in soil tillage (higher resistance to wear).

Analysing the results obtained in the case of the four active part types, hardened by different methods, compared to the control part on the equipment, in hard working conditions, in a very difficult field, we can see that the lowest wear was registered for active parts (chisels) hardened by MAG method using SK ABRA MAX O flux cored wire as brazing filler, approx. 5% compared to 8% for the control part.

This hardening method can be a solution taking into account that it is not expensive and the application technology is relatively simple.

ACKNOWLEDGEMENT

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A NEW DESIGN CONCEPT: BENCH FOR DAILY ACTIVITIES
/
UN NOU DESIGN CONCEPT: BANCA PENTRU ACTIVITATILE ZILNICE

Lect. Ph.D. Eng. AVRAMESCU A.-M.[1)], Lect. Ph.D. Eng. DOBRE C.-G.[2)]
[1)] University Polytechnic Bucharest, Faculty of Aerospace Engineering / Romania
[2)] University Polytechnic Bucharest, Faculty of Mechanical Engineering and Mechatronics / Romania
Tel: 0724594846; E-mail: avr_ana@yahoo.com

Keywords: *design project, CAD models, bench for daily activities*

ABSTRACT

This paper has the objective to propose a new Eco-design project and also to introduce the design project of an innovative product in order to improve the use of eco-design for daily activities. Because of the innovative nature of the project, a first study to assess the subject of the project is to be done. So, we focused our project on the activities of design. Before starting the design project, it is essential to propose a planning for every stage of the project from defining the needs to the CAD models. This planning takes place via Gantt chart to represent the different stages of the design process to do with the needed time. The first stage consists in defining the users' needs of the product. This could be realized by collecting the maximum of information to get a vision about the project. So, we made a survey for the users' bench. The next stage is the functional analysis to define the functions of the future product by analysing the different life cycle situations of the product. After that, the phase of creativity is started to find solutions by the design team and a choice of final solution is made. Finally, the final solution is described and evaluated using the predefined specifications document. Based on this evaluation, several modifications are imported to the design.

REZUMAT

Lucrarea de faţă are ca scop propunerea unui proiect Eco-design, precum şi prezentarea proiectului de design al unui produs inovator care să îmbunătăţească utilizarea eco-design-ului în activităţile de zi cu zi. Datorită naturii inovatoare a acestui proiect, este necesar un prim studiu care să precizeze subiectul proiectului. Astfel, ne-am centrat proiectul pe activităţile de design. Înainte de a începe design-ul proiectului, este esenţială planificarea fiecărui stadiu al acestuia, de la definirea nevoilor la modelele CAD. Planificarea se realizează prin intermediul graficului Gantt, pentru reprezentarea diferitelor stadii ale procesului de design. Primul stadiu constă în definirea nevoilor utilizatorilor produsului. Acest lucru se poate face prin colectarea unui număr maxim de informaţii, pentru a obţine o viziune asupra proiectului. Prin urmare, am realizat un chestionar în acest sens. Al doilea stadiu este analiza funcţională pentru definirea funcţiilor viitorului produs, analizându-se diversele situaţii ce pot interveni în ciclul de viaţă al acestuia. Apoi urmează faza de creativitate, demarată în vederea găsirii de soluţii de către echipa de design, urmând să se adopte o soluţie finală. In cele din urmă, soluţia finală este descrisă şi evaluată pe baza specificaţiilor predefinite. Prin această evaluare design-ului i se aduc mai multe modificări.

INTRODUCTION

Eco-urbanism is a new approach to urban planning that is taking into account many restrictions (restraints and indicators) imposing the urban development on the environment. The adjustment degree of eco-friendly urban design is to be seen in every stage of urban planning [4, 7, 9].

Such decisions environment-conscious will lead to a sustainable city in this new information era. The sustainable city model is outlined by the morphology and its complexity [13, 15]. In this model, the city has a core based on different kind of knowledge and technology, maintaining the urban metabolism and the social cohesion [1, 6].

The products developed for performance and for a preferential life cycle are monitored through behaviour analysis within the range of an established period of time and are corrected via feedback in the project stages [13]. The eco-design is meant to deliver eco-friendly products [3, 9, 10].

Ecologically, the assessment of the quality of a product is based on the volume of the damages to the environment during the entire life cycle [11]. The assessment of the damages is a complex procedure that could extend production time and cost [2, 6, 14].

The eco-friendly project consist in different ways of action: the development of a methodology in order to assess the ecological impact; investigating, analysing and synthesizing the implementing procedures of the eco-friendly aspects in order to obtain higher performance in developing the product [1, 2, 6]. For higher eco-friendly performance of the eco-designed products there are used several methodologies, instruments and software, that are created based on the industrial eco-design.

Eco-friendly designing

The term *urban furniture* is used for items and equipment in the public space, installed for different purposes [5, 8, 12]. Urban furniture means benches, street lights, playgrounds, platforms, curb-stones, pavement endings, traffic lights, road signs, bus stations, tram stations, taxi stations, fountains, public statues, traffic barriers and trash cans [17].

The street lights, for example – in order to have spaces to be used during the night time the solution was to lighten them. The public spaces poorly lit are the most dangerous ones, because it is the place of the most crimes. The lighting could be general lighting or accent lighting. The general lighting is obtained in most cases using tall lighting pillars, uniformly distributed in the public space. Their height is determined by the height of the constructions around [16, 17].

The defining elements of a public space must be outlined with accent lighting. To outline an item, the lighting must be placed very near. The most important elements of a public space are: the main building, the statue or the fountain in the square, an ensemble of buildings, vegetation, and urban furniture [12, 16].

MATERIAL AND METHOD

The paper is envisioning designing a concept for the Coltea park. The project is a bench with a lighting frame (figure 1). The purpose was to maintain the main theme of the park, therefore the design being very suggestive, inspired by the musical note of "two fourths".

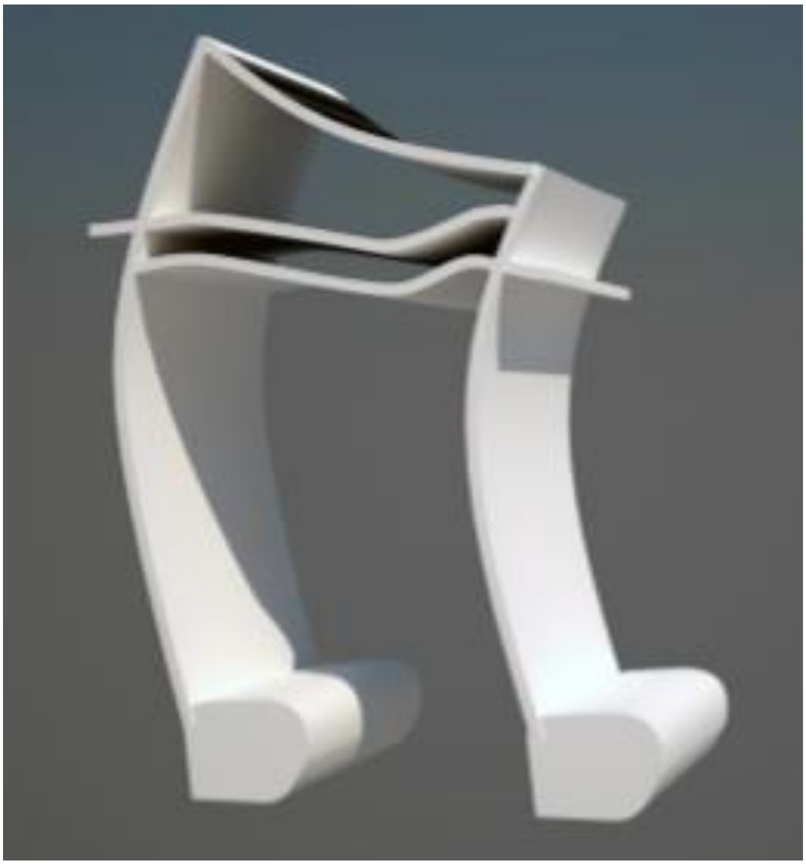

Fig.1 – Side view of the piece

The material of this kind of furniture is recyclable plastic, very hard and resistant. This kind of furniture is meant for different purposes (figure 2). The round shape at its base serves as bench, the upper part is a pergola and the other side is open to the park.

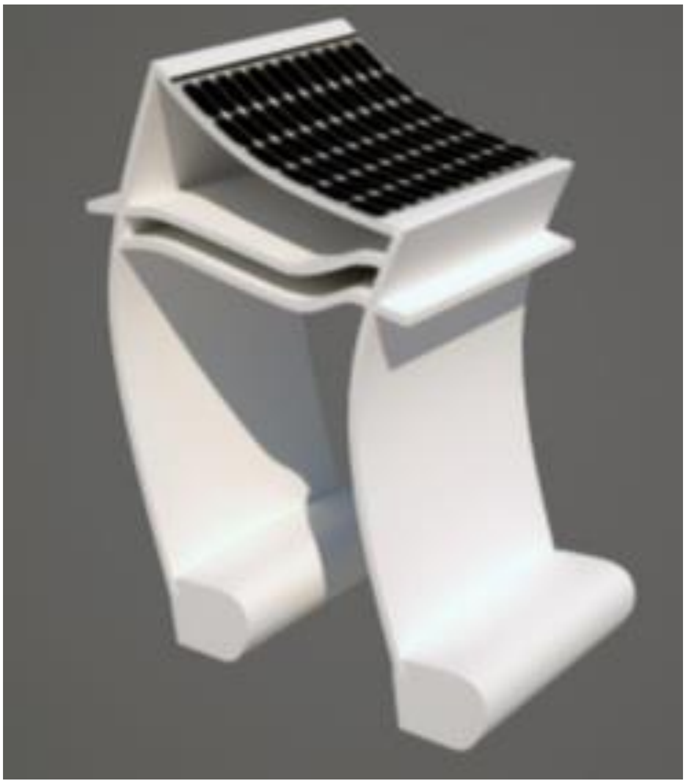

Fig.2 - Side view of the piece

The upper part consists in a solar panel in order to recharge the battery of a phone at the base. The exterior ends have also a lighting purpose at a height of 250 cm.

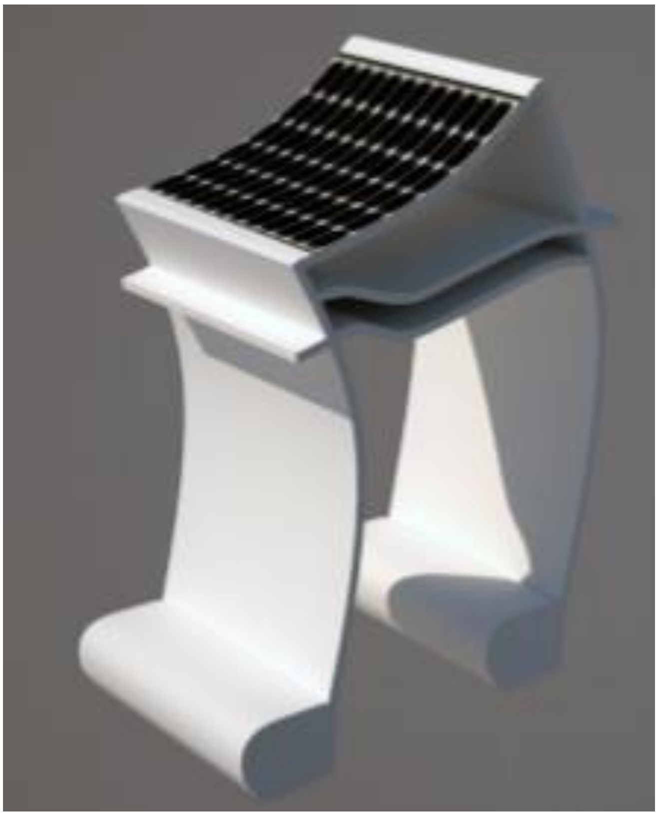

Fig.3 - Side view of the piece

The bench is 120 cm tall, with a width of 55 cm. The distance between the two benches is 150 cm (figure 3). The product is waterproof, easy to clean, flexible to design options, sustainable, better than wood, except the wood composite, and it's easy to paint and repair.

RESULTS

The recycled plastic products are very sustainable and need minimum maintenance. Moreover, these products can be re-recycled at the end of their life cycle (figure 4).

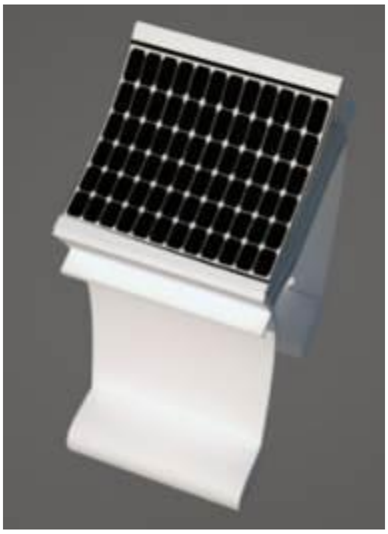

Fig.4 – View from above of the public bench concept

These materials are completely inert, presenting no leaks of chemicals in waters or soil, even in humid environments. The purchase of recycled plastic products stimulates the demand collected for recycling, materials that are saved from the landfill. Instead of being painted, the material is restored only where it presents tiny scratches (figure 5). These interventions do not diminish the product visually.

Fig.5 – Side view of the ensemble

Fig.6 – View of the ensemble with lighting

The light is essential for our wellbeing. A good lighting could transform for the better a room, a building, an item. Depending on the activities that are taking place in a certain space, we would need a direct lighting but also an indirect or diffuse lighting (figure 6). Our product totally respects the consumer's needs as the major component of the development process, strictly connected to the conception of a product, the selection of the best quality/price ratio, the testing of technical and aesthetic performance and also the competitive promotion on the market.

CONCLUSIONS

The innovation concept serves to design, develop and manufacture new products. These new products will have to be able to combine functionality, sensible fabrication methods, use of natural materials and an interface attractive and useful at the same time.

The developing of new products is an important, but risky activity. Usefulness means to meet certain physical and biological human needs at the level of performance for which the product has been conceived. Our product is no exception. Therefore, the ensemble has a usefulness based on the general human needs: to artificially create a good environment for different activities. From the usefulness we get to the end use of the product.

The ensemble is for large, crowded spaces, and without the natural light is the perfect product for those who are out after dark. As any new product, it must replace an old one. As such, an essential criterion is to introducing a new feature for the user's benefit or to enhance the technical performance of the previous product. Our product totally fulfils that request. Another important aspect is that the product must be innovative and attractive.

To develop a new concept is never an easy or direct activity; it requests careful research, right planning, and deep control. Therefore, it is a multidisciplinary approach, with methods form marketing, engineering and industrial design. Combining social sciences, technology and practical arts is never easy, but mandatory in order to meet the demand.

No matter the product, it must be very careful designed in order to be efficient. It must be comfortable, inexpensive, easy to use or repair, simple, economical, ready to be manufactured and distributed in order to have a powerful advantage on a competitive market.

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ECO-DESIGN – THE PERFECT BALANCE OF ESHETICS, ERGONOMY AND ECO-DESIGN
/
PROIECTARE ECOLOGICĂ – ECHILIBRUL PERFECT ÎNTRE ESTETICĂ, ERGONOMIE ŞI ECO-DESIGN

Lect. Ph.D. Eng. AVRAMESCU A.-M.[1)], Lect. Ph.D. Eng. DOBRE C.-G.[2)]
[1)] University Polytechnic Bucharest, Faculty of Aerospace Engineering / Romania
[2)] University Polytechnic Bucharest, Faculty of Mechanical Engineering and Mechatronics / Romania
Tel: 0724594846; E-mail: avr_ana@yahoo.com

Keywords: *eco, design, environment*

ABSTRACT

The paper analyses the eco-design as a means for growth and innovation of a conceptual tool with a great impact upon the environment. The applicability is to study the development of eco-design strongly related to the environment we live in and the balance of aesthetics, economy, ecology and usefulness. As a concept, eco-design is a large topic and a priority for every advanced country. The project in this paper is based upon technical, economic, aesthetic and social criteria.

REZUMAT

Lucrarea de faţă are ca temă Eco-designul, un mijloc de creştere şi inovaţie ca un instrument conceptual, care are un impact foarte mare asupra mediului înconjurător. Obiectul de studiu aplicat va fi dezvoltarea proiectării ecologice în strânsă legătură cu mediul în care trăim şi echilibrul dintre estetică, economie, ecologie şi utilitate. Conceptul de „Eco-design" este un subiect de mare anvergură, tratat cu prioritate în toate ţările dezvoltate. Proiectul propus are la bază criterii tehnice, de piaţă, economice, estetice şi sociale.

INTRODUCTION

Everything surrounding us is a form of eco-design a way or another. In time, this science harmoniously developed, combining the multifunctional features of products, services and systems with their aesthetics. Now, the design is able to usefully harness the ecology [6, 11, 14].

The environment is an integrative part of every development process and consists in connections and relationships between people and natural resources. Therefore, the environment changes are not only natural, but also the effect of the practical manifesting of different development patterns, practices and lifestyles. Conversely, any change in the physical environment has important socio-economic consequences that are influencing the quality of life [2, 9, 13, 16].

ECO – composition particle meaning „house", „environment", „ambiance" [fr. éco-, it. eco-, cf. gr. oikos]. DESIGN – Domain targeting to harmonize the human environment, from creating common items to urbanism and landscaping. Based on this DEX definition, we could define eco-design as a harmonization and an improvement of the environment we live in.

Eco-design could also mean a balanced approach of art and science, a thorough consideration of the environment in order to enhance our way of living. For a better understanding of these two concepts, we must define first: the eco concept comes from the scientific branch of ecology meaning the environment study in order to enhance our way of living (from the Greek *oikos* – house, and *logos* – to study) [3,12, 15, 16].

In other words, the term defines the science that studies the „domestication of nature", regarding the way individuals, including the human being, are living together. Ecology is a young science, continually evolving. It is based on a system theory (systemic ecology). The environment is a system having subsystems having also subsystems and so on. (e.g.: the wood is a system, the ants in the wood is a system, an ant-hill is a system, an ant is a system). All systems, subsystems, components and elements of the environment are interconnected and interrelating with each other. Influencing a system means influencing all systems / subsystems [1, 4, 7, 12, 14].

The design is a creative activity with the purpose of creating objects, processes, services and systems with multifunctional features all along the life cycle of a product. Therefore, design is the main factor of innovative humanization of technologies and an important factor of the cultural and economic exchanges. In the 21st century, the worldwide practices of civilized countries have the concept and the study of design as mandatory discipline in the educational system, because the design is the discipline that introduces us to the concepts of beauty and good in the objective world [5]. The eco-design concept consist in integrating the environment in the design stage of a product, taking into consideration the entire life cycle of that product, from purchasing raw material to dumping the product to the trash [8]. Eco means economy and ecology at the same time. Based on a good design process, eco is a concept that targets reducing the damaging impact of a product upon the environment. Implementing the concept of eco-design is a necessity with the main purpose of designing the entire life cycle of a product based on the ecological needs [2, 6, 10, 14, 16].

Eco-design could also mean a new configuration of products, taking into account the environment, but also the costs. Eco-designed products must meet certain criteria, such as: recycling, low consuming of materials and energy, sustainability, non-toxicity, optimal benefits for the customer, using local resources [2, 6, 8, 15]. With eco-design, the whole development of a product – from manufacturing to the end of the life cycle – is kept under observation in order to find the most suitable and environment-compatible solutions.

The stages of eco-design

The designers of products and processes have to make sure that all aspects leading to meeting the customers' needs are highly developed in terms of functional performance, economical profitability, technical viability and also environmental impact [7, 9].

The purpose of eco-design in the frame of sustainable designing is to diminish the impact of the products and processes upon the environment all along the life cycle, plus maximum of profit, performance and quality. Sustainable design means taking into account the economic and environmental aspects, but also the social and ethical consequences [10, 15, 16].

The main stages of the designing process are: analysing / planning / defining the tasks, concept designing, integrated designing, detailed designing, prototype / testing and launching on the market. These are very well defined stages of the classical production algorithm, completed with the ecological aspects, based on specific methodologies and tools [4, 7, 9].

In the first stage of analysing / planning / defining the tasks we assess the actual and future situations, identify the main objective and its specifics, with care for the ecological and social aspects in order to list the requirements of the future product. In that stage the ecological functions must be defined and developed [9, 13].

Eco-design is based on different components synthesized lately as X Complex Design (E – environment, M – manufacturing, A – assembling, D – dissembling, R – recycling, S – service, LC – life cycle etc.) [11, 16]. Eco-design is a process that differs from the traditional designing in the ecological aspects considered in order to preserve and reuse the natural resources, optimize the energy consumption and the use of raw material, minimize the waste and totally remove the damages imposed on environment during the product life cycle [5, 7, 13].

MATERIAL AND METHOD

The space we live in and use every day for different activities must be protected. The importance of the public space becomes grater if we take into account the ecological benefits of a healthy environment due to plants and vegetation. A public space could have a number of roles: aesthetic, psychological, symbolic, ecological, and social. Our project is for a very crowded and phonically aggressed space: Coltea Park (figure 1).

Fig.1 – Front view of Coltea Park

Renowned for the cultural and musical events that are taking place here, Coltea Park has as a symbol a „broken" violin (figure 2). An ecological approach for the public space design is not a new one, but a very important one for the future of our city. Located in University Square, Coltea Park is a popular place as a concert venue. Coltea Hospital could be seen in the background.

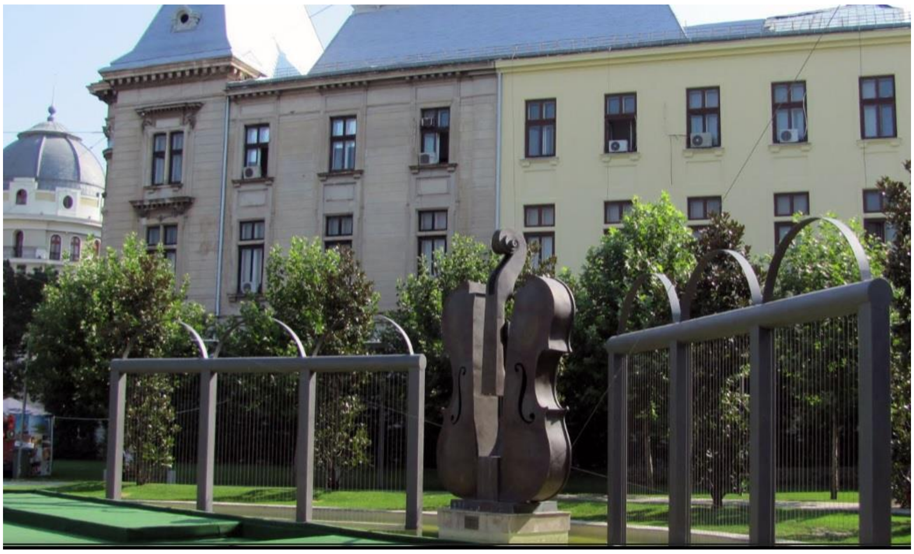

Fig.2 – Present view of the park

The most important step for accomplishing this project is about materials. The main features of eco-materials outline a longer lifespan of a product, a better use and the diminishing of waste. The main purpose is to apply an eco-process that is profitable and uses the recycled wood as raw material for high quality items of urban furniture.

RESULTS

The new concept we present here is a furniture ensemble with two shapes, figure 3. When closed is representing a bench for two, when opened is representing a table for five.

Fig.3 – View from above of the public bench concept

This design meets the public needs as the park is a place where young students gather and that could be used for cultural, social and artistic activities.

The product is made with wood from recyclable ecological resources. It is easy to clean and very resistant. This type of wood is a unique combination of aesthetics and natural but also of sustainability and flexibility. It is highly resistant in a humid or sunny climate, but also to big temperature gaps, figure 4.


Fig.4 – Side view of the ensemble

The profiles have a polished appearance just like the natural wood (figure 5). Because of its structure and composition, the composite wood is not releasing toxic gas or leaching dangerous chemicals in the environment. The composite wood comes from a recycled material and could be 100 percent recycled after use. Having a good resistance, the composite wood is saving natural wood that has a shorter lifespan.

Fig.5 – Side view of the ensemble

Chair / table diameter is 140 cm and each chair is 45 cm long. The backrest is 80 cm and the axis 60 cm. The gliding stands are 70 cm each from the axis to the chair. The table is supported by a metallic structure for gathering the chairs when the ensemble is closed (figure 6). Also, each chair has a gliding stand that connects it to the table. Therefore, the chairs cannot be moved.

Fig.6 – View of the opened ensemble

The shapes are inspired from the shape of a trumpet in order to respect the theme of the park. In making the ensemble, the priority was meeting the needs of the public space. Near the park are the University building, the National Theatre and Coltea Hospital. Therefore, the park could be a meeting place for the public frequenting the area or passing by, but also a place for artistic events during the summer time (figure 7 and figure 8).

Fig.7 – Closed ensemble – suggestion of presentation

Fig.8 – Open ensemble – suggestion of presentation

CONCLUSIONS

The paper presents the conceptual process of implementing modern technologies in order to improve the performances of a product and obtain a modern design using eco-materials for aesthetic purposes.

In time, the materials industry has become increasingly interested in environment and product life cycle having the objective to develop an ecological attitude in consumers.

Supporting the use of eco-materials in creating different products, the industry is establishing the foundation for an efficient mechanism leading to a recycling attitude and recycled products.

Because of the new user experience with eco-design, the industry is increasingly interested in environment issues and toward creating the eco-awareness in consumers.

These are important steps toward a sustainable development creating positive effects for every part involved in the process. Eco-materials are a challenge for designers, executives, techs but also for users.

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THERMO-MECHANICAL TREATMENT PROCESS OF AlZn5Mg3Cu ALLOY AND OPTIMIZATION OF TECHNOLOGICAL PARAMETERS
/
PROCESUL DE TRATAMENT TERMOMECANIC AL ALIAJULUI AlZn5Mg3Cu ŞI OPTIMIZAREA PARAMETRILOR TEHNOLOGICI

Conf. PhD.Eng. Pandia O.[1)], Prof. PhD.Habil.Saracin I.[2)], Lect.PhD. Eng. Neacsu M.[3)], Ph.D. Eng. Ganea –Christu I.[4)], PhD. Eng. Rădulescu D.L.[1)]
University of Agricultural Sciences and Veterinary Medicine Bucharest, Romania [1)], University of Craiova, Faculty of Agriculture, Romania.[2)] University of Dunarea de Jos, Galati [3)], INMA Bucharest[4)]
Tel: 0745762957; E-mail: olimpia_pandia@yahoo.com

Keywords: optimization, aluminium alloy, thermo-mechanical treatments.

ABSTRACT
The paper presents the results of experimental researches aimed to optimize the thermo-mechanical treatment process applied to AlZn5Mg3Cu alloy used in aviation industry. The optimal solution is determined by finding some values of independent variables, so that to obtain the best value for objective-function. Objective function in the case of optimizing thermo-mechanical treatment regime studied is represented by the energy consumption "Q = f(t, τ, ε)" under certain restrictions regarding mechanical properties values researched. Researches were based on an experimental program of thermo-mechanical processing applied to aluminum alloy studied in order to obtain the required values of mechanical properties with minimal cost.

REZUMAT
Lucrarea prezintă rezultatele cercetărilor experimentale în vederea optimizării procesului de tratament termomecanic care a fost aplicat aliajuluiAlZn5Mg3Cu utilizat în industria aeronautică. Determinarea soluţiei optime se face prin aflarea unor valori ale variabilelor independente, astfel încât să se obţină cea mai bună valoare pentru funcţia – obiectiv. Funcţia obiectiv în cazul optimizării regimului de tratament termomecanic cercetat o reprezintă consumul de energie "Q = f(t, τ, ε)" ţinând cont de anumite restricţii în ceea ce priveşte valorile proprietăţilor mecanice cercetate. Cercetarile au la baza un laborios program experimental de procesare termomecanică aplicat aliajului de aluminiu studiat pentru obţinerea unor valori impuse ale proprietăţilor mecanice cu cheltuieli minime.

INTRODUCTION

The alloy studied is part of the system AlZnMgCu, series 7000. Due to their superior mechanical characteristics obtained through thermal and / or thermo mechanical processing, this alloy is used with very good results in the aviation industry and machinery industry. These mechanical characteristics are obtained by controlling the precipitation hardening process [7, 5].

Thermo mechanical processing for AlZnMgCu alloys involves a combination of plastic deformation and artificial aging. Cold flow deformation accelerates and intensifies the age-hardening process. This acceleration is closely related to the degree of plastic deformation. The experimental data presented in the literature have revealed that the acceleration of the precipitation process is mainly determined by an accumulation of dislocations up to oversaturation during plastic deformation. This increases the efficiency of diffusion phenomena in artificial aging, subsequent to plastic deformation [1, 3].

By using modern techniques of investigating materials such as atomic probe, tomography researchers systematically managed to see the microstructure of the precipitates resulted (obtained) after applying some regimes of heat treatment (aging or artificial re-aging) and thermo mechanical treatments for AlZnMgCu alloys.

The parameters of the thermo mechanical treatment regime influence the achievement and evolution mechanisms of the precipitates during the recovery and re-aging stages [6].

The AlZn5Mg3Cu alloy is deformable and hardenable and after the application of some heat treatment and / or thermo mechanical treatments, the mechanical characteristics values obtained recommend it to be used in the aviation industry. The technical and economic performances of a metallurgical process depend on the process parameters and on the conditions and mode of operating of the system as a whole. [4].

Determining the optimal solution is made by determining the values of the independent variables so as to obtain the best value for the objective -function (the optimized function). In the case of optimizing the thermo mechanical processing parameters of the alloy studied, the objective function is represented by the consumption of energy *"Q = f (T, τ, ε)"*, where *T* and *τ* are the temperature, respectively the time for the final artificial aging, in this case, and *ε* is the degree of plastic deformation, given the restrictions on the values of the mechanical properties investigated.

In this work, the mathematical model is given by the equations for calculating the energy *Q* consumed with heat treatment furnace and the mini rolling mill where the plastic deformation of the studied alloy samples was performed.

The model equations express the relationships between the process parameters and are deducted either by theoretical analysis or based on experimental observations (empirical) [8].

MATERIAL AND METHOD

The materials for experimental research are samples made of AlZn5Mg3Cu aluminium alloy whose chemical composition is shown in Table 1, and which fall within the requirements of EN 573-3-2013.

Table 1

Chemical composition of the AlZn5Mg3Cu alloy researched / mas. %

Element / Alloy	Zn	Mg	Cu	Si	Fe	Cr	Mn	Al
AlZn5Mg3Cu	5	3	0,75	0,5	0,5	0,2	0,25	remainder

According to EN 485-2-2013[10] after thermo mechanical processing, the values obtained for the main mechanical characteristics must be at least equal to those shown in Table 2.

Table 2

Mechanical properties of AlZn5Mg3Cu alloy

Property / Alloy	Rm / [MPa]	$Rp_{0,2}$ / [MPa]	A_5/ [%]	HB
AlZn5Mg3Cu	450	370	8	133

Figure 1 schematically shows the thermo mechanical processing that the samples studied have undergone.

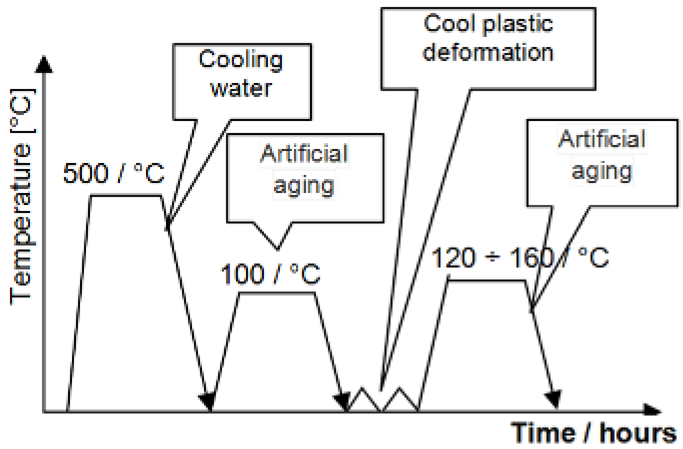

Fig 1 - Schematic representation of thermo -mechanical processing

The thermo mechanical processing consisted of the following technology sequences:

- solution quenching at 500 °C for 2 hours;
- preliminary artificial aging at a temperature of 100 °C for 1 hour to stabilize the structure of the material;
- cold plastic deformation with three degrees of deformation ε_1 = 10%, ε_2 = 20% and ε_3 = 30% to achieve the set dimensions;

- after having performed these deformations, a final artificial aging heat treatment is made at the following temperatures: T_1 = 120 °C, T_2 = 140 °C, T_3 = 160 °C with the holding time: τ_1 = 8 hour, τ_2 = 12 hour, τ_3 = 16 hour for each temperature.

At the end of thermo-mechanical processing, the samples dimensions are: length *L = 200 / mm, width l = 60 / mm, thickness h = 5 / mm.*

RESULTS

After the thermo mechanical treatment, the samples were subjected to mechanical tests, after which the values of the R_m, $R_{p0.2}$, A_5, HB properties were determined as shown in Tables 3. The values listed in the Tables represent the average of 5 measurements.

Table 3

The values of the mechanical properties after applying thermo-mechanical treatment with high plastic deformation degree ε = 10 / %

The time for the artificial aging / hours	Artificial aging temperature / °C											
	120				140				160			
	Rm / MPa	Rp02 / MPa	HB	A5 / %	Rm / MPa	Rp02 / MPa	HB	A5 / %	Rm / MPa	Rp02 / MPa	HB	A5 / %
8	402	316	123	9.2	394	318	118	10	364	305	115	10.4
12	424	345	131	8.8	412	329	129	9.7	380	325	121	10.3
16	461	371	148	8.6	441	367	137	9.1	394	341	132	9.5

Table 4

The values of the mechanical properties after applying thermo-mechanical treatment with high plastic deformation degree ε = 20 / %

The time for the artificial aging /hours	Artificial aging temperature / °C											
	120				140				160			
	Rm / MPa	Rp02 / MPa	HB	A5 / %	Rm / MPa	Rp02 / MPa	HB	A5 / %	Rm / MPa	Rp02 / MPa	HB	A5 / %
8	466	429	134	8,6	433	391	130	9	426	374	119	9.2
12	481	436	147	8	462	398	143	8.7	456	385	135	9
16	492	453	159	7.6	477	416	153	8.2	465	403	142	8.5

Table 5

The values of the mechanical properties after applying thermo mechanical treatment with high plastic deformation degree ε = 30 / %

The time for the artificial aging /hours	Artificial aging temperature / °C											
	120				140				160			
	Rm / MPa	Rp02 / MPa	HB	A5 / %	Rm / MPa	Rp02 / MPa	HB	A5 / %	Rm / MPa	Rp02 / MPa	HB	A5 / %
8	485	430	153	8.3	454	392	141	8.6	429	363	132	8.7
12	498	450	164	8.1	473	420	154	8.4	462	385	144	8.5
16	523	465	170	8.0	505	440	162	8.1	484	417	155	8.3

Thermo mechanical processing researched revealed that not for all combinations of processing thermo mechanical parameters considered (time, temperature, degree of plastic deformation) were obtained the values of mechanical properties studied that fit the requirements of specific norms in force.

AS the mechanical properties were considered as depending on the three parameters of the thermo mechanical treatment regime, the mechanic features were considered as depending on three variables of thermo-mechanic treatment, namely: $R_m = R_m (T, \tau, \varepsilon)$, $R_{p0.2} = R_{p0.2} (T, \tau, \varepsilon)$ $A_5 = A_5 (T, \tau, \varepsilon)$, HB = HB (T, τ, ε).

With the help of MATLAB software package was performed the functions interpolation with three variables, using a specific function namely *interp3.*

It was performed sequentially interpolation for all four mechanical characteristics studied based on the three parameters: T- artificial aging final temperature τ– artificial aging final time and ε - degree of cold plastic deformation preceding the final artificial aging.

Because aluminium alloys are "sensitive" to small variations of the temperature of the heat treatment, a variation of five by five degrees was set, resulting in a number of 9 interpolated values of temperature, between 120 / °C and 160 / °C.

Artificial aging time from 8 hours up to 16 hours has been discretized with one hour interval, resulting in 9 interpolation values.

For the degree of plastic deformation in the range of 10 /% - 30 /% was set of a number of 21 increasing values with 1 /% interval which was interpolated.

After interpolation, a volume of 1701 interpolated values for each property resulted.

Under these conditions, the thermo mechanical optimization process has meant in the first stage finding among these 1701, data corresponding to each property, only those which meet all the restrictions imposed by EN_485-2-2013, and in the second stage was calculated the energy consumption necessary for thermo -mechanical processing for all situations identified in the first stage and the selection of the variant for which the energy Q is minimal.

In order to calculate energy consumption as heat (thermal energy) was calculated total energy Q_{total}, consumed by heat treatment furnace in which is made the final artificial aging according to Figure 1 and at the rolling mill used for plastic deformation. These calculations were performed using the following relationship:

$$Q_{total} = Q_{total\ oven} + Q_{lam}, [2], \tag{1}$$

where: - $Q_{total\ oven}$ - the amount of heat necessary to attain and maintain the treatment temperature throughout performing the heat treatment

- Q_{lam} – the amount of energy consumed for rolling samples.

$$Q_{total\ oven} = Q_A + Q_B, \qquad [2], \tag{2}$$

Q_A – the amount of heat (energy) consumed during the furnace heating;

Q_B- the quantity of heat (energy) consumed in the maintaining the temperature of heat treatment during the whole treatment period;

$$Q_{lam} = U \cdot t_{lam} \cdot I \ / \ \text{kWh} \quad [2], \tag{3}$$

Q_{lam} – energy consumed for cold plastic deformation;
U –electric voltage of supply for rolling mill motor;
U = 380 / V;
τ_{lam} –rolling time of a sample / hours;
I – electrical current intensity used at rolling / A.

The program drafted in MATLAB by using the tool interp3 and heat balance equations (1), (2), (3), shows that for any value imposed of the total 1701, for any of the four properties, was obtained a number of possible variants which may be determined by optimum calculation in terms of the total energy consumption.

Based on these data (information) was carried out a graphical interface with the help of the program, graphical interface that allows viewing (simulation) of those possible situations and the choice of a large number of possible values for any of the four properties, as an example of such simulation in Fig. 2.

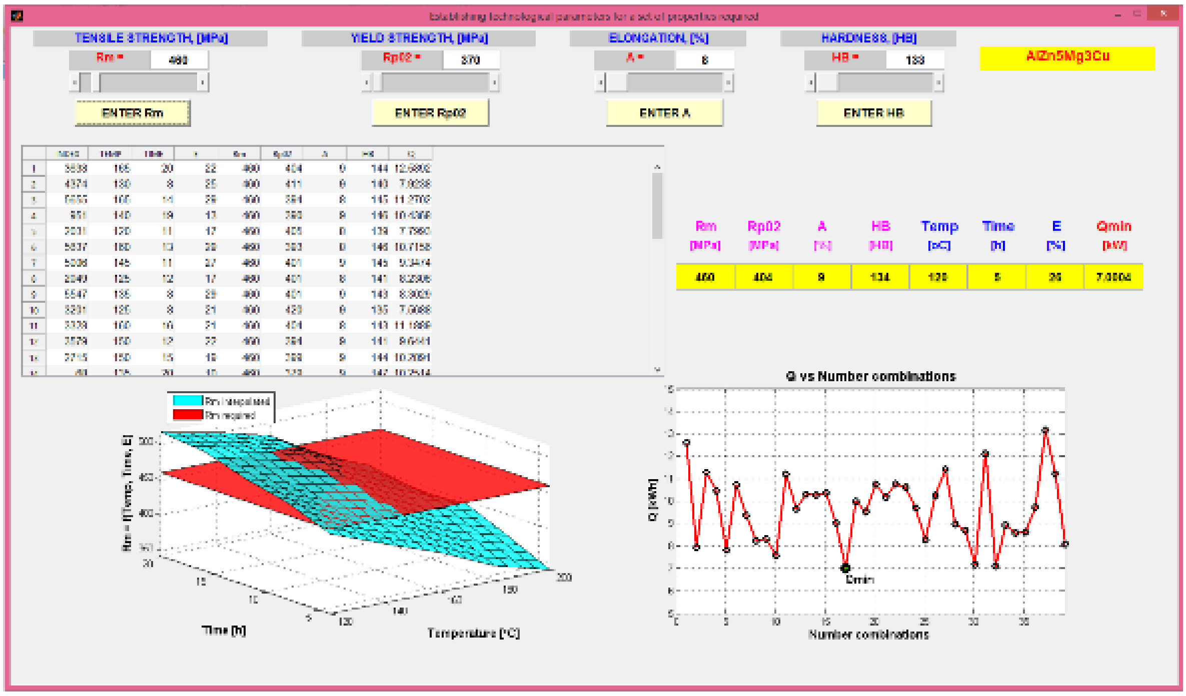

Fig. 2 - Values of thermo- mechanical treatment parameters to achieve R_m = 460 MPa

CONCLUSIONS

After conducting the research described in this paper, the following conclusions were drawn:

- the thermo- mechanical processing carried has highlighted the dependence of the level of resistance mechanical properties values on the degree of cold plastic deformation preceding the final artificial aging;
- the resistance mechanical properties values are directly proportional to the values of aging time and inversely proportional to the heat treatment temperature;
- the mechanical strength of the alloy processed has the highest values for artificial aging of 16 hours and a temperature of 120 ºC, and the lowest resistance values in this thermal processing are for the aging time of 8 hours and the temperature of 160ºC;
- the value of the alloy elongation at breaking is decreasing with increasing the final artificial time and final artificial aging temperature decreasing , as well as, with increasing plastic deformation degree;
- the graphic interface created using MATLAB enables simulation and identification based on mathematical calculation, of the minimum amount of Q_{total}, which means finding the optimum of the thermo- mechanical processing;
- with the help of the graphical interface, there can be distinguished, in tabular form, the values of the thermo- mechanical processing parameters for those situations where it is desired to obtain a particular value of one or more properties of the studied ones.

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AGRICULTURAL FEEDSTOCK CHARACTERIZATION USED IN BIOGAS PLANTS / *CARACTERIZAREA SUBSTRATULUI AGRICOL UTILIZAT ÎN INSTALAŢIILE DE BIOGAZ*

Lect. Ph.D. Eng. Dincă M.*[1], Assoc. Prof. PhD. Eng. Ferdeş M., Prof. Ph.D. Eng. Paraschiv G.[1], Prof. Ph.D. Eng. Voicu Gh.[1], Lect. Ph.D. Eng. Ungureanu N.[1], Lect. Ph.D. Eng. Ionescu M.[1], Lect. Ph.D. Eng. Muşuroi G.[1], As. Ph.D Stud. Eng. Zăbavă B.[1]
[1] University Politehnica of Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
Tel: 0761938017; E-mail: mirela_dilea@yahoo.com

Keywords: *agricultural feedstock, corn stalks, wheat straw, alfalfa*

ABSTRACT
Anaerobic digestion is a biochemical decomposition process that is used for the treatment and energy recovery from biomass, like organic residues, agricultural and industrial wastes, animal manure and energy crops. The paper presents results of experimental research on the physico-chemical characteristics of the agricultural biomass (corn stalks, wheat straw and alfalfa) that can be used in co-digestion with animal manure in biogas plants. Parameters with a significant role in the process of anaerobic fermentation were assessed: total soluble solids (TSS%), the pH, the moisture content as well as the reducing sugars in the liquid fraction of the tested substrate.

REZUMAT
Fermentaţia anaerobă este un proces biochimic de descompunere, utilizat pentru tratarea şi recuperarea de energie din biomasă, ca de exemplu reziduuri organice, deşeuri agricole şi industriale, dejecţii animaliere şi plante energetice. În lucrare sunt prezentate rezultatele unor cercetări experimentale privind caracteristicile fizico-chimice ale biomasei agricole (tulpini de porumb, paie de grâu şi lucernă) care poate fi utilizată ca substrat alături de dejecţiile animaliere în instalaţiile de producere a biogazului. Au fost evaluaţi parametri cu un rol important în procesul de descompunere anaerobă, şi anume: solide solubile totale (TSS%), pH-ul, conţinutul de umiditate şi zaharurile reducătoare.

INTRODUCTION
In the last period, the anaerobic fermentation of organic fraction has been recognized as a valuable method that can convert the substrate used into useful products such as biogas and digestate (*Khalid et al, 2011*).

The most commonly used substrate for biogas production by anaerobic fermentation process is the manure containing nutrients necessary for the growth of anaerobic microorganisms. However, due to the low concentration of total solids and a high concentration of ammonia present in the manure, it is a common practice to blend in various residues of crops and energy crops (*Regueiro et al, 2012*). The anaerobic digestion of agricultural wastes mixed with animal manure, in a co-digestion mode, can improve significantly the fermentation process and also the biogas production. The most important reason for using co-digestion of animal manure and agricultural biomass is the adjustment of the carbon and nutrient balance and also the quality and stability of the digestate (*Cestonaro et al, 2015; Parawira et al, 2004*). Moreover, agricultural wastes are a desirable material to co-digest with dairy manure because of its high biodegradability.

The final products of anaerobic fermentation process are the biogas that is a mixture of methane (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S), nitrogen (N), oxygen (O_2) and water vapors and the digestate that can be used as soil amendment (*Scano et al, 2014*). The biogas production resulted from the anaerobic fermentation of organic fraction is considerably influenced by the substrate composition (*Ahn H.K., 2010*). Even for the same species of the biomass used, its composition may vary according to geographical area, the season of harvest and the storage mode (*Templeton, D.W., 2009*). Thus, the characterization of substrate components used in anaerobic digestion process for obtaining biogas is very important to estimate the biogas production.

Lately, there were carried out a lot of experiments aiming determination of biogas production resulting from anaerobic fermentation of vegetal biomass, animal manure and other biodegradable wastes (*Cuetos et al, 2011; El-Mashad and Zhang, 2010; Xie et al, 2011*).

Zhang et al (2013) investigated biogas production by co-digestion of goat manure with three crop residues, namely, wheat straw, corn stalks and rice straw, under different mixing ratios. Results showed that the combination of goat manure with corn stalks or rice straw significantly improved biogas production at all carbon to nitrogen (C/N) ratios. Goat manure (GM)/corn stalks (CS) (30:70), GM/CS (70:30), GM/rice straw (RS) (30:70) and GM/RS (50:50) produced the highest biogas yields after 55 days of fermentation.

In the present paper, there were tested the physico-chemical characteristics of the agricultural biomass consisting of corn stalks, wheat straw and alfalfa, in order to identify the most efficient substrate that can be used in co-digestion with animal manure in biogas plants. It is well known that the anaerobic digestion of organic matter is related to its composition, thus it is necessary to find out what the characteristics of the substrate to be fermented are. Parameters with a significant role in the process of anaerobic fermentation were assessed: total soluble solids (TSS%), the pH, the moisture content as well as the reducing sugar in the liquid fraction for corn stalks, wheat straw and alfalfa.

MATERIAL AND METHOD

Corn stalks, wheat straw and alfalfa plants used during experiment were obtained from a household located in the Teleorman County, Romania.

Regarding the biomass processing, grinding was done with the help of an electrical grinder for vegetable residues Viking GE150 and then with a laboratory mill Grindomix GM-200 for 1 minute at 5000 rpm (fig. 1).

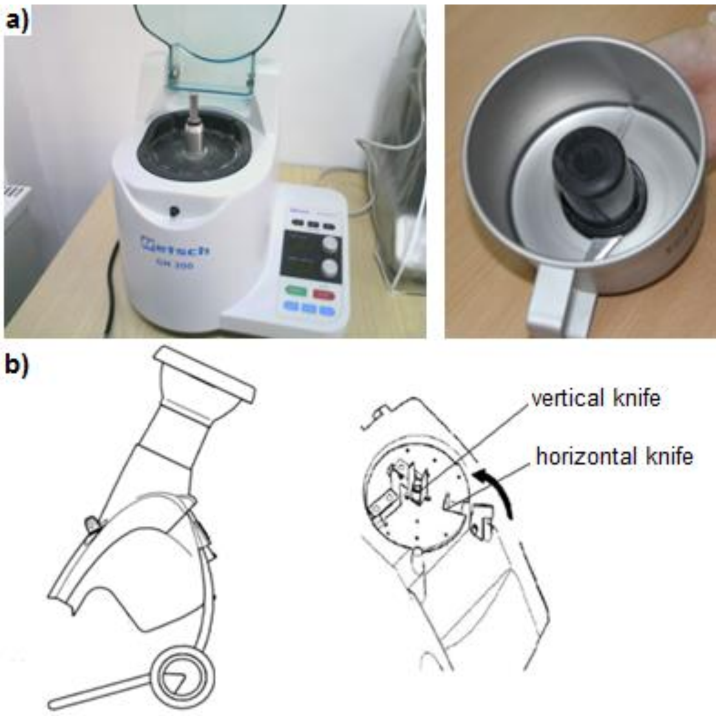

Fig.1 – a) Laboratory mill Grindomix GM-200 and b) Grinder for vegetable residues Viking GE150

The proportion agricultural substrate – water is presented in Table 1. Each quantity of the tested substrate was placed in the same quantity of water in tightly closed Erlenmeyer flasks. After that, the Erlenmeyer flasks were placed in the bacteriological thermostat for 7 days at a temperature of 35 °C (fig. 2). During the experiment, liquid samples were collected for analysis. Assessment of the agricultural substrate was done by analysing and interpreting the following parameters: total soluble solids (TSS%), the pH and the reducing sugar.

The content of total soluble solids (TSS) was determined with a thermo-balance, after the centrifugation of initial samples at 5000 rpm followed by filtering through a membrane with pores of 0.45 µm. The pH of the liquid samples was determined using a pH meter type Hanna.

In order to estimate the concentration of sugars in the samples taken, was used the method in which is used the 3.5-dinitrosalicylic acid (DNS) (*Miller G.L., 1959).* The absorbance was measured at 540 nm using the T92+ UV VIS spectrophotometer, PG Instruments.

The moisture content for each type of agricultural biomass was measured using a KERN RH 120-3 thermo-balance and the results were the following: corn stalks (14.49%), wheat straw (12.23%) and alfalfa (11.44%).

Table 1

The proportion of substrate used in experiments (w/w)

	Corn stalks (g)	**Wheat straw (g)**	**Alfalfa (g)**	**Water (g)**
Erlenmeyer flask 1	15	-	-	300
Erlenmeyer flask 2	-	15	-	300
Erlenmeyer flask 3	-	-	15	300
Erlenmeyer flask 4	5	5	5	300
Erlenmeyer flask 5	7,5	-	7,5	300
Erlenmeyer flask 6	7,5	7,5	-	300

Fig.2 - Bacteriological thermostat and Erlenmeyer flasks with tested biomass

RESULTS

Based on the data obtained from experimental tests, were plotted the variation diagrams for each index analysed (TSS, pH and reducing sugar) as a function of digestion time (fig. 3 - 5).

The total soluble solids contain soluble sugars, soluble proteins, mineral salts, pigments and water-soluble compounds that are used as nutritive substrate for different groups of microorganisms involved in anaerobic digestion and biogas production. TSS value refers to the amount of soluble compounds released into the fermentation medium from the vegetal material, mainly substances with low mass. In addition, soluble substances could be formed by the hydrolysis reactions due to the exoenzymes released by hydrolytic bacteria in order to degrade the macromolecular substrate at assimilable compounds with low mass.

The initial TSS values differ depending on the used substrate type. Analysing the data, it can be observed that in all cases TSS value tends to increase. For the milled corn stalks, the TSS values have increased from 0.5%, value recorded after 24 hours, to 2.5% after 168 hours of incubation.

During the experiment, all the TSS values increase because of substrate degradation, the highest value being 2.6% after 168 hours of incubation, for the mixture of corn stalks and alfalfa biomass. In time, the bacterial populations will consume nutrients from the medium and the TSS values will decrease significantly.

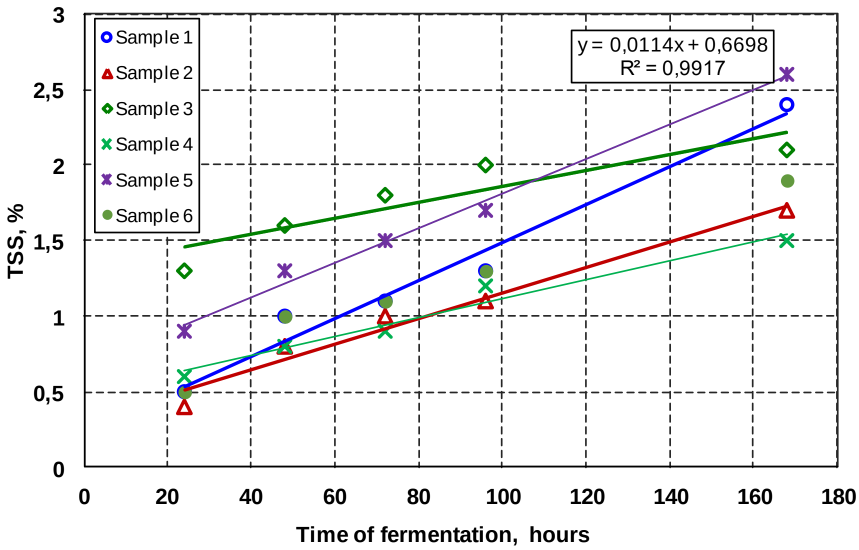

Fig. 3 – The TSS variation during fermentation process

The evolution in time of the pH variation for each tested substrate is shown in Figure 4. The pH is a key parameter that provides significant information regarding the stability of anaerobic digestion process. In our case, the pH of analysed liquid samples had an ascending tendency, characteristic for this type of fermentation.

During the 168 hours of experiments, the pH values were maintained in the acid domain due to, probable, the fermentations that produce organic acids, such as acetic, propionic, butyric, fatty acids, alcohols etc.

For each the tested substrate, as well as in the case of thereof mixture, after 24 hours, the pH value start to increase, and at the end of fermentation period have values ranging from 5,8 to 6,5 units.

It can be considered that in this case takes place the first two phases of anaerobic digestion, namely hydrolysis and acidogenesis, where act hydrolytic and acidogenic microorganisms, like: *Streptococcus, Lactobacillus, Bacillus, Escherichia coli, Salmonella.* The highest pH values were recorded for the mixture of corn stalks and alfalfa, from 5.35 units after 24 hours and reaching 6.5 units at the end of the experiment.

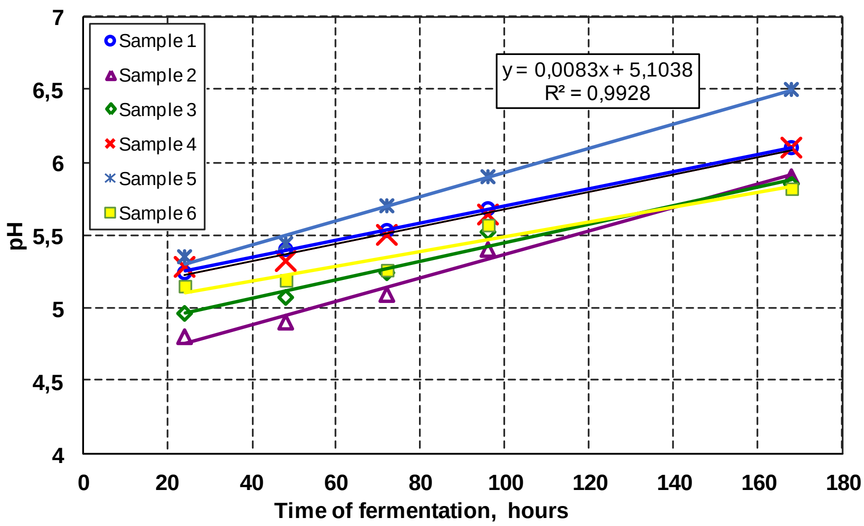

Fig. 4 - The pH variation during fermentation process

Due to cellular multiplication and the fermentation produced by these, the reducing sugar concentration had a slightly increasing trend for all the tested substrates during the 168 h of incubation. In time, al the values increase due to saprophytic microorganisms activity with a degradation action of polysaccharides (cellulose and starch) in the plant cell.

During this phase, the sugar concentration is mainly due to extraction process of sugar in water and less to microorganisms' activity, beginning to adapt to the environment and multiply. The growth of microorganisms occurs approximately after the first 24 - 48 hours. They consume the substrate, and also reducing sugars; however, sugars accumulate in the medium at least in the first 168 hours of incubation.

After 24 hours the highest concentration of sugars was found in the case of substrate consisting of corn stalks, 0.420 mg/ml, while the lowest concentration was detected in the case of wheat straw, being about 0.115 mg/ml.

Compared to the first day, after 168 hours, for the mixture of corn stalks and alfalfa, sugar concentration increased about 10 times, reaching 2.7 mg /ml.

There is a close correlation between the concentration of sugars and total soluble solids concentration that increase almost simultaneously and are higher in the mixture of corn stalks and alfalfa biomass.

The lowest results were recorded from wheat straw having a siliceous coating, which does not allow microorganisms to access the polysaccharide vegetable wall.

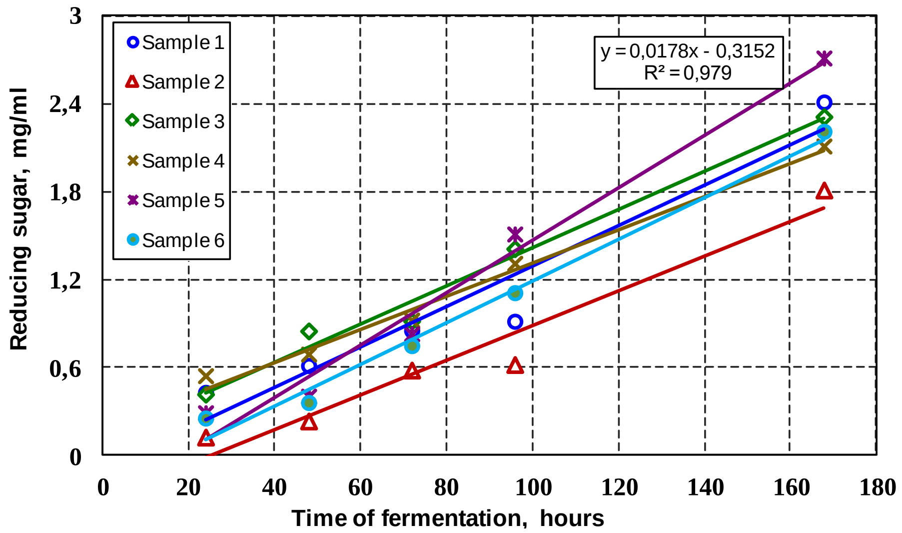

Fig. 5 - The reducing sugar variation during fermentation process

CONCLUSIONS

The anaerobic fermentation is an effective biological process for treating the organic wastes derived from the agricultural and zootechnical sector. The biogas production resulted from the anaerobic fermentation is considerably influenced by the substrate composition.

The achievement of these experiments contributes to the optimization of anaerobic digestion process, in order to obtain biogas from biomass. The characterization of substrate components used in biogas plants is very important to estimate the biogas production.

From the experiments conducted, it was found that the concentration of sugars and total soluble solids increased almost simultaneously in the mixture of corn stalks and alfalfa biomass. After 168 hours, for the mixture of corn stalks and alfalfa, sugar concentration increased to 2.7 mg /ml. For the same substrate, the pH value reached 6.5 units at the end of the experiment.

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AUTOMATED SYSTEMS FOR DIRECTING WORKING BODIES AT AGRICULTURAL MACHINERY
/
SISTEME AUTOMATE DE DIRIJARE A ORGANELOR DE LUCRU LA MASINILE AGRICOLE

Dipl. Eng. Anghel S.*[1)], Ph.D. Eng. Matache G.[1)], Ph.D. Eng. Sovaiala Gh.[1)], Ph.D. Eng. Blejan M.[1)], Dipl. Eng. Alexe A.-M.[1)]
[1)] Hydraulics and Pneumatics Research Institute INOE 2000-IHP, Bucharest / Romania;
Tel: 0213363991; E-mail: sava.ihp@fluidas.ro

Keywords: *automated systems, agricultural machinery, probes, header*

ABSTRACT

This paper presents the results achieved by INOE 2000-IHP under a research project in which we have adjusted the header of Semanatoarea C140 harvester, giving it the ability to rotate against the harvester by equipping it with a hydraulic cylinder which is able to control header rotation to the left and to the right against the longitudinal axis, by means of four probes located on the header in the area of the cutting device. The automation system, taking over the signals emitted by the four probes (sensors) which give evidence of the header position against the ground, is also presented.

REZUMAT

Lucrarea prezinta rezultatele obtine de INOE 2000-IHP in cadrul unui proiect de cercetare in care a adaptat hederul combinei Semanatoarea C140, oferindu-I acestuia posibilitatea sa se roteasca fata de combina prin dotarea cu un cilindru hidraulic care sa poata actiona rotirea hederului in stanga si in dreapta fata de axa longitudinala, prin utilizarea a patru palpatori amplasati pe heder in zona aparatului de taiere. Este prezentat, de asemenea, sistemul de automatizare ce preia semnalele date de cei patru palpatori care semnalau pozitia hederului fata de sol.

INTRODUCTION

Modern agriculture uses guidance systems for machines in process of working, by resorting to GPS guided platforms in plowing, planting, treatment application, harvesting, etc. In practice it has been noticed that positioning of the working device, for example the cutting device of the harvester header, the blade used for cutting roots in orchards, the nozzle for spraying against pests, influences the quality of agricultural work and indirectly the production obtained per hectare.

Agricultural machinery consists of the system generating power for movement, to which are attached the working bodies, such as plows, header of the harvester, grader levelling blades of scrapers, etc. The systems generating power for movement are usually made up of motors attached to frames with all the necessary systems. Driving and traction systems consist, at most agricultural machinery, of elastic wheels filled with air at low pressure to avoid damage to soil structure. The agricultural machinery's accurate position against the ground, while working, is difficult to control because of unevenness of the ground, elasticity of the drive train and the response forces inside the working bodies. In agricultural practice a need has risen for performing high quality work, such as threshing grain and vegetables at a small distance from the ground, or carrying out cutting roots operation in intensive and super intensive orchards, where the cutting knife must meet a certain depth of cutting and a certain angle against the row of trees. Generally, the working bodies are attached to the system for moving and they are mounted in front of the machine in harvesters or are towed in the back of the tractors. As the carrier machine has a random moving, because of the elasticity of the drive train and unevenness of the ground, the working body will have random movements, very difficult to control by the operator of the machine. For the harvester, in order to obtain high speeds, the header's cutting blades are kept at a long distance from the ground not to touch the ground. *(Anghel S. et al., 2015)*

MATERIAL AND METHOD

INOE 2000 IHP is concerned with improving the performance of agricultural machinery through participation in research projects jointly with other institutes and high education entities, among which we mention the Project under RELANSIN programme: Electro-hydraulic system for actuation, drive and control of the header for straw plants at the C140 agricultural harvester, project implemented in collaboration with Semanatoarea SA, PUB and INMA Bucharest, over the period 2004-2007. The project emerged from the need of Semanatoarea factory to assimilate into production the harvester equipped with a cutting device at a short distance from the ground. The work was developed in the prototype phase by using four probes, located on the header in the cutting device area, as in figure 1. The work consisted in adapting the header by creating the possibility for it to rotate against the harvester and installation of a hydraulic cylinder that can control rotation of the header to the left and to the right against the longitudinal axis. Driving of the header in a vertical plane has remained to be done by means of single-acting cylinders of the harvester. On the header, have been installed four probes (sensors) which measure the distance from the ground to the cutting device, via four potentiometers that send signals to the automation system. (*Anghel S. et al., 2015*)

Positioning of the probes can be seen in the area behind the header, as in figure 2 and figure 3.

Fig. 1 - Front view of the harvester, where one can notice the four probes under the header

Fig. 2 - Probes mounted behind the header on the left

Fig. 3 - Probes mounted behind the header on the right. One can also notice the rod acting the rotary potentiometer, which conveys a signal about the position of the probe to the automation system

Fig. 4 - Automation box located under the cabin

Fig. 5 - System functioning test, performed at Semanatoarea SA mounting facility. It can be noticed that the harvester header performs a corresponding movement when the probe is actuated.

Fig. 6 – Cylinder for rotation of the header against the harvester

The solution for probing system automation

The automation system was developed by taking over the signals given by the four probes, which signaled the header position against the ground. From the four Y signals there are choose two, Y1 and Y2, which indicate the tallest height of the ground, and a command is given for the header not to get closer to the ground.

Fig. 7 – Functional tests on the field of the Fundulea Institute

The operation software of the electronic module was developed by using the MPLAB integrated development environment and the ANSI C HI-TECH compiler. For programming the microcontroller, the ICD2 programmer was used. This programmer is integrated into the MPLAB environment and it is connected to the PC by RS232 serial interface or USB interface. ICD2 allows to program the microcontroller “in circuit”, meaning that the electronic module has a J25 connector that the programmer connects to, which is not requiring the extraction of the microcontroller from the circuit to be programmed. (*Blejan M. et al., 2014)*

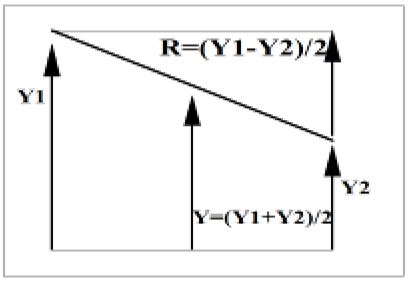

Fig. 8 - Kinematic diagram

There has been used the kinematic diagram shown in figure 8. After choosing the two signals, the worst of 4, noted as Y1 and Y2, there is obtained the signal Y=(y1=y2)/2 and the signal R=(y1-y2)/2, which, depending on the values obtained, control the electromagnets of hydraulic directional control valves, which has the effect of adjusting the header position by lifting/lowering or rotating to the left/right.

Y1 – information from the header height sensor 1

Y2 – information from the header height sensor 2

Y – header height above the ground, respectively the action of lifting cylinders

X – rotation of the header, respectively the action of the rotation cylinder

Important note: parameters Y and R are decoupled, respectively actuating the lifting cylinders only changes the Y, and actuating the rotating cylinder only changes the R. (*Blejan M. et al., 2015)*

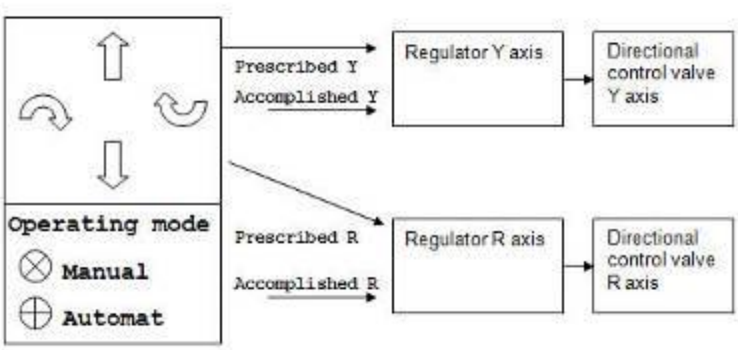

Fig. 9 - Automation diagram

The automation system shown in figure 9 is composed of two automatic adjustment loops, independent from each other, one for adjusting header height above the ground *Y*, and the other one for adjusting header rotational speed *R*.

The operator panel allows setting the program for the two control loops via a joystick control with commands UP, DOWN, LEFT ROTATION, RIGHT ROTATION. *(Blejan M., Ilie I., Cristescu C., 2015)*

Determining the work regime is done from the operator panel by using a key with two positions:

- AUTOMATIC MODE: in which the automation system is active.
- MANUAL MODE: in which the automation system is deactivated.

RESULTS

The electro hydraulic system for drive, control and adjustment of the header for straw plants in the C140 harvester allows tracing the ground profile and maintaining an even height for cutting straw.

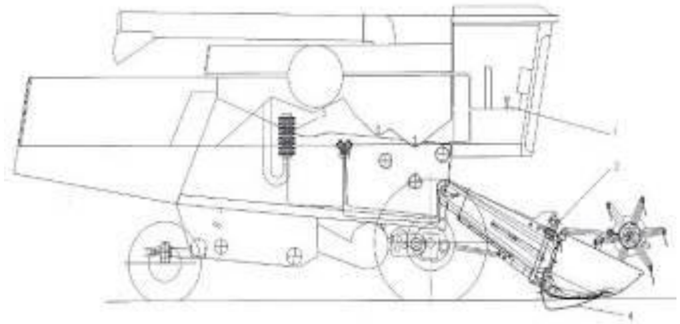

Fig. 10 - The electro hydraulic system for drive, control and adjustment of the header for straw plants in the C140 harvester

The system shown in figure 10 consists of: *(Sovaiala Gh. et al., 2015)*

1.- Electronic control system located on the switchboard. It comprises hardware parts consisting in the microprocessor board, potentiometric transducers for angle measurement located on the probes, joystick, cables and connecting wires, and also control software;

2- Mechanical device allowing header rotation in the perpendicular plane actuated by double-acting hydraulic cylinder. It is made up of: fixed flange; mobile flange; adapting device for the elevator; probes with rotation device, sensors and hydraulic cylinder; *(Popescu T.C., Vasiliu N., Vasiliu D., 2013)*

3 – Hydraulic drive system adjusted (fig. 11) (*Popescu T.C. et al., 2011*) allowing actuation of the header rotation cylinder; It consists of the facility existing on the harvester which is adjusted by adding a section comprising a directional control valve, directional throttle valves and unblockable non-return valves connected via pipes and hoses to the hydraulic cylinder;

4 – Probing system.

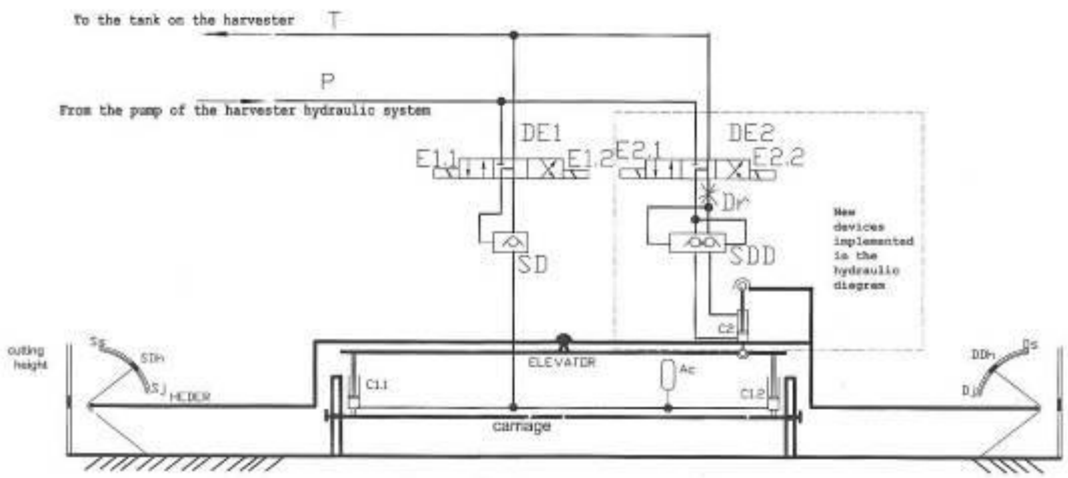

Fig. 11 – The hydraulic drive diagram for the header with the new devices implemented in the drive diagram of the existing harvester

The electro hydraulic system to drive, control and adjust the header in the C140 harvester is designed to improve performance in harvesting straw plants. (Matache *G., Alexandrescu St., Sovaiala Gh., Pavel I., 2013*) Maintaining a constant cutting height in harvesting straw plants is done at this harvester in the vertical plane only, via the operator's command on the lifting / lowering cylinders of the header. The knife cutting line is always in a plane parallel to the plane in which the harvester wheels are set on the ground. In practice there are situations when the plane in which the harvester wheels are set is not parallel to the ground (one harvester wheel is in tractor groove or in an excavation, or the soil has ripples). Since the forward speed of the harvester has increased, it is difficult for the operator to track the cutting height. At the harvester upgraded by introducing several probes the ground profile is replicated in the cutting knife area, maintaining constant cutting height all along the header length regardless of the placement of wheels or ground profile. *(Matache G. et al., 2013),*

Along the header length near the plant cutting knives four probes are located; they trace ground profile, as in figure 12. The signal is taken over via a crank gear system and it is conveyed to the rotation transducers.

The four probes send four signals to the electronic control block. The operator from the cabin sets a certain cutting height. This cutting height is turned into a signal which is compared to the four signals received from the probing system. The electronic system sets an acceptable zone (which is adjustable) around the cutting height which is piloted by the operator. If signals from the operator sense movement toward or away from the ground by at least one probe passing beyond the acceptable zone, then a signal is sent to adjust header position. *(Popescu T.C. et al. 2009)*

Adjustment of header position is done in the following steps: at least one probe signals passing beyond the acceptable zone and movement toward the ground; the electronic system selects two signals which represent the zones which are nearest to the ground; it calculates the half-sum and half-difference of those signals and if the half-sum is lower than the value piloted by the operator a signal is sent to lift the header; if the half-difference is positive or negative a signal is sent for rotation in one direction or the other in order to bring the signal from the probes in the zone pre-set by the operator.

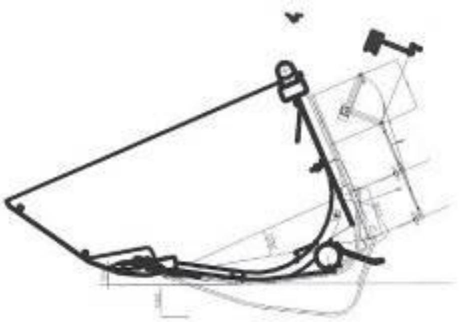

Fig. 12 – The harvester header equipped with probes and the system conveying the cutting height value to the rotation transducers

System actuation is done in two modes:

- Manual mode, when the operator controls from the joystick buttons the tracing of ground profile by upward / downward movement in a vertical plane and by left / right rotation in a transversal plane;
- Automatic mode, when tracing of ground profile is done by sensing the advance front in four zones by means of probes installed on the header.

CONCLUSIONS

Following the research conducted with the harvester, on the fields of Fundulea Institute, there has been proven the project reliability. Observations have been made on the sizing of the header rotational axis, taking into account the situation when the harvester, in movement, gets to rest on the header against the ground. In order to keep a low price for the harvester, servo technique was not used in the adjustment of the header position, and the classic equipment used corresponded with the needs of the project.

Another machine working on a similar principle is the machine for trimming the root system of the trees in intensive and super intensive orchards. According to the working technology used in intensive and super intensive orchards, the soil is no longer than a support for fruit trees. Water and mineral elements are supplied by irrigation systems. Irrigation in orchards is done on a line on both sides of the row axis.

The trees develop their root system in a circle around their trunk. All roots that go beyond the irrigated area are cut using special devices for cutting roots. The knife of such machines is a blade which must cut the root system of trees to a certain depth and angle.

Because of elasticity of the tractor drive train, unevenness resistance of the ground to cutting and the positioning of the working machine against the longitudinal axis of the tractor, an unbalanced force is applied on the cutting knife that twists the working assembly (tractor and machine) and pulls the knife off the ground. For proper operation it is necessary to provide a device for adjusting the position of the knife by using touch sensors and sensors for tilting the cutting device.

Fig. 13 - Roots cutting machine

In the figure above one can see the cutting knife being pulled off the ground, the tractor twisting because of elasticity of the drive train, and thus cutting is no longer complying with the parameters required by the orchard technologist.

In the modern agriculture, for getting good results, one must take into account all aspects concerning the work of the active bodies of the agricultural machines.

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CURRENT TRENDS IN TECHNICAL EQUIPMENT FOR SEPARATING IMPURITIES FROM CEREAL SEEDS, THEIR CONSTRUCTIVE AND FUNCTIONAL PARAMETERS
/
TENDINŢE ACTUALE PRIVIND ECHIPAMENTELE TEHNICE PENTRU SEPARAREA IMPURITAŢILOR DIN SEMINŢELE DE CEREALE, PRINCIPIILE LOR CONSTRUCTIVE ŞI FUNCŢIONALE

PhD. Eng. Brăcăcescu C, PhD. Eng. Ganea C., PhD. Stud. Eng. Pruteanu A., PhD. Stud. Eng. Găgeanu I., PhD. Eng. Sorică C.
INMA Bucharest/ Romania
E-mail: carmenbraca@yahoo.com

Keywords: cleaning, seeds, vibrating sieves, specific mass

ABSTRACT

The precleaning and cleaning of cereal seeds before their storing or processing represents a complex technological process, which includes several technical equipment constructive types designed to separate and remove the impurities existing in the seed matter. The paper presents a series of current representative models from national and international companies, as well as an analysis on their constructive and functional principles. At the end of the paper are presented the advantages of using these types of technical equipment for pre cleaning / cleaning cereal seeds.

REZUMAT

Precurăţirea şi curăţirea seminţelor de cereale înaintea depozitării sau procesării lor reprezintă un proces tehnologic complex, care include o multitudine de tipuri constructive ale echipamentelor tehnice proiectate pentru separarea şi îndepărtarea impurităţilor existenete în masa de seminţe. Lucrarea prezintă câteva modele reprezentative de actualitate ale firmelor producătoare atât din ţară cât şi din străinătate precum si o analiză asupra principiilor lor constructive şi funcţionale. La finalul lucrarii sunt prezentate avantajele utilizarii acestor tipuri de echipamente tehnice de precuratire/curatire a semintelor de cereale.

INTRODUCTION

The need for primary processing of cereal seeds after the harvesting stage and the intensity degree of this technological process applied varies from country to country.

Where this operation is necessary to be performed at the highest standards, state of the art technical equipment are used, which combine several principles of separating impurities (*Brăcăcescu C. et. Al*)

Also, the current focus lies on a "*sustainable and mainly organic agriculture*", leading to increasing the importance of technical equipment destined for pre-cleaning due to the high degree of impurity of crops resulted by eliminating the chemical procedures of preventing factors negatively influencing their development (spraying, chemical processes, etc.,).

Internationally, there are numerous companies producing a large range of technical equipment for separating impurities from the mass of cereal seeds, from the simplest ones, with manual command up to the complex and completely automated technological lines (*Falko O.*).

To reduce the number of technical equipment and implicitly of technological spaces, the modern milling units performing use complex installations carrying out the separation by combined principles, the most used following the specific mass difference being the ones and aerodynamic properties of various components of seed mixtures (*Costin I.*).

MATERIALS AND METHODS

Depending on the principle of separation and the type of impurities is used a wide range of technical equipment and installations for carrying out the separation of impurities.

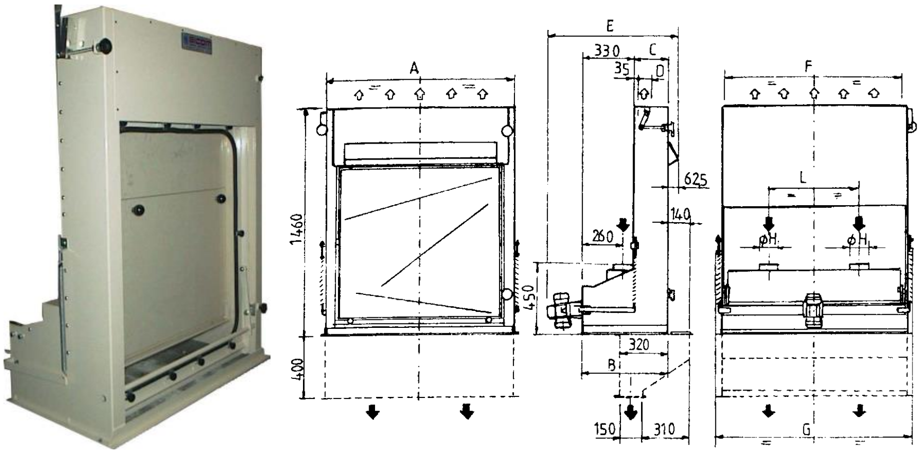
During documentation were studied a series of booklets of well-known foreign companies in the field, pointing out their concern to produce high-performance technical equipment, with reduced specific consumptions of material, energy and space, with easy and accessible adjustments.

State of the art technical equipment used for pre-cleaning and cleaning cereals is capable to ensure:

- Separation on vibrating sieves driven by vibration generators with unbalanced tables;
- The aspiration of impurities from the mass of product with / without air recirculation;
- Mixed solutions for achieving an intensive separation;
- Constructive solutions for which the cost/benefit ratio is favourable for the user;
- Efficient primary processing, finesse cleaning, sorting by size or specific mass.

In the following are presented the constructive, functional and technical characteristics for several types of representative technical equipment for cleaning cereal seeds, produced by well-known European companies in the field.

The STVA Vibrating Vertical Aspirator of SICOM Company-Italy (fig. 1) is used in the cleaning of granular products to eliminate foreign objects, cods and lighter particles. The machine is made up of a vibrating feed bin, suspended from elastic supports, and an adjustable aspiration channel, the flexibility of which allows its adaptation to any operating conditions. The lighter parts are lifted by a current of air which surrounds the product along the entire width of the aspiration channel, and are carried upwards. The cleaned product falls into the lower outlet. On request the machine can be fitted with a collection bin and magnetic safety device to retain any ferrous objects, installed underneath the machine.



a) b)

Fig. 1 - STVA Vibrating Vertical Aspirator of SICOM Company-Italy [14]

a)-view; b) –constructive dimensions

Technical characteristics: $P_{motor\text{-}vibrator}$=0,95kW; p (pressure)$_{working}$=70...80 mm col.$H_2O$.

The air-recycling aspirator MVSQ, Bühler, Switzerland is applied for the separation of low-density particles in an aspiration channel from granular agriculture products. It is characterized by its excellent separating efficiency, which ensures a high degree of separation:

- The uniform distribution of the air across the entire width of the aspiration channel and the dually adjustable wall in the vertical aspiration channel ensure stable and reliable separation.
- The degree of separation can be selected with high precision, preventing unnecessary product loss.

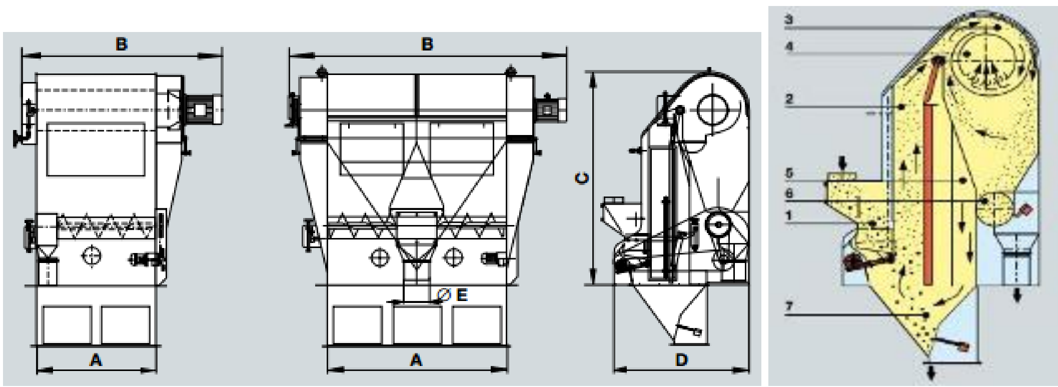


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Fig. 2 – Constructive and functional diagram of the air-recycling aspirator MVSQ, Bühler, Switzerland [10]

- 1. product feed with eccentric drive; 2-aspiration channel with double-adjustable wall; 3-integrated separator for low-density product; 4-radial fan for recycling air; 5-air recycling channel; 6-screw conveyor with discharge gate for low-density product; 7-outlet with finger valves for discharge of heavy product

The product is fed through an inlet spout to a vibratory feeder and spread uniformly across the entire width of the separation channel. In this vertical aspiration channel with its double-adjustable wall, the curtain of product is loosened and the low-density particles are separated. The clean heavy product is discharged from the machine through finger valves, whereas the light fraction is separated from the air in a special separator and is then discharged by a screw conveyor and retarding gate. The air is recycled by a radial fan back to the aspiration channel. The possibilities of control by a double-adjustable wall and the air volume (using built-in butterfly valve) permit an optimal adjustment of the air-recycling aspirator to the particular application.

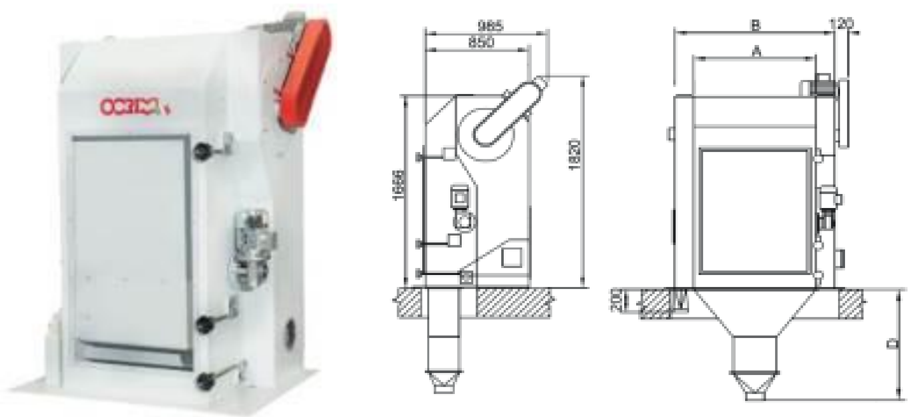
Table 1

Technical characteristics

Type	Capacity [t/h]		Aspiration [m^3/min]		Net weight [kg]	Volume by sea [m^3]
	cleaning	precleaning	cleaning	precleaning	net	
MVSQ-60	9	40	4	8	555	3.9
MVSQ-100	16	66	6	10	650	5.15
MVSQ-150	24	100	2x4	2x6	900	7.7

The TRR-Air recirculating aspirator, Ocrim, Italy performs an accurate and improved efficiency separation of light impurities in a closed air recirculating system. It can be used as a single unit or with either the grain separator and with the intensive separator.

The machine is constantly maintained under negative pressure by the incorporated impellers for suction of light impurities in a closed air recirculating system. Air chamber is provided with a screw conveyor for discharge of dust and light impurities.



a) b)

Fig. 3- The TRR-Air recirculating aspirator, Ocrim, Italy [8]

a)-view; b) –constructive dimensions

Table 2

Technical characteristics

Type	Capacity [t/h]*		Exhaust [m^3/min]	Power [kW] at 50Hz			Net weight [kg]	Shipping volume [m^3]
	cleaning	pre-cleaning		driving motor of the impeller	gearmotor	vibrating motors at 50Hz		
TRR 07B	9	35	8,5	3	0.37	2x0.3	380	3.4
TRR12B	20	80	13,5	4	0.37	2x0.3	600	4.8
MVSQ-150	24	100	16	4	0.37	2x0.3	700	5.5

*Capacity referred to wheat with moisture of maximum 13%

The use of aspirator separators, with air recirculation within the technological flow of cleaners, shows the following main advantages:

- reducing by approximately 80% the consumption of air necessary for the separation process;

- reducing specific material consumption and investment costs, by eliminating aspiration networks and the equipment for decanting and filtering.

The Conical turbo-aspirator TTC, from Ocrim, Italy offers optimum separation of light particles from wheat or maize products with minimum air consumption and reduced dimensions. It is essentially composed of two conical hoods, with large plexiglass windows for visual inspection, a rotary blade distributor and a butterfly valve. Turbine type rotary blade distributor activated by air flow ensures uniform product distribution over entire section. High efficiency is achieved by control of exhaust air speed position of the turbine distributor relative to the conical exhaust chamber. Telescopic tube with vertical and horizontal adjustment permits centring of incoming product onto the turbine distributor. The position of the feed entry and ability to rotate through 360° simplifies the installation. It is designed to eliminate dust pockets.

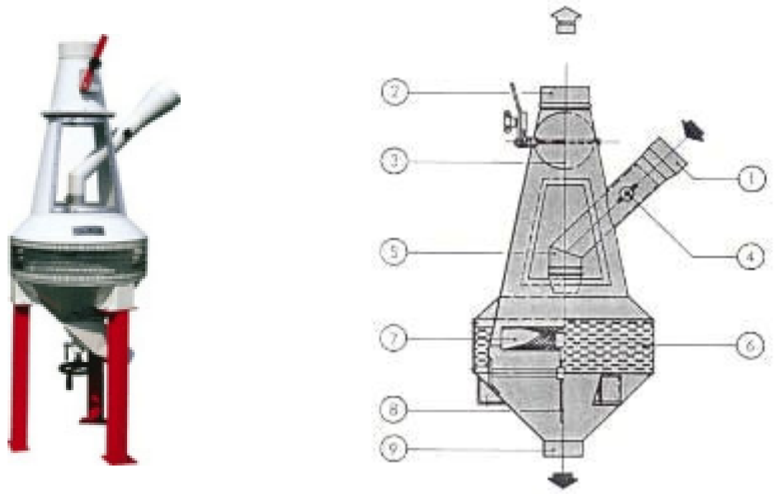


Fig. 4 - Conical turbo-aspirator TTC, from Ocrim, Italy [9]

1-product feeding inlet; 2-aspiration coupling; 3-flap for adjusting air flow; 4-flap for adjusting product flow; 5-feeding pipe; 6-aspiration slots; 7-turbine with blades; 8-turbine shaft; 9 evacuation tube.

Table 3

Technical characteristics

Type	Maximum capacity [t/h]				Exhaust [m^3/min]	Power of gearmotor [kW]	Net weight [kg]	Shipping volume [m^3]
	Wheat		Maize					
	precleaning	cleaning	Hominy grits	Brevery grits				
TTC 450	10	4	3	1.5	18÷23	0.37	41	0.60
TTC 600	15	6	4.5	2.5	28÷38	0.37	52	0,90
TTC 800	25	9	7	3.5	50÷70	0.37	213	2.80

Vibrating separators are technical equipment which achieves the separation of impurities from the cereal mass based on the difference of specific weight, using inclined plane surfaces that have a vibrating movement (fig. 5). They are commonly called gravitational separators.

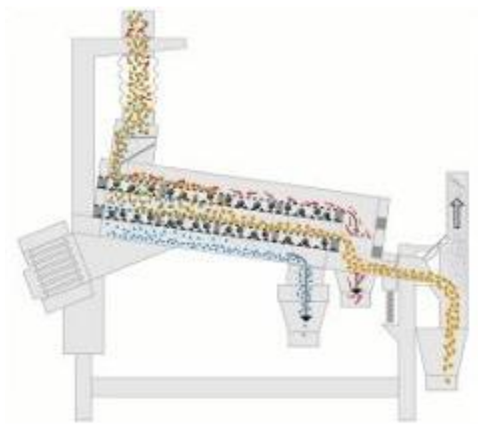


Fig. 5 – Functional diagram of a vibrating separator

The gravity separator (fig. 5) provides excellent classification efficiency and thus ensures improved quality of the end product – at a continuous and consistent quality level:
Using intelligently conceived air distribution, the material being fed through is precisely separated into three fractions according to specific gravity: high-density (heavy), mixed, and low-density fractions. Throughput can reach a maximum of 2.5 t/h.

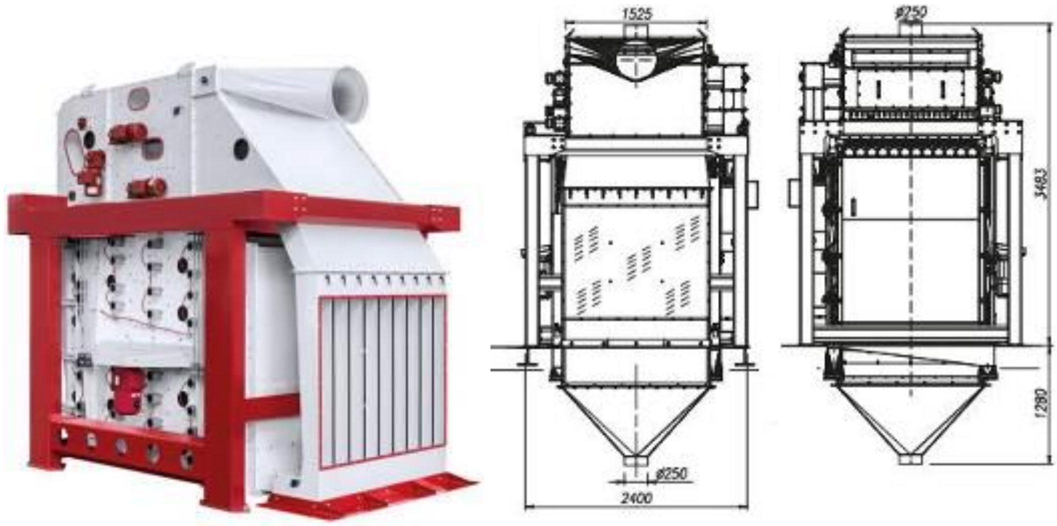
Gravitational separators show a series of common constructive-functional particularities, such as:

- Waiving traditional systems for producing the oscillating movement and introducing electric motor-vibrators to ensure the amplitude of the vibrating movement;
- Eliminating mechanical transmissions;
- Increasing the loading index on the working surface;
- Reducing specific energy consumption by 2-5 times;
- Easy maintenance and exploitation;
- Increased reliability.

For these types of equipment, adjustments can be made to the following parameters: inclination of separation surfaces; vibration propagation direction, vibration amplitude.

Pre-Cleaning /Cleaning Separator, Golfetto Sangati, Italy

Machine utilized for the pre-cleaning and cleaning of grains. It is composed by a central oscillating body which contains aluminium frame groups pneumatically fixed with a sifting surface of 24 sq. m. The machine is composed by a settling group at the entry and a suction channel at the exit.



a) b)

Fig. 6 - Pre-Cleaning / Cleaning Separator, Golfetto Sangati, Italy [12]

a)-view; b) –constructive dimensions

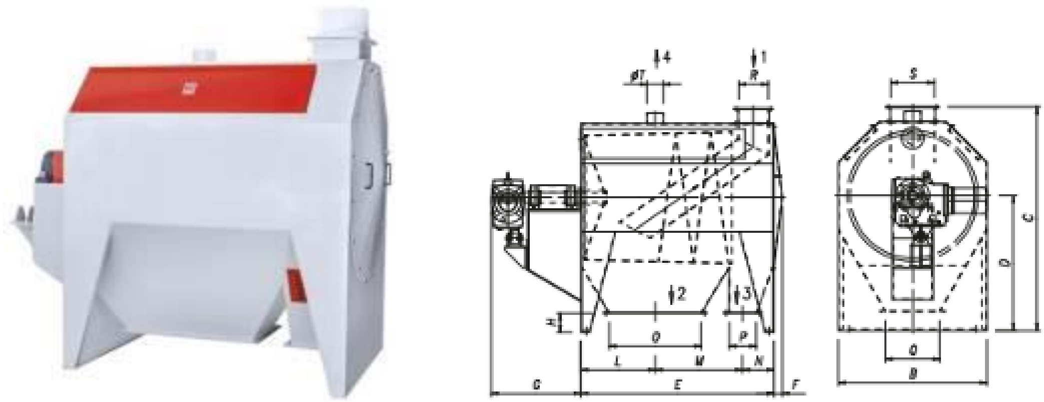
Table 4

Technical characteristics

Type	***Capacity [t/h]**		**Aspiration [m^3]**	**Power of:**			**Weight [kg]**
	silos	**cleaning**		**Main drive motor [kW]**	**motor closed circuit aspirator [kW]**	**Gear motor [kW]**	
GS 24/150	120-300	50	200	3	2x0,55	3x0.55	6500

*Soft wheat 0.75t/m^3

Pre-cleaning Separator SPR, Golfetto Sangati, Italy is utilized for the pre-cleaning of grain and separation from large foreign bodies. It reduces the wear on the subsequent machines in the production process. The cylinder rotation is obtained by means of a gear motor.



a) b)

Fig. 7 - Pre-cleaning Separator SPR, Golfetto Sangati, Italy [11]

a)-view; b) –constructive dimensions

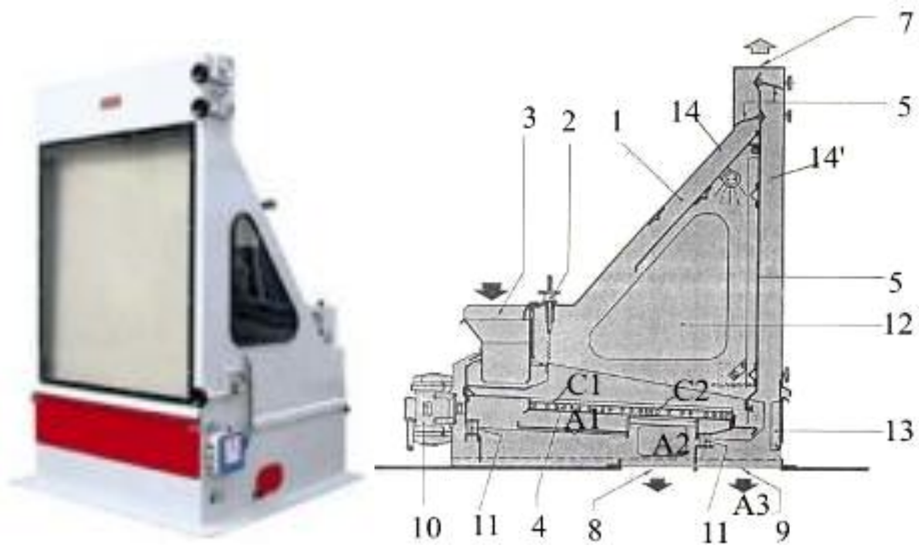
Table 5

Technical characteristics

Type	Air [m^3/1*]	Motor power [kW]	*Capacity [t/h]
SPR 200	12	0.75	200
SPR 400	15	1.1	400
SPR 600	20	3	600

*Soft wheat 0.75t/m^3

The combined separator series TRC produced by Ocrim company in Italy (fig. 7) represents a combination of gravity classifier and vertical aspirator classifying grain into two grades: light and heavy product. The aspiration operates effectively to reduce energy consumption and to simplify cleaning sections. Aspiration action is combined with the classification of grains into two streams of different density: 70-75% heavy, 25-30% light. It is mainly consisting of an aspiration chamber and a vibrating sieve mounted on four vibration pads and driven by two vibratory motors. The aspiration chamber has two independent devices for air regulation; the first device is for the product stratification on the deck; while the other is only for the aspiration of the light density fraction. The regulation of air stream velocity is made by varying the cross-section of the aspiration channel. Sieve cleaning is performed by means of rubber balls. Large inspection panels allow an easy visual surveillance of the grains being processed.



a) b)

Fig. 8 – Combined separator series TRC, Ocrim company, Italy [8]

a) view; b) constructive-functional diagram

1-frame; 2-device for adjusting the feed; 3-feeding case; 4- vibrating sieve; 5- mobile wall; 6-aspiration adjustment flap; 7-aspiration connector; 8-channel for evacuating small size seeds; 9- channel for evacuating large size seeds; 10-motovibrator; 11- elastic suspensions; 12-observation window; 13-visiting door; 14,14'-aspiration channels

Table 6

Technical characteristics

Type	Maximum capacity [t/h]			Exhaust [m³/min]	Power of vibrating motors [kW]	Net weight [kg]	Shipping volume [m³]
	Wheat	Maize					
		Hominy grits	Brevery grits				
TRC 075	9	7.2	2.25	72	2x0.3	335	3.50
TRC 125	14	11.2	4.75	112	2x0.3	440	4.70
TRC 150	19	15	6	135	2x0.3	495	6.30
TRC 175	24	19.2	7.25	157	2x0.3	550	7.50

RESULTS

Studying the performance of vacuum separators and gravity separators above presented, operated by vibrations generators, compared to the same categories of machinery but operated kinematically, it results that:

- vacuum aspirators equipped with inertial generators (electric motor-vibrators) cover a large range of working capacities at a power reduced almost at half for the maximum values reached by those with kinematic drive;
- for gravitational separators equipped with inertial generators, the working capacity is superior to the capacity of those with kinematic drive at powers of motor-vibrators that are approximately 5 times smaller.

The obvious superiority of the yield of technical equipment driven with inertial vibrating systems is due to the use of the phenomenon of multiplying the force transmitted by the vibration excitatory device characterized by the multiplication coefficient " k_y ".

Table 7

Comparison between the technical characteristics of aspiration separators driven with the two types of vibration generators

No.	Characteristic	M.U.	Kinematic excitation	Inertial excitation
1	Working capacity : -pre-cleaning -cleaning	t/h	 15-40 5	 2-67 6-12
2	Vibration amplitude	mm	12-16	14
3	Installed power	kw	1.1-3.92	1.1-1.5
4	Number of sieve levels	piece	2-4	2
5	Number of sieves/equipment	piece	2-8	2-4
6	Sizes : -length -width -height	 mm mm mm	 2020-2350 1500-2750 1876-2500	 1945-2310 1328-1900 1255-1600
7	Equipment weigh	kg	820-2800	750-950

Table 8

Comparison between the technical characteristics of gravitational separators driven with the two types of vibration generators

No.	Characteristic	MU	Kinematic excitation	Inertial excitation
1	Working capacity	t/h	3.5-4	6-15
2	Oscillation frequency	Hz	5-7.5	25
3	Eccentricity	mm	10-12	-
4	Electromotor actuating power	kw	0.8	0,1
5	Sizes : -length -width -height	 mm mm mm	 1500-2200 800-1600 1100-160	 1500 800-1700 1400-1500
6	Equipment weigh	kg	250-800	300-470

It is also observed the decrease of overall dimensions, due to simplification of driveline of the body with sieves, leading to material savings and increased reliability.

CONCLUSIONS

At international level, there is a tendency of using more complex technical equipment for separating impurities from cereal seeds, using the combined principles of separation and the adjustment of work parameter values.

For optimal use of the machine, it is also important to take care in making the various adjustments (to the flow of grain, the suction, and possibly to the speed of vibration of the sieves).

The features of the vibratory sieve separator are as follows:

- smooth and silent operation.
- drive by electric vibratory motors for negligible maintenance and highly effective screening.
- good access to sieves and easy sieve change.
- possibility to change the sieve inclination angle within the range of 0 – 12°.
- choice of aspiration systems from basic aspiration case to high performance pneumatic channels.

The modern design of the vibratory sieve separator allows it to achieve high quality cleaning at large capacities, whilst having small overall dimensions and low power consumption.

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CONSIDERATIONS ON THE EQUIPMENT USED FOR WASTEWATER SETTLING – A REVIEW
/
CONSIDERAŢII PRIVIND ECHIPAMENTELE UTILIZATE PENTRU DECANTAREA APELOR UZATE- REVIEW

As. Ph.D. Stud. Eng. Zăbavă B.ŞT.*1), Prof. Ph.D. Eng. Voicu Gh.1), Lect. Ph.D. Eng. Safta V.V.1), Lect. Ph.D. Eng. Ungureanu N.1), Lect. Ph.D. Eng. Dincă M.1), Lect. Ph.D. Eng. Ionescu M.1), As. Ph.D. Stud. Eng. Munteanu M.1), Assoc. Prof. PhD. Ferdes M.1)

1) University Politehnica of Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
Tel: 0731538941; E-mail: bianca.dragoiu@yahoo.com

Keywords: *wastewater, treatment plant, clarifiers*

ABSTRACT

Water is one of the world's most valuable resources, yet it is under constant threat due to climate change and resulting drought, explosive population growth, and waste. We optimize processes to reduce the volume of water used, take all possible measures to prevent contamination and use highly effective methods – some of which we developed ourselves – to treat wastewater. Wastewater is water that has been used and must be treated before it is released into another body of water, so that it does not cause further pollution of water sources. The purpose of wastewater treatment is to improve water quality, so that it can be discharged into the environment without harming environmental factors. This paper presents the types of equipment used in settling wastewater (United States Environmental Protection Agency, 2007).

REZUMAT

Apa este una dintre cele mai valoroase resurse ale lumii, dar este constant sub pericol din cauza schimbărilor climatice rezultat al creşterii explosive a populaţiei, şi a deşeurilor. Optimizam procesele pentru a reduce volumul de apă uzata, luam toate măsurile posibile pentru a preveni contaminarea şi utilizarea unor metode foarte eficiente - unele dintre care le-am dezvoltat noi înşine - pentru tratarea apei uzate. Apă uzată este apa care a fost utilizata şi trebuie tratata înainte de a fi evacuata in alta sursa de apă, astfel încât să nu producă poluarea suplimentară a surselor de apă. Scopul tratării apelor uzate este de a îmbunătăţi calitatea apei, astfel încât să poată fi deversata în mediul înconjurător, fără a afecta factorii de mediu. Această lucrare prezintă tipurile de echipamente folosite în decantarea apelor uzate (United States Environmental Protection Agency, 2007).

INTRODUCTION

Pollution is one of the major problems of mankind nowadays. Water pollution is mostly due to the industrial development, population growth and urban discharge into rivers and lakes of wastewater, more or less treated. Wastewater is the liquid end product or by-product of a municipal, domestic or industrial activity (*Jency et al., 2015*).

Wastewater is water that has been used and must be treated before it is released into another body of water, so that it does not cause further pollution of water sources *(United States Environmental Protection Agency, 2007).*

The first mechanical and biological processes for plants designed to treat municipal wastewater emerged early by the end of the 19th century. Mechanical, biological and chemical treatment of industrial wastewater was introduced from around the mid-1950s. Prior to this, it had been assumed that chemical wastewater could not be treated biologically (*Wastewater Treatment Plant*).

There are several levels of wastewater treatment; these are primary, secondary and tertiary levels of treatment. Most municipal wastewater treatment facilities use primary and secondary levels of treatment, and some also use tertiary treatments.

The first stage of wastewater treatment takes place in the preliminary treatment plant where materials such as oils, fats, grease, grit, rags and large solids are removed. Primary settlement is sometimes used prior to the biological treatment. Radial or horizontal flow tanks are normally employed to reduce the velocity of flow of the waste water such that a proportion of suspended matter settles out. Biological treatment of waste waters takes place in fixed media or suspended growth reactors using activated sludge, biofiltration, rotating biological contactors, constructed wetlands or variants of these processes. Chemical treatment is used to improve the settling abilities of suspended solids prior to a solids removal stage or to adjust the properties or components of waste water prior to biological treatment (e.g. pH adjustment, reduction of heavy metals or nutrient adjustment). It may also be used for precipitating phosphorus in conjunction with biological phosphorus treatment. Secondary settlement separates the sludge solids from the outflow of the biological stage. Tertiary treatment refers to processes which are used to further reduce parameter values below the standards set out in national regulations. The term is often used in reference to nutrient removal. Sludge treatment can be a significant part of a waste water treatment plant and involves the stabilization and/or thickening and dewatering of sludge prior to reuse or disposal (*Wastewater Treatment Manuals primary, secondary and tertiary treatment, 1997*).

In Figure 1 is presented the technological flow in the mechanical-biological stage of a wastewater treatment plant.

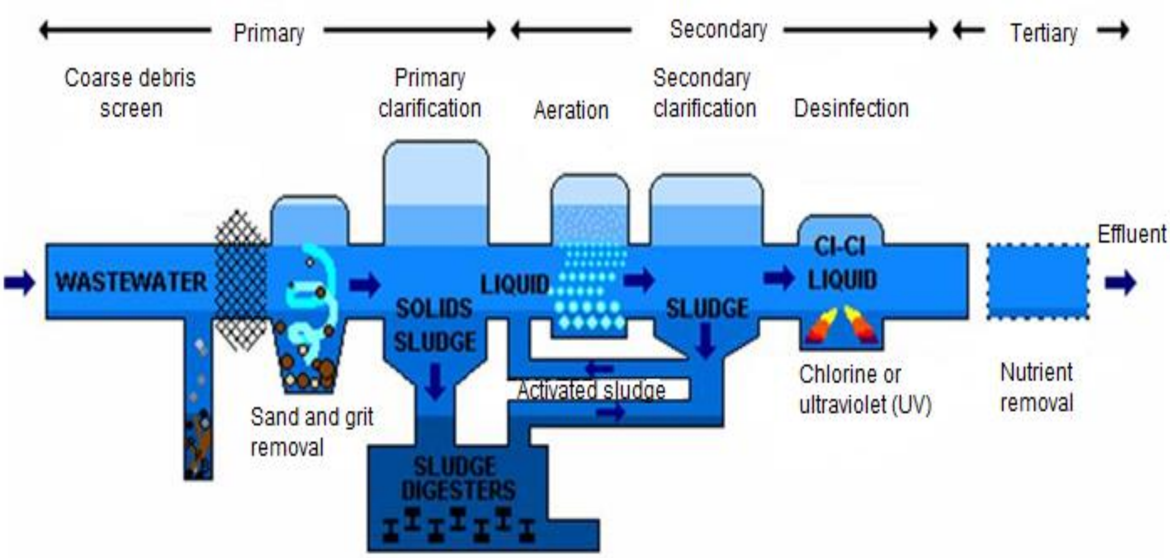

Fig. 1 - Diagram of a mechanical-biological wastewater treatment plant

MATERIAL AND METHOD

Gravity separation of solids from liquid, producing a clarified overflow and a thickened solids underflow, has long been used in the wastewater treatment industry. Often, the terms *clarification* and *thickening* or *sedimentation* are used to describe gravity separation unit operations, depending on if the process focus, or objective, is on the clarified liquid or the thickened solids, respectively.

Decanting is a method of separation by sedimentation of solid particles in a fluid under the action of gravity, hence the name of the gravity separation. Using this method it is possible in the case in which the solid particles are heavier than the liquid suspension. The solid particles fall under its own weight at the bottom of the tank called the settling tank, forming a mixture: solid - liquid more or less concentrated form of sediment sometimes called sludge.

Different varying factors influence the sedimentation process such as those that occur in practice. The efficiency of the sedimentation depends on:

- size and form of the particles; the larger the particle size, the faster sedimentation occurs;
- density of the particles; if the difference between the particle density and the carrier liquid is larger, then the sedimentation process is faster;
- composition of the suspension;
- concentration of the suspension; the larger the concentration, the larger the sedimentation process efficiency.
- suitability of the particles to flocculation;
- temperature; with higher temperatures, the viscosity of the liquids is reduced and thus particles settle faster (*Wastewater lecture note. Delft University of Technology*).Section of Sanitary Engineering]

The efficiency of settling all plants depends on the uniformity of the current distribution in the section perpendicular to the direction of water flow. For this purpose, entry to the settling is installed in front of openings through which water is admitted, deflectors, side skirts, diffuser walls routing and provided with holes or slots. Uniformity should also be ensured during drain. For this, the clarified water evacuation is carried out after overflowing, placed on one or both sides of gutters drain. In front of weirs it provided a submerged wall that prevents floating solids entrainment and fat. Also, are needed to ensure equal flow distribution between settling tanks, collection and removal of the continuous foam on the water surface in the clarifier, collection and disposal, preferably continuously, the sludge deposited at the bottom of the settling tank (*Textile Engineer Handbook / Manualul inginerului textilist, 2003*).

Getting a clear and decanted as sediment as poor liquid in a short time settling characterizes the effectiveness of the operation.

Clarification is the oldest and most widely used operation in the effective treatment of wastewater. The operation consists of removing sediment, turbidity and floating material from raw wastewater. Wastewater contains impurities that remain suspended in the water flow, but who can settle by gravity into calm waters. The process of sedimentation of solids in water is used in both the primary stage and the secondary stage to the waste (*Templeton and Butler, 2013*).

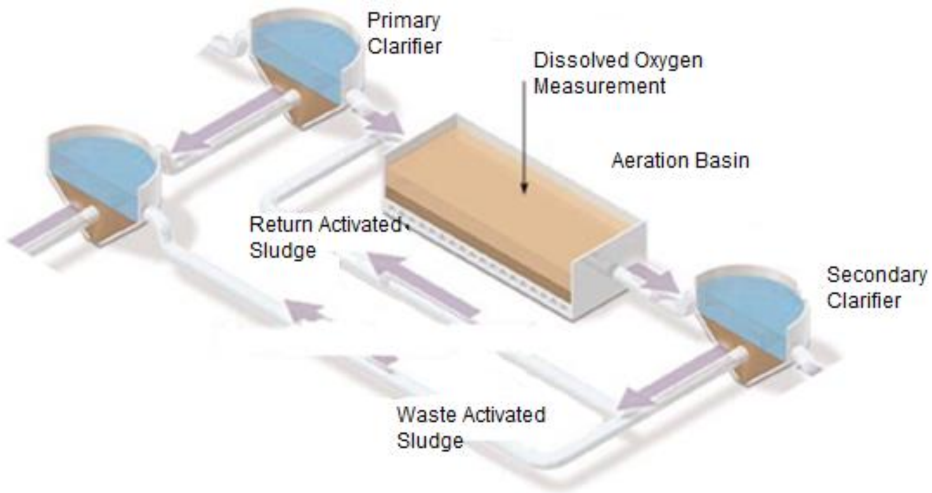

Fig. 2 - The place occupied by settlers in the wastewater treatment plant

RESULTS

Clarifiers are settling tanks built with mechanical means for continuous removal of solids being deposited by sedimentation. A clarifier is generally used to remove solid particulates or suspended solids from liquid for clarification and (or) thickening. Concentrated impurities, discharged from the bottom of the tank are known as sludge, while the particles that float to the surface of the liquid are called scum. After fulfilling the role of the treatment plant, decanters can be primary, secondary and tertiary.

Primary clarifiers

Usually the primary sedimentation tank comes after the grit chamber. Here are separated as many of the settleable undissolved particles as possible. This sludge is called primary sludge. In some plants (oxidation ditch types) where there is no primary sedimentation tank installed, the undissolved particles are caught in the activated sludge and are stabilized there (*Wastewater lecture note. Delft University of Technology).*

Classification of primary clarifiers

a) The direction of flow of wastewater, primary clarifiers are*:*
- horizontal primary clarifiers (can be longitudinal and radial; are mostly used);
- vertical primary clarifiers;
- primary sedimentation tanks inclined

b) After the way settled sludge discharge, the primary clarifiers are classified as follows:
- clarifiers with manual sludge discharge (very rare in the case of small wastewater treatment plant capacity
- gravity drainage sludge clarifiers (clarifiers inclined)
- exhaust mechanical sludge clarifiers (by scraper blades mounted cranes, chain systems, bridges swivel).

Longitudinal tanks

Longitudinal horizontal decanters concrete basins are characterized by their rectangular shape plan and horizontal direction of water flow – Figure 3. The lengths of these separators are an average of up to 30 m and 100 m; the average depth is 3 m and 4 m maximum.

The water enters the tank through a series of orifices, provided with baffles disposed on the upstream wall. After settling through space, passing over a spillway at the downstream end (always adjustable in height) and further into a water canal that leads to other installations.

The sludge deposited on the bottom slab (which has an average slope of 1%) is pushed by a scraper blade located on a bridge scraper towards the upstream end, which is the so-called sludge funnel.

Sludge from the funnel is removed by hydrostatic pressure. Pushing mud deposits in the hopper can be done also with an endless chain provided with a series of blades that drives the sludge.

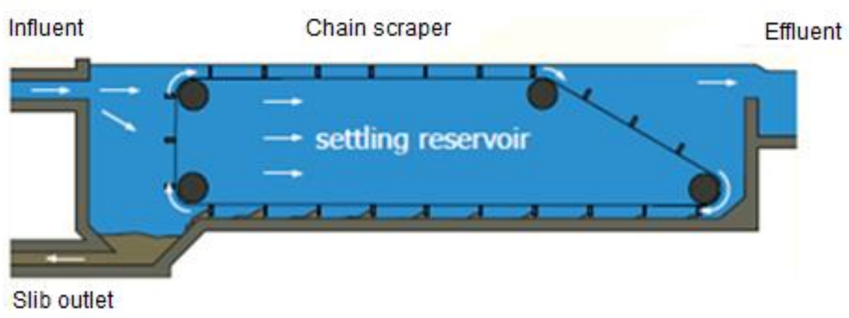

Fig. 3 - Rectangular settling installation
(Wastewater lecture note, Delft University of Technology)

Round tanks

With round sedimentation tanks the wastewater is fed into the middle and is discharged through a trough on the outer periphery. In Figure 4 is drawn a cross-section of round tanks. Above the tank there is a bridge that slowly rotates with sludge scrapers attached, these move the sludge on the bottom slowly towards the central sludge funnel, where it is removed. The bottom is built with a slight slope. For the effluent trough there is a scum board or baffle for holding back the floating solids. The floating solids (usually fat) are pushed into a scum trough by the floating scum scrapers that are attached to the bridge.

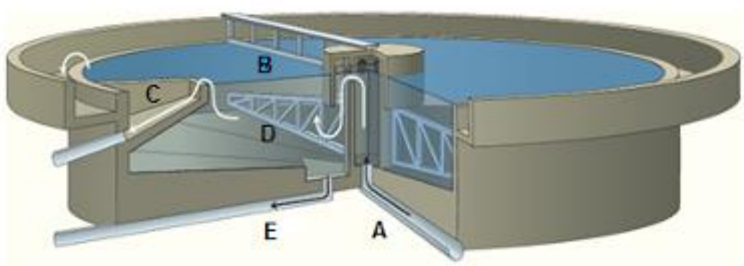

Fig. 4 - Settling reservoir with a circular layout with sludge scraper and floating scum scraper
A. Wastewater inlet B. Floating scum scraper C. Scum trough D. Sludge scraper E. Sludge outlet
(Wastewater lecture note, Delft University of Technology)

In Table 1 is presented the comparison of circular and rectangular clarifiers (*WEF Manual of Practice No. FD-8 Second Edition)*.

Table 1

Comparison of rectangular and circular clarifiers

<table>
<tr><th></th><th>Rectangular clarifiers</th><th>Circular clarifiers</th></tr>
<tr><td rowspan="5">Advantages</td><td>Less land and construction cost in a multiple unit design</td><td>Short detention time for settled sludge</td></tr>
<tr><td>Longer flow path and less chance for short-circuiting than centre-feed/peripheral overflow circular clarifiers</td><td>Better effect of dynamic filtration</td></tr>
<tr><td>More even distribution of sludge loads on collectors</td><td rowspan="3">Simple and more reliable sludge-collecting system</td></tr>
<tr><td>Can be shallower</td></tr>
<tr><td>More effective foam/scum trapping and positive removal</td></tr>
<tr><td rowspan="4">Disadvantages</td><td>Longer detention time for settled sludge</td><td>Centre feed/peripheral units have higher potential for short-circuiting</td></tr>
<tr><td>Possibly less effective for high solids loading</td><td>Lower limits for effluent weir loading</td></tr>
<tr><td rowspan="2">Increased maintenance of collectors</td><td>High head loss for flow distribution</td></tr>
<tr><td>More susceptible to wind effects</td></tr>
</table>

Vertical primary clarifiers

Vertical primary clarifiers are less used and are recommended if there is not enough land to build horizontal clarifiers. Water route is mainly in the vertical direction: water is fed into the central tube settler provided at the bottom with a deflector for uniform distribution, then scroll decanter is discharged upwards and sideways in a circular trench through a discharge pipe.

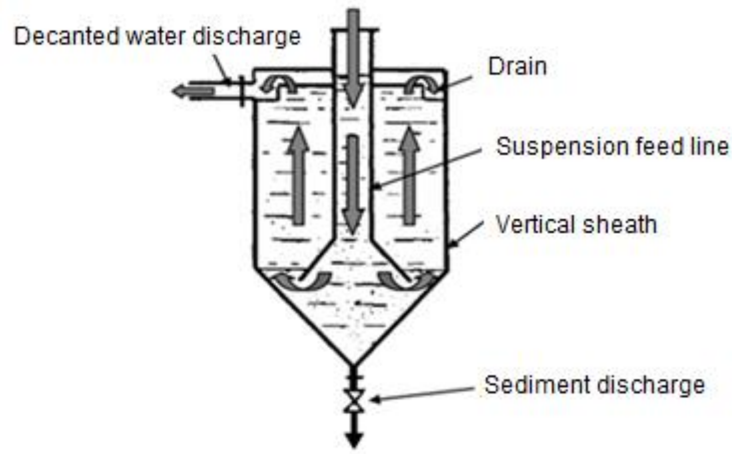

Fig. 5 - Vertical primary clarifier

Primary inclined sedimentation tanks

There are systems in which current flow of waste water undergoing treatment takes place upwardly at an incline to the horizontal so that gravity to drain the sedimented sludge on the bottom slab to a collecting tank. This is the operating principle of lamellar clarifiers, which are very modern installations, presenting the major advantage that are built vertically, thus requiring a surface layout greatly reduced compared to conventional clarifiers. In figure 6 is presented an inclined clarifier.

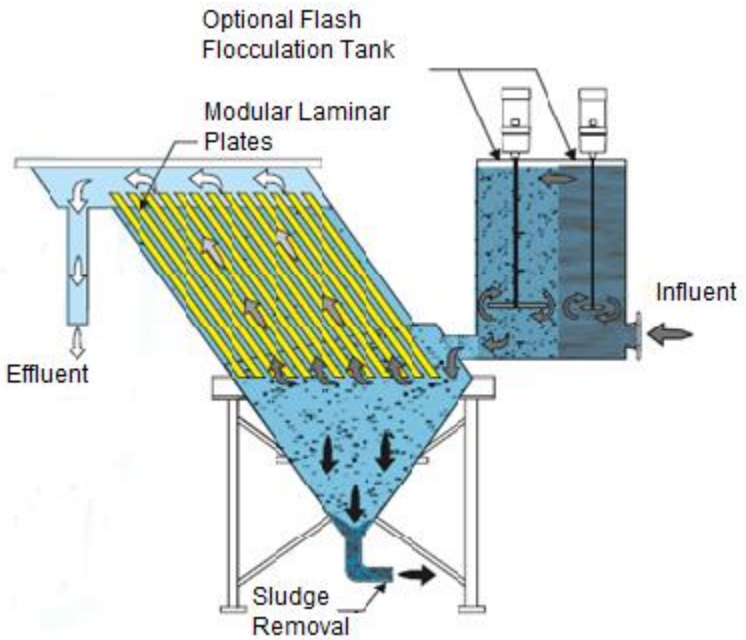

Fig. 6 - Inclined clarifier

Sludge discharged from the primary clarifiers can have three routes:

- to methane tanks for fermentation and biogas production
- to biological treatment stage, that is considered an activated sludge containing organic substances and bacteria form a biological treatment accelerated in combination with air insufflation;
- to sludge dewatering station to be easily transported and stored

Secondary clarifiers

Following primary treatment, wastewater is often sent to what is known as secondary treatment. In secondary treatment, up to 90 percent of the organic matter in the wastewater can be removed by leveraging naturally occurring biological processes. A final step, known as secondary clarification, allows wastewater to settle before it is reintroduced into the environment or sent for further treatment, which is often referred to as tertiary treatment.

Constitute an important part of the biological treatment step and serving to sludge - suspended solids decanted resulting from biological treatment. Sludge from these decanters have a higher content of water is heavily flocked, easily and quickly falls into decay.

Sizing secondary clarifiers is similar primary clarifiers, taking into account waste water flow, sedimentation rate, hydraulic loading surface, settling time, loading surface with solids and sludge recirculation coefficient (*Trambouze, 1999*).

Secondary clarifier is one of the most commonly used unit operations in wastewater treatment plants. It is customarily designed to achieve the separation of solids from biologically treated effluents through the clarification of biological solids and the thickening of sludge (*Ali et al., 2011*).

CONCLUSION

Wastewater contains impurities that remain suspended in the water flow, but they can settle by gravity into calm waters. The process of sedimentation of solids in water is used in both the primary stage and the secondary stage to the waste.

The solid particles fall under its own weight at the bottom of the tank called the settling tank, forming a mixture: solid – liquid, more or less concentrated form of sediment sometimes called sludge.

Usually the primary sedimentation tank comes after the grit chamber. Here are separated as many of the settleable undissolved particles as possible. This sludge is called primary sludge. Secondary clarifier is one of the most commonly used unit operations in wastewater treatment plants. It is customarily designed to achieve the separation of solids from biologically treated effluents through the clarification of biological solids and the thickening of sludge.

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NEW TREND IN THE APPLICATION OF NANOTECHNOLOGY IN WASTEWATER TREATMENT - CeO_2 PHOTOCATALYST
/
O NOUĂ DIRECŢIE ÎN APLICAREA NANOTEHNOLOGIEI ÎN EPURAREA APELOR - FOTOCATALIZATORUL CeO_2

Assoc. Prof. Ph.D. Eng. Covaliu I.C.[1]*, Lect. Ph.D. Eng. Ionescu M.[1], Prof. Ph.D. Eng. Paraschiv G. [1], Prof. Ph.D. Eng. Biriş S.Şt. [1], Ph.D. Eng. Matei C.[1], Assist. PhD. Toma L.[1], IDTIII PhD. Matache Mihai Gabriel[2]
[1]) Universities Polytechnic Bucharest/ Romania;
[2]) National Institute of Research-Development for Machines and Installations Design to Agriculture and Food Industry, Romania
Tel: 0722791791; E-mail: cristina_covaliu@yahoo.com

Keywords: *nanotechnology, wastewater treatment, photocatalyst,* CeO_2*.*

ABSTRACT

The study presents the application of nanotechnology in wastewater treatment field through photocatalysis which implies the using of semiconductor nanomaterials, such as CeO_2*. Photocatalysis also named "green technology" consists of photo-degradation of various organic pollutant compounds persistent in water up to* CO_2 *and* H_2O*, under UV or visible light. Several researchers have recently reported the photocatalytic behaviour of* CeO_2 *to degrade some organic pollutants from water.*

REZUMAT

Studiul prezintă aplicarea nanotehnologiei în domeniul epurării apei prin intermediul fotocatalizei ce implică utilizarea unor nanomateriale semiconductoare, ca de exemplu CeO_2*. Fotocataliza, denumită şi "tehnologia verde" constă în degradarea diferiţilor compuşi organici poluanţi persistenţi până la* CO_2 *şi* H_2O *sub actiunea UV sau a luminii vizibile. Câţiva cercercetători au publicat de curând comportamentul fotocatalitic al* CeO_2 *aplicat în scopul de degradării unor poluanţi organici din apă.*

INTRODUCTION

Nanotechnologies are considered at the moment "emerging technologies" that can revolutionize a large number of application areas. More than 10 years after the launch of the National Initiative in Nanotechnology (USA, January 2000) considerable progress has been made in many countries of the world (about 60 have their own nanotechnology programs), and by 2020 a decisive impact on quality of life and of the environment is expected. From this point of view, the new "plan" from US (2011-2020), developed after wide internationally consultations, targeted the beginning of a new period, where the research focus is on the directions of application, [25].

EU rules on reducing harmful emissions for the environment and for the final user is a more acute concern for specialists in various fields of research and industry.

Recently there has been developed a new class of materials known as photocatalytic materials which present certain requirements, namely capability of catalysing pollutants, organic or inorganic, through the presence of a semiconductor which produces strong oxidizing and reducing species on the semiconductor surface due to the absorption of light energy, [12].

There are known various processes for advanced treatment of wastewater, which have the disadvantage of high costs, generation of by-products (for example, sludge in large quantities, whose treatment and, optionally, incineration requires advanced technology, high energy-intensive consumption and expensive).

Advanced Oxidation Processes are technologies whose effectiveness is recognized for the treatment of wastewater containing heavy biodegradable or non-biodegradable organic compounds and with high toxicity. Advanced oxidation processes are photolysis, heterogeneous photocatalysis and homogeneous photocatalysis, [15].

The organic compounds that can be found as pollutants in wastewater from industrial sources or household consumption should be removed or destroyed before it reaches the environment. Such pollutants can often be found in groundwater and surface water which also requires treatment to obtain an acceptable quality of drinking water. Growing concern over environmental pollutants suggested the need to develop new treatment methods, so that the photocatalysts have gained attention in the degradation of pollutants, [2].

Photocatalysis defined as "green technology" is one of the main challenges for the treatment/decontamination of air and water. Its principle is based on the simultaneous action of light and a catalyst (semiconductor) that allows the destruction of the polluting molecules, without degrading the environment. The catalyst most commonly used is titanium dioxide (TiO_2), which is non-toxic and economically efficient, [15].

Photocatalysis is a promising method, which can be used in photo degradation of various organic compounds, persistent in water and air. The principle of photocatalysis is the mineralization of organic compounds up to CO_2 and H_2O, by UV (VIS) irradiation in the presence of a photocatalyst responsive to radiation in this area. So, photocatalytic system is often represented as an "artificial photosynthesis", [19].

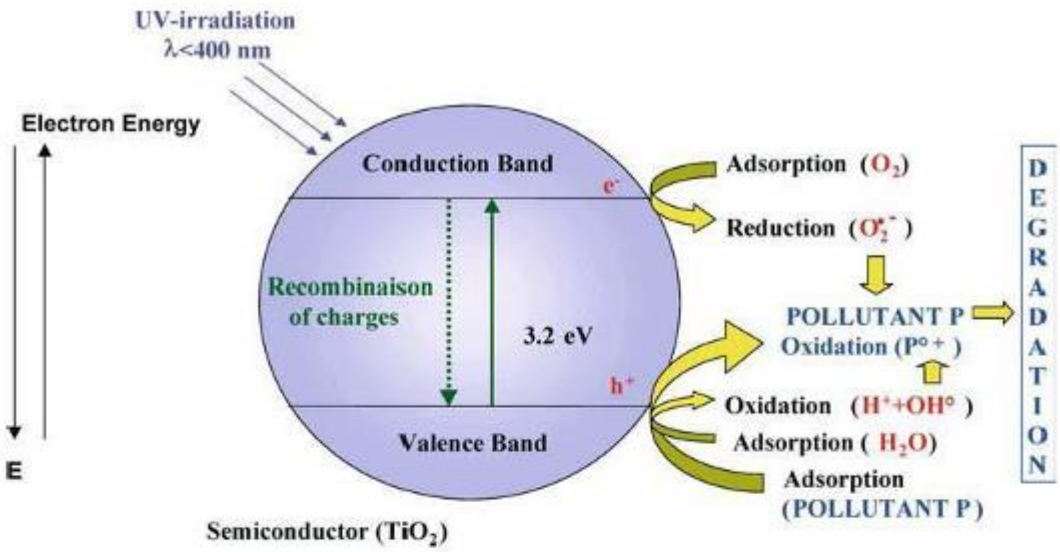

Fig. 1 - A semiconductor photocatalyst activation mechanism [24].

Advantages of catalytic methods compared to conventional methods of treatment are:
- pollutant transfer is not just from a phase to another (as, for example, at the activated carbon adsorption), but there is a chemical change of the respective pollutant;
- total mineralization of the toxic organic compound can occur;
- does not generate sludge therefore require no additional costs for disposal;
- can be applied to the degradation of refractory organic compounds, which cannot be removed by conventional methods;
- the degradation of refractory compounds includes either the complete mineralization thereof, or a pre-treatment phase, by conversion into compounds which can be removed by conventional methods (for example, biological treatment);
- can be applied to the treatment of contaminants present in the effluent, in low concentrations (of the order of ppb); no by-products are formed or they result in reduced amounts;
- are ideal for reducing the presence of the compounds formed in conventional processes;
- improves the organoleptic qualities of the water treated to be used as drinking water;
- there are situations where power consumption is lower than in other processes (such as, for example, incineration), [15]

The process of photocatalysis has been extensively studied using TiO_2, an ideal material in terms of their chemical and economically viable.

The properties of titanium dioxide which gives him a wide use are:
- high capacity production of hydroxyl radicals in an aqueous medium under UV irradiation;
- potential to amend the band gap and to use solar radiation;
- chemical inertness, including under extreme conditions;
- commercial availability at a relatively low price;
- various methods with low complexity for the preparation in the laboratory, both in powder form and in the form of layers, [5]

The major disadvantage presented by TiO_2 is the fact that it can absorb radiation only in the ultraviolet region of the solar spectrum. Another disadvantage of the TiO_2 is that electron-hole recombination (the charge carrier) occurs within a time interval of the order of nanoseconds and without promoters (e.g. Pt or RuO_2) photocatalytic activity decreases. Deposition or incorporation of metal ions as dopants in TiO_2 particles may influence performance of these photocatalysts. This affects the dynamics of electron-hole recombination and interfacial load transfer. The most effective improvement of the photoactivity by doping was noted on the "nano" particle size, in which the dopant ions are located in the first 1-2 nm on the surface, [2].

By doping a semiconductor, the band gap reduction is achieved (Eg doped <Eg semiconductor), thus modifying the wavelength of photocatalytic activation toward the visible region of the visible spectrum. B. Some researchers reported that they were able to obtain photocatalytic TiO_2 in the visible range, by its doping with Fe (III), [20].

There have also been synthesized and tested new semiconductor materials with photocatalytic properties. Development of materials for photocatalysis (photocatalysts) requires the identification and optimizing the properties governing photocatalysis processes.

In order to be used in the processes of photocatalysis, semiconductors must fulfil some general conditions:
- photocatalytic activity by generating electron-hole pairs at radiation absorption with energy equal or greater than the band gap energy (energy needed for the migration of an electron from the valence band to conduction band);
- chemical and biological inert which ensures the catalyst integrity at the end process (does not react/not degrade);
- stability in photocorrosion processes;
- photocatalytic activity in the visible domain or near ultraviolet;
- convenient price;
- minimized toxicity, [5].

It is well known that rare-earth oxides have been applied widely in many fields. The cerium dioxide (CeO_2), one of them, is used in numerous applications in catalysts [14], catalyst supports [16], cosmetics materials [21], ceramic materials [23], oxygen gas sensors [9], solid oxide fuel cells [13] and fluorescent materials [11]. Nano sized materials have been intensively studied in recent years because it was noticed that their significant properties are different from the bulk, [3]. Thus, in the last few years, many studies on the preparation and properties of CeO_2 nanocrystalline have been made [22].

CeO_2 has some identical properties with the TiO_2, such as wide band gap, nontoxicity, and high stability. Moreover, the photogenerated electron–hole pairs have longer lifetimes than those generated by other photocatalysts, e.g. TiO_2. Due to its unique 4f electron configuration, CeO_2 has been frequently used as a component to prepare complex oxides or as a dopant to improve titania-based catalysts' performances [18; 17]. The pure CeO_2 has been investigated under UV irradiation concerning water splitting for the obtaining of hydrogen gas [7; 1] and photodegradation of toluene in the gas phase [8]. Several researchers have recently reported the photocatalytic behaviours of CeO_2 under sunlight irradiation to degrade dyes [22; 4]. Another study analyses the utilization of CeO_2 for photocatalytic degradation of sulfo group-containing azo dyes in aqueous suspension irradiated by visible light. Acid orange 7 was chosen as model target to examine the adsorption and degradation of azo dye on CeO_2 irradiated by visible light. The CeO_2 presented a high photoactivity regarding the degradation of azo dye and has been demonstrated to be a promising alternative for the treatment under visible light irradiation of wastewater containing dye, [10].

CONCLUSION

CeO_2 has been shown to be an effective catalyst due to the redox potential of the Ce^{4+}/Ce^{3+} couple and to its resistance to chemical and photocorrosion, but also for the strong light absorption in the UV region (absorption edge, 385–400 nm). But, the disadvantage presented by the CeO_2, meaning the large band gap (3.2 eV), limits further application of CeO_2.Thus it would be hugely beneficial to extend the light absorption of CeO_2 to the visible light region. In order to reduce this disadvantage, many methods have been investigated to shift the absorption of CeO_2 onset by doping or coupling with other materials.

ACKNOWLEDGEMENTS

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REDUCING CONVENTIONAL FUEL CONSUMPTION BY IMPLEMENTING HYBRID ENERGY PRODUCTION SYSTEMS
/
REDUCEREA CONSUMULUI DE CARBURANT CONVENŢIONAL PRIN IMPLEMENTAREA SISTEMELOR HIBRID DE PRODUCŢIE A ENERGIEI

Ph.D. Eng Dumitrescu C.*[1)], Prof. Hab. Ph.D. Eng. Dulgheru V. [2)], Ph.D. Eng. Cristescu C.[1)], Eng. Dumitrescu L.[1)], Ph.D. Eng. Blejan M.[1)], Ph.D. Eng. Radoi R.[1)]

[1)]National Institute for Optoelectronics subsidiary Hydraulics and Pneumatics Research Institute, INOE 2000-IHP, Bucharest, Romania;
[2)] Technical University of Moldova, Mechanical Faculty, Chişinău, Moldova
Tel: 0727391783; E-mail: dumitrescu.ihp@fluidas.ro

Keywords: *renewable energy, reducing consumption, conversion energy, hybrid system, energetic autonomy*

ABSTRACT

Benefiting from significant renewable energy resources, Romania has made great strides in recent years in the field of converting solar and wind energy; in addition to these, hydraulic energy has been exploited for several decades. For the conversion systems of these types of energy, lately there have emerged technical solutions at competitive prices, making them accessible to smaller users as well. Thus, in remote areas, renewable energy intelligently exploited can provide autonomy in terms of energy or, in case they are used in hybrid systems, a significant reduction in costs.

REZUMAT

Beneficiind de importante resurse de energie regenerabila, Romania a realizat in ultimii ani pasi importanti in domeniul conversiei energiilor solara si eoliana; pe langa acestea, energia hidraulica este exploatata de mai multe decenii. Pentru sistemele de conversie ale acestor tipuri de energii, in ultimul timp au aparut solutii tehnice la preturi competitive, care le fac accesibile si utilizatorilor mai mici. Astfel, in zonele izolate, energiile regenerabile exploatate inteligent pot oferi autonomie energetica sau, in situatia in care sunt utilizate in sisteme hibrid, o reducere semnificativa a costurilor.

INTRODUCTION

The use of renewable energy as sources of obtaining clean energy is a current concern, and for certain areas on Earth this is the only way to obtain useful (electrical, thermal, mechanical, etc.) energy in order to increase quality of life. 2015 was a very favourable year for development of renewable energy conversion systems; besides continuous technical progress recorded in increasing the efficiency of conversion systems, decrease in oil prices created pressure for reducing the cost of energy produced from renewable sources. In this context, increasing the amount of energy from renewable sources recorded significant values in almost all categories, as one can see in the following comparison table. Investments in new production capacities were of about 285 billion $. (*REN21, 2016*).

Table 1

Synthetic indicators for renewable energy for 2015, globally

	M.U.	2014	**2015**
Electricity			
Power from renewable sources (total, excluding hydropower)	GW	665	**785**
Power from renewable sources (total, including hydropower)	GW	1.701	**1.849**
Hydroelectric power	GW	1.036	**1.064**
Biomass energy	GW	101	**106**
Geothermal energy	GW	12,9	**13,2**
Photovoltaic (PV) solar panels	GW	177	**227**
Wind energy	GW	370	**433**
Heat			
Solar capacity and capacity of heated water	GW_{th}	409	**435**

As one can notice, the highest increases were registered in the use of wind power (+ 63 GW) and in the use of photovoltaic solar panels (+ 50 GW). Regarding electricity, percentage obtained from renewable sources is 23.7%, by 2015, of which 16.6% is hydropower.

Regarding the situation nationally, the installed capacity in the National Energy System on 1st of April 2015 was of 22,308 MW overall: water 6,376 MW (28.5%), coal 5,718 MW (25.6%), hydrocarbons 4.539 MW (20.3%), wind 2.953 MW (13.2%), nuclear 1.413 MW (6.3%), solar 1.208 MW (5.4%), biomass 100 MW (0.45%) and geothermal energy 0.05 MW. [http://www.digi24.ro, 2016]. On 1st of April 2016 increases were recorded in most categories of sources of electricity production, as follows: (*http://www.agerpres.ro, 2016*).

Table 2

The installed capacity of renewable energy sources (MW)

Renewable energy source	2015	2016	Increase (%)
Photovoltaic solar energy	1208	1343	11.2
Wind energy	2953	3129	6
Micro hydropower	567	588	3.7
Biomass	100	103	3

Having at its disposal a wide range of types of renewable energy, Romania met the objectives set by the 2009/28/EC Directive, also known as the 20/20/20 Directive, which provides reaching by 2020 a quota of 24% of energy from renewable energy; this target has already been reached by 1st of January 2014, when the installed electric power had a value of 4.349 MW.

MATERIAL AND METHOD

Despite progress in recent years in our country, there is still significant potential to increase the amounts of energy produced from renewables [Study, 2006]; this is especially important in remote areas, which are not supplied from the common electricity network. In the absence of possibilities for initial investment in conversion systems (for wind, solar, hydro energy), for most of the time electricity is provided by means of generators driven by heat engines; this solution has the disadvantage of a significant consumption of conventional fuel (Diesel fuel or gasoline).

Hydraulics and Pneumatics Research Institute (INOE 2000-IHP) is currently implementing a project on reducing the consumption of conventional fuel used to produce electricity at an isolated area target which belongs to the Ministry of Administration and Interior and is located near the bank of the Danube (mobile docking pontoon). This area target has a unique source of electricity, namely an electric generator driven by a Diesel engine with an output of approx. 10 kW. Besides electricity supplied for direct consumption, the generator charges a group of electric accumulators which provide a backup supply to consumers.

If this group of electric accumulators can be charged from a different (renewable) source, consumption of conventional fuel used for the heat engine which drives the electric generator would drop significantly; On the other hand, some consumers (of lower importance) can be powered from the renewable source, using intelligent energy distribution.

To achieve the ultimate objective (reducing fuel consumption) (*Popescu, 2010, Popescu 2013*), in the first project phase, at the end of which a basic solution must be proposed, action must be taken in these directions:

- determine the critical and non-critical consumers in the location;
- determine the renewable energy sources and their potential for use;
- develop the intelligent distribution algorithm and schematic diagram.

Determining the critical/non-critical consumers implies dividing the electric consumers found in the location in 2 categories, depending on their importance in meeting the role of the area target. Within the category of critical consumers there falls the specific work equipment, while within the category of non-critical consumers there fall the consumers which ensure working conditions for staff (air conditioning, food preparation, producing domestic hot water, cleanliness, operation of audio-video broadcast media for information, etc.).

Taking into account the role of each electrical consumer and operating conditions, it was determined that the electrical power needed for critical consumers is of about 5 kW, while for non-critical consumers it is 2.5 kW.

Determining the available and usable renewable energy sources is the most important work direction. Since the site is located near the banks of the Danube, on the water, theoretically it benefits of renewable energy from multiple sources: hydro, wind, solar, biomass.

Biomass energy was eliminated early in the project, because its exploitation requires, on the one hand, finding the biomass and processing it (chopping, drying), and on the other hand burning it produces only heat energy; globally, harnessing biomass is more complicated than other types of renewable energy.

Harnessing water energy, given the relatively low speed of the Danube in the area of interest, this can be done by using floating micro-hydropower plants which use kinetic energy. Energy of flowing water, for a speed of 1 m/s, is about 500 W for a section of 1 m2. [*Bostan 2007, Bostan 2011*]. To estimate the actual value one must consider Betz's coefficient – 0.593, the maximum theoretical efficiency of conversion – and also the fact that most current solutions ensure a coefficient of water kinetic energy use within the value of 0.1...0.2. [*Maican, 2015*]

A very important aspect to functionally optimize the micro hydropower plants is choosing the optimum hydrodynamic profile of blades which allows increase in the conversion factor (the Betz's coefficient) due to hydrodynamic bearing forces. The increase in the degree of conversion is also achieved by ensuring optimum position of the blade in relation to water currents in different phases of engine rotation; an orientation mechanism of blades is used for this purpose. Thus, virtually all blades (even those who move against water currents) are simultaneously involved in generating overall torque. The blades that move in the direction of water currents use both hydrodynamic forces and water pressure to generate torque. Moving against the water currents, the blades only use hydrodynamic bearing forces to generate torque. Due to the fact that the relative speed of the blades against the water current is virtually two times higher, the hydrodynamic bearing force is relatively large, and the torque generated is commensurable with the one generated by water pressure. The following figure shows the diagram of a micro hydropower plant based on kinetic effect (MHCF). (*Bostan, 2011)*

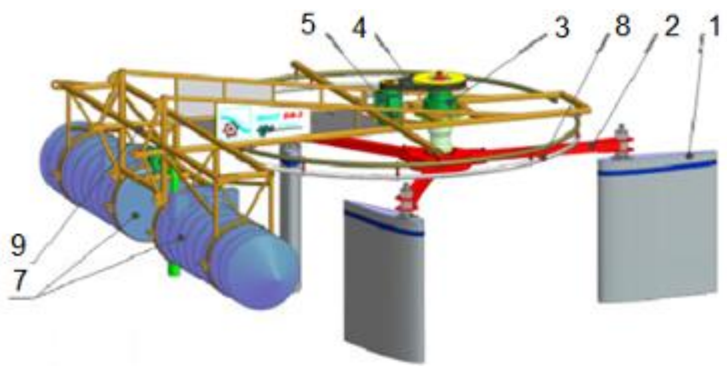

Fig. 1 - MHCF with hydrodynamic profile of blades

1 – blades; 2 – hydrodynamic rotor; 3 – speed multiplier; 4 – belt transmission; 5 – power generator; 6 – pump; 7 – floats; 8 – guidance device; 9 - frame

Since the flow rate of Danube does not exceed, in the most part of flowing on Romania's territory, the speed of 1 m/s, [Strechie, 2008], micro hydropower plants operating on kinetic effect could be a solution for producing energy from water. Yet another aspect that must be considered is surface freezing of the Danube in winter; this makes hydraulic energy only be considered a backup solution.

To determine the possibilities for using wind energy there have been studied maps of the area wind potential and actual measurements were performed on site, which indicated maximum speeds of up to 5 m/s (figure 2).

Fig. 2 - Wind speed on site

This speed is insufficient for a good functioning of classical wind turbines, which require speeds of 8…15 m/s for optimal functioning. Low speed first rises the issue of starting-up the wind turbine; to overcome this, we have considered a combined wind turbine solution, which uses a Savonius rotor for starting-up and a larger size Darrieus rotor for actually generating electricity, as one can see in Figure 3.

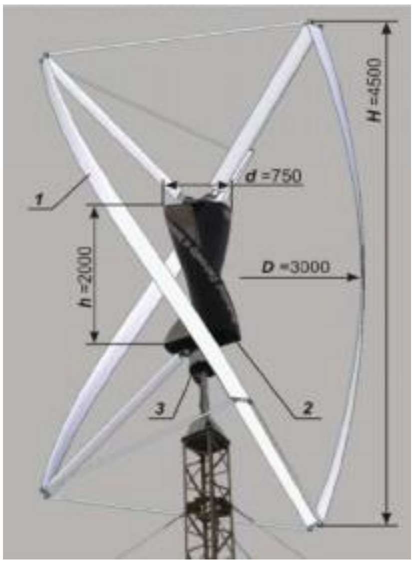

Fig. 3 - Mixed wind turbine, adjusted for low-speed wind
1 – Darrieus main rotor;2 – Savonius rotor; 3 – turbine shaft

The safest renewable energy source, which has a high potential in the south of our country, is solar energy. The availability of this type of energy is confirmed both by solar potential maps, and by on site measurements, in which there have been recorded values over 1000 W/m2 for solar radiation. Another advantage of solar energy is that it can be used both to obtain heat energy (using thermal solar panels), and electrical energy, by using photovoltaic panels. Solar energy can be combined with hydro or wind energy, depending on the level to which reducing fuel consumption is intended and of course depending on the value of the investment that can be done.

RESULTS

Taking into account the analysis conducted so far, it is expected that solution that will be proposed will be based on solar energy, to which we can add hydro and/or wind energy. The figure below shows the block diagram of the electrical installation which will be proposed for implementation, in which the current electrical energy source (generator set consisting of electric generator and drive heat motor) is combined with a system of photovoltaic solar panels, to which we can add one or several sources of renewable energy (synthetically represented by a wind turbine), resulting in a hybrid energy system.

Compared to the current situation, on the block diagram, the battery charge controller, connection box and energy source have been added.

The battery charge controller provides charging of the existing accumulators from renewable sources, thus reducing the demand on the generator set and enabling consumption of a quantity of electricity produced from renewable sources.

The connection box ensures the connection of strings of photovoltaic panels / wind turbines to the battery of accumulators charge controller.

To increase energy efficiency of photovoltaic panels and thermal solar panels are needed orientation/ guidance systems called trackers, which maximize the amount of solar energy collected, by adjusting the position of the solar panel, tacking the apparent movement of the sun during the day (figure 4, 5). Usually, drive of solar panels is done by means of electric, pneumatic or hydraulic systems/ trackers [Şerban, 2012].

In the specialized literature there are three types of solar orientation systems: the equatorial system, the pseudo-equatorial system and the azimuth system.

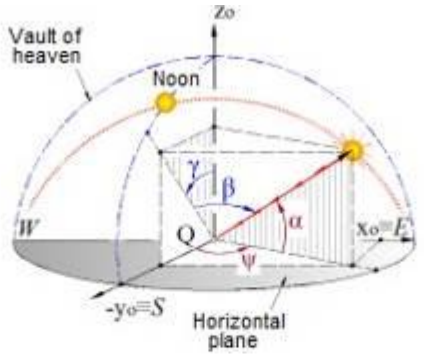

Fig. 4 - Global and local reference systems and sun angles corresponding to the equatorial system

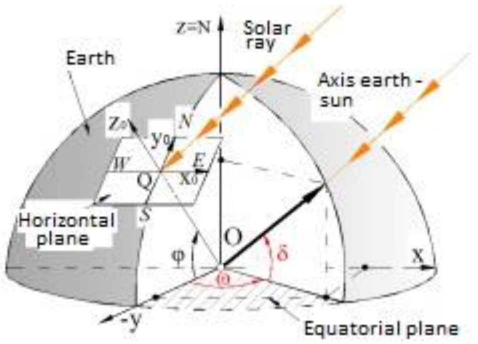

Fig. 5 - Global and local reference systems and sun angles corresponding to the pseudo-equatorial and azimuth systems

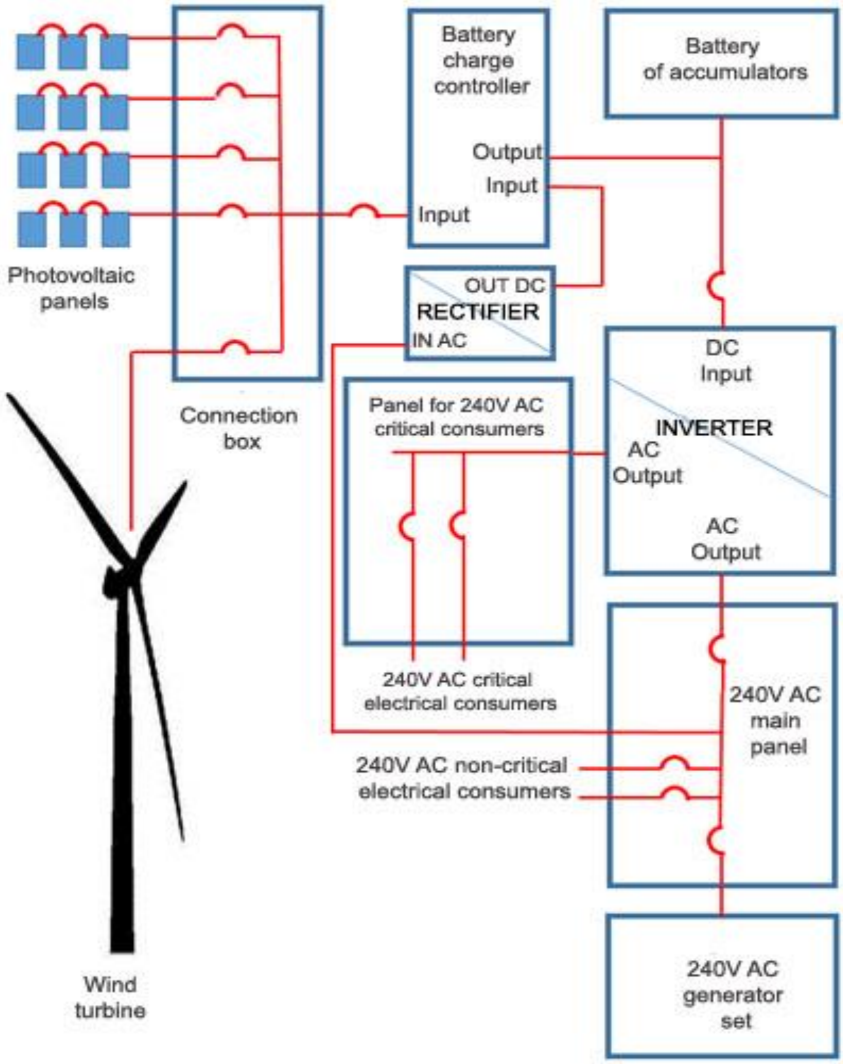

Fig. 6 - Schematic diagram of the electrical installation with renewable and classical source

CONCLUSIONS

From the materials presented above in this paper the following conclusions can be drawn:

- The renewable energy which has the highest potential for use is solar energy; this is clear from both the solar potential map, and from direct measurement on site, where a value of 1015 W/m^2 has been recorded; means of converting solar energy for producing heat and electricity can be developed in our country at competitive prices, out of components available on the market;

Solar energy can be used both for producing electrical energy, using photovoltaic (PV) solar panels, and for obtaining heat energy by using thermal solar panels; producing both types of energy leads to lower fuel consumption;

Wind energy, although present in the area of interest, is characterized by wind values below 5 m/s, which makes it unsuitable for use, given that common speeds are in the range 8…15 m/s; on the other hand, since the target areas are located at the shore, high roughness of the land causes wind speed to have a high degree of variability;

The low speed of Danube, all along its length (max. 1 m/s), makes the placement of floating micro hydropower plants uneconomical; add to this the threat of damaging them in winter time, because of frost;

The space that can be used allows very good conditions for placing solar panels, either thermal or electric, there being available an area of approx. 50 m^2 for placing the panels; on this area there can be installed two solar thermal panels, with a standard surface area of approx. 2 m^2, and the remaining area can be used for mounting of photovoltaic panels.

Reducing fuel consumption used at the location in order to produce electricity by using renewable sources is feasible, being supported by the large amount of renewable energy in the work areas, especially solar energy; the estimated percentage at this stage of the project, which will have to be confirmed in the actual design phase, is 20…35%., depending on the value of the future investment.

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AN EDUCATIONAL ALTERNATIVE TO THE HUNTING OF POKÉMONS: REDUCING THE IMPACT OF ILLEGAL WASTE DEPOSITS
/
O ALTERNATIVĂ EDUCAŢIONALĂ LA VÂNAREA DE POKEMONI: REDUCEREA IMPACTULUI DEPOZITELOR ILEGALE DE DEŞEURI

Math. Cardei P.
INMA Bucharest / Romania
petru_cardei@yahoo.com

Keywords: *waste deposits, environment protection, Pokémons, education*

ABSTRACT

This article provides an educational method with practical applications in maintaining and improving environment quality. The method exposed is an application which starts from the results obtained by the author in the cross-border project, "Network and web platform to improve the public awareness on environmental management and protection in the cross border area Giurgiu – Rousse and adjacent cross border areas", led by INMA Bucharest in the period 2014-2015. It is known that in these cross-border projects are applied the research results, and generally do not make research activity. However, if such project activities are profound enough, it is very likely that they become the source of new results, which arise after new research. The researcher applying the results cannot stop his mind and always seeks answers to new questions. In such circumstances appeared this article. Addressing, (partially, the first two stages) to the pupils in primary school or bigger, the method is applied as a useful alternative to the hunting of Pokémons. At a higher level, (stages three and four), the method needs the presence in the team of some specialists. Therefore, I propose collaboration between those who build the base of the pyramid (children, youth) and those who complete the top of the pyramid: teachers, specialists.

In order to implement this method, the paper aims especially educators, who, this way, have the chance to achieve several important goals: focus the energy on school children in a manner that is useful for the society, increase students' knowledge level, improve physical capacities, by moving on land with different profiles, early familiarization of the students with basic GIS techniques, maturation of children's way of thinking regarding environment delicate matters. For these reasons, the method proposed in this article can be called an educational solution to the problem of illegal waste deposits.

REZUMAT

Lucrarea oferă o metodă educaţională cu aplicaţii practice în menţinerea şi îmbunătăţirea calităţii mediului. Metoda expusă este o aplicaţie care porneşte de la rezultatele obţinute de către autor în proiectul Tranfrontalier "Retea si platforma web pentru imbunatatirea constiintei publice privitoare la gestionarea si protectia mediului in zona transfrontaliera Giurgiu – Ruse si in zonele adiacente zonei transfrontaliere", condus de către INMA Bucureşti în perioada 2014-2015. Este cunoscut că în aceste proiecte transfrontaliere se aplică rezultatele cercetărilor şi în general nu se desfăşoară activităţi de cercetare. Totuşi, dacă aceste activităţi sunt suficent de profunde, este foarte posibil să devină sursa unor noi rezultate, care apar în urma unei noi cercetări. Cercetătorul care aplică rezultatele nu îşi poate opri mintea şi este mereu în căutare de răspunsuri pentru întrebări noi. În astfel de circumstanţe a apărut lucrarea de faţă. Adresându-se (parţial, primele două etape) copiilor din şcoala primară sau mai mari, metoda este aplicată ca o alternativă utilă la vânarea de Pokemoni. La un nivel mai înalt (etapele trei şi patuu), metoda necesită prezenţa unor specialişti în echipă. Astfel, propun colaborarea între cei ce construiesc baza piramidei (copii, tineri) şi cei care completează vârful piramidei (profesori, specialişti).

În scopul implementării metodei, lucrarea îi ţinteşte în special pe cei ce educă care, în acest fel, au o şansă să îndeplinească mai multe ţinte: focalizarea energia pe copii de şcoală într-o manieră utilă pentru societate; creaşterea nivelului de cunoştinţe al elevilor, îmbunătăţind capacităţile fizice prin deplasarea pe terenuri cu profiluri diferite; familiarizarea timpurie a elevilor cu tehnicile de bază ale GIS; maturarea gândirii copiilor în probleme delicate de mediu. Din aceste motive, metoda propusă în acest articol poate fi numită soluţie educaţională la problema depozitelor ilegale de deşeuri.

INTRODUCTION

The illegal waste deposits (illegal dumping, according to [15], [16], [17], also litter, [18], fly-tipping, according to [19]), domestic or industrial, represent a major problem for the humankind, today. The waste, annually cover, at a rate increasingly larger[1], land for agricultural use, vacant lands or with other destinations (Italy, [16], Holland, [20], England, [21], Hungary, [22], Canada, [28], Australia, [29]). Methods of greening exhausted landfills, recycling, conservation methods etc. have been developed and applied. Despite the appreciable results of the scientific actions against human population's waste, illegal waste deposits (illegal dumping) have appeared [16]. Results of the lack of general, environment education and of authorities' lack of reaction, the illegal waste deposits are more and more numerous and have a spatial distribution which makes them difficult to remove. These deposits are usually multiple and distributed relatively randomly in space. Often such illegal landfills appear in the vicinity of recreational areas, tourist areas, but also in residential areas, farmlands, forests, in the areas bordering backwaters or rivers, industrial areas, roads, urban areas, etc.

Removing the illegal deposits of waste is a difficult operation, because in many cases the waste quantities are small and are located at great distances from each other. The effort to remove these deposits is often developed on rough terrain, which makes the operation very expensive and costs cannot be covered, even partially, by the price obtained for such recyclable waste (plastic, paper, glass, etc.). Many of these landfills contain construction debris (rubble, asphalt, bitumen) or organic waste. Often, some of the waste decompose rapidly, and produce odours and substances hazardous to health.

For the above mentioned reasons, locating, assessing and eliminating illegal waste deposits have become important issue, especially in areas characterized by a low level of environmental education. It is also important the action to prevent the formation or restoration of such deposits, by ensuring security patrols, written propaganda in the field and school education.

In this paper, I propose a method that, in the first part aims detecting, determining the geographical coordinates and the marking on a GIS map, available on the Internet, of illegal waste deposits locations. All these actions can be developed by school children aged 10-12 years or bigger.

MATERIAL AND METHOD

The method of reducing the impact of illegal waste deposits on the environment is a method to identify and remedy environmental problems that have quite a high frequency in Eastern Europe, as shown in studies made in [1] and worldwide [16, 20, 21, 22, 28, 29] . The method formulation is a starting one; it can be improved or remade, taking into account any suggestions.

The working method consists of four major steps:
- Identification and evaluation in the field of illegal waste deposits;
- Marking the location and completing data found in the field ([2], [3], [4]), on the GIS map;
- Determining the environmental risks of the deposit found;
- Monitoring the illegal waste deposits.

A synthesis of this method is presented in Table 1.

The monitoring stage can be performed for observing the evolution of each type of waste. Also, through the monitoring are reported exceeded emission limits of the substances resulting from the decomposition of part of the waste, or exceeded admissible amount of waste. It is recommended that this stage is conducted in collaboration with authorities that can trigger actions for: elimination of the illegal waste deposits, ecological activities, surveillance and interception of the persons who made illegal waste dumping.

The proposed method is apparently, a non - repressive, method. It is not in our intention, even in the monitoring phase, to provide security of the areas affected by illegal waste deposits, or the punishment of the people who dumped waste in those areas. However, collaborating with administrative organs responsible for repressive action is not ruled out, especially if monitoring indicators show increasing quantitative dangers or if environmental risks exceed limits for certain objectives. The legislation is well established in many countries, regarding the problem of illegal waste deposit [22], [24], US, [25], the UK, [26] all countries in Europe, [27], Australia.

[1] There is the temptation to create a population model that is doomed to extinction, partially or totally, suffocated by its own waste. Are we approaching a generalized scaphism? Maybe a prey-predator mathematical model which takes into account the waste, generated by two (or more) species.

Table 1

The synthesis of the method for reducing the impact of illegal waste deposits on the environment.

Stage	Activity
M1) Identification and assessment	A1) Visual localization of the area illegally occupied by waste
	A2) Marking the border of the waste location, using a GPS device (determining the geographical coordinates of a number of points on the border, [5], [6], [7])
	A3) Identifying the types of waste main components (plastic, glass, debris, organic remains, asphalt, etc.)
	A4) Estimating the amount of each type of waste found in the illegal deposit
	A5) The inventory of the environmental targets to be protected, located near the illegal waste deposit
	A6) Photographs of the deposit area, date marked in order to serve as a proof (proofs or comparison with deposit state at subsequent dates)
M2) Marking on the map and completion of data determined in field	A1) Recording the coordinates of the polygon border points, representing the illegal deposit surface, in the GIS database
	A2) Linking the neighbouring points (in order to determine the court orders retained by the GPS device), through line segments, obtaining thus the marking of the polygon including the waste
	A3) Introducing the numerical estimates in the GIS database: the approximate area of the polygon hosting the illegal waste deposit, the estimated types and quantity of each type of waste, environmental objectives in danger that are located near the illegal waste deposit
M3) Environmental risk assessment	A1) Environmental risk calculation using data from M2) and an algorithm for calculating environmental risk, in accordance with the law.
	A2) Updating environmental risks taking into account all database updates from M4 step.
M4) Monitoring of illegal waste deposits	A1) Monitoring of the evolution of area border [2] occupied by each deposit monitored.
	A2) Evidence of estimated quantity evolution for each type of waste existing in the deposits monitored.
	A3) Actions of emergency response for extreme cases of toxic substances emissions, fast extensions of the monitored deposits or other unpredictable events.

The important thing is that the method includes stages that can be applied with the help of humans passionate about: trips, theoretical and applied geography, mathematics, computer science, etc. In these activities people use and develop their passions. For example, A1 and A2 activities from the M1 stage can be performed with pupils aged more than 10 - 12 years. The condition is setting up organized groups with leaders from among teachers, maybe within the scout organizations. With a minimum training, the same groups of children can also address the activities A3, A4, A5 and A6 all from M1 stage.

From the experience in the cross-border project activity [1], I can say that the same groups of children aged more than 12 (maybe even less) can easily work with the basic functions of GIS programs. These children can achieve easily the activities in M2 stage. Through these activities, the participants can considerably widen their geographical knowledge; they can obtain a general spatial vision of the relief area, especially if the same children worked in M1 activity.

Given the activities in M1 and M2 stages, I can motivate the tint, slightly humorous, of the article title, referring to illegal landfills hunting to the detriment of Pokémons hunters. I believe that the first type of hunting is more helpful for the people. I cannot predict the extent to which the option offered in this article will gain followers among Pokémons hunters. I can only hope. I believe that, involving children and students in these activities, it is possible to bring a greater spiritual gain (for the entire mankind), than the hunting of Pokémons. Children can understand that all of us form, at a certain scale, a unique body that cannot heal itself and cannot be saved than acting coherently. I ask you: if you go into the

[2] Although the amount of waste can remain constant or decreasing, the waste deposit border can extend (because of the wind, rain, animals, etc.). Thus, the waste may reach the minimum distances permissible in relation to environmental protection objectives.

house with dirty feet and dirty the floor, will you punish your feet? I don't think so, but you have to clean the floor and also the legs. You must be careful not to repeat the mistake; eventually you'll be careful to clean the feet before entering the house. This way, dealing with environmental issues in case of children and students can be implemented.

The stage of determining environmental risks, [10], can only be based on criteria developed by environmental experts. Only in their absence, authors may propose their own environmental risk criteria. In this stage, it is appropriate to have the participation of higher education students in environmental matters and also of high school students, at least of those in their final years. Higher education students in environmental matters can perform this way the hours of practical applications.

The materials needed to apply the method described above are:
- A GPS device;
- Camera;
- Notebook and pencil;
- Computer with Internet network, equipped with media programs;
- GIS database program type;
- An elementary environment course.

Depending on the area that illegal waste deposits' "hunters" want to cover, a road vehicle might be necessary to achieve goals which are impossible to reach by moving on foot or by bike.

The GIS database can be a commercial software (AutoCAD Civil 3D, ArcGis, IDRISI TAIGA), [9], or a free software (Google Earth, SAGA GIS, GRASS GIS), [8]. In the project [1], I used the free software Google Earth, [12], [13]; it was enough for our aims and easy to use.

High evidence elements

For the entire identification - assessment – monitoring - remediation activity to have efficiency as high as possible, it is useful to report local databases (zonal), to a central database. In the central database, it can be established in what conditions and which is the optimal route for the recovery and remediation actions to be carried out with maximum efficiency. Also, at the central computer we can make decisions about emergency actions in respect to those deposits which release into the soil, air and water, active and toxic substances. The institutions that centralize data and which can make decisions may be, for example, environment responsible government institutions or NGOs specialized in environment issues.

The results of this method (even just those obtained after the first two stages) constitute valuable information for those dealing with waste collection and recovery. If a web page contains the situation of the illegal waste deposits, and quantitative estimates of plastic, paper materials etc., then, the collectors, using this information, can act in the closest areas to partially unload these deposits, efficiently and quickly.

RESULTS

Here we present some results of identification-assessment activities, carried out within the cross-border project, [1], in Giurgiu, Romania. In the four figures presented below are given: localizations of illegal landfills marked on the map from Google Earth archives, photographs of illegal waste deposits and some estimates for the contents and amounts of waste. The environmental objectives located near the illegal waste deposits that must be protected in particular are also highlighted.

In Figure 1 a geographical map is shown, containing the marks of five locations with illegal landfills. The localization has been made in the field, using a professional GPS device (not one for traffic or mobile phone). The locations of the identified deposits are included in an area of 25 km length and 5 km wide. The area is situated at west of Romania's capital, Bucharest.

Fig. 1 - Bookmarks for illegal landfills in the north-western part of Giurgiu County

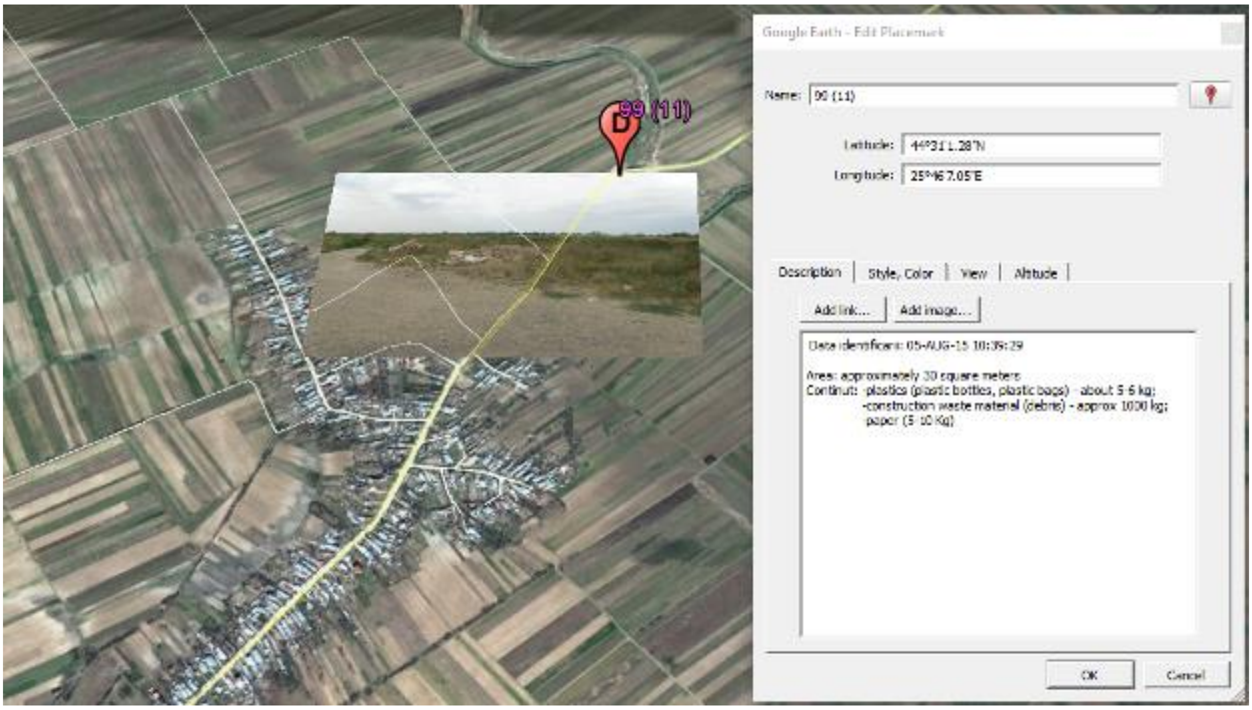

Fig. 2 - Illegal waste deposit with photo attached and the database in detail (explicit data)

In Figure 2 are presented details of the location with label 99, containing illegal landfills. The aerial map from the Google Earth database (background) includes the photo showing the waste. In the right side of Figure 2 is superimposed (the box), the digital database and information corresponding to the deposit marked. The box contains the label (in global and local project databases [1]), geographic coordinates, date of identification, the main types of waste and the estimated quantities of each waste type. If, on the electronic map of Figure 1, the location labelled 97 is detailed, then we obtain the image in Figure 3. In the detailed aerial map of Figure 1, the location with the label 97, two images are superposed. These images are given in Figure 3. In the photo, top left, there is an overall look of the landfill and we can see that the waste is placed preferentially on a roadside. The waste comes from repairs to some roads, most of it consisting in parts of concrete slabs and of asphalt coverage. The reintegration in nature of this waste is a very long process in time. In the photo on bottom right of Figure 3 we can see that, close to the waste (less than 200 m), existed at the identifying time vehicles containing beehives in action. In general, these wastes are not harmful for hives, besides the possible asphalt emission of harmful gases when ground temperature exceeds 40-50 degrees Celsius.

Fig. 3 - Marking an illegal waste deposit on GIS map database, Google Earth (background), in Giurgiu - waste from the construction and repair of roads (top left); environmental objective to be protected (bottom right): vehicle with beehives, in picking process.

Fig. 4 - Marking of two illegal waste deposits, on the GIS map database, Google Earth (background), in Giurgiu - household waste (photos). The environmental objective to be protected is a small river to which storage areas are tangent.

In Figure 4 are given detailed images from GIS database Google Earth, from the location labelled 93. The wastes are located right on the banks of a creek. Most of them are domestic wastes; some of them are in contact with water and possibly in the process of dissolving. It can be noticed that nearby (50 -100 m) there are buildings for living or buildings for agricultural use. Therefore, there is the possibility of spreading toxic substances or which only disturbs human activity (smell).

CONCLUSIONS

The results presented in this section show that the method (at least the first two stages) can be applied in purely school environment. This conclusion is supported by the results of the project [1], [14]. In the activities of the project [1], we identified and marked dozens of such illegal landfills within Giurgiu County (Romania) and in an extended area of the Rousse province. These illegal landfills were reported, but this activity was not the main one in this project. Otherwise, the number of these deposits probably would have been much higher.

The performances of Google Earth GIS software are more than sufficient for the required level by the activities of the first two stages of the method. In addition, Google Earth is extremely simple to use and has very many utilities for student's education, primarily in the field of geography, but also history, tourism, etc. The third and fourth stages of this method are only possible with the involvement of responsible factors in the intermediate or higher education, but also of environmental factors: national or regional environmental agencies, and NGOs. A research project could fully implement such a method (possibly improved). The main problems of this project regard the third and fourth stage, in which we needed to have involved persons in higher education: environment and informatics and the responsible environmental factors mentioned above. Linking local computer databases and the complex monitoring are the minimum results that the project must reach. Higher targets would consist in: the forecast of the amount of recovered material and of the time necessary to eliminate the illegal waste deposits.

In perspective, it can take into account the achievement of detection method (positioning, identification, estimation) using satellite or aerial tracking of illegal deposits. We can also try identifying their position by using less specialized drone. In perspective, it would be the achievement of a comprehensive monitoring service based on satellites and drones.

ACKNOWLEDGEMENT

This article extends the results of the project [1], in which the author participated during the years 2014-2015. This way, I express gratitude to collaborators (from INMA Bucharest and from the "Angel Kanchev" University of Rousse) and I hope that the results of the project [1], still have a great potential to be applied, with material and spiritual implications.

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A SOLUTION TO THE PROBLEM OF OPTIMIZING THE WORKING ROWS DIRECTION FOR AN AGRICULTURAL MACHINE WORKING ON A PARCEL OF CONVEX POLYGON FORM
/
O SOLUŢIE LA PROBLEMA OPTIMIZĂRII DIRECŢIEI RÂNDURILOR DE LUCRU PENTRU O MAŞINĂ AGRICOLĂ CARE LUCREAZĂ PE O PARCELĂ ÎN FORMĂ DE POLYGON CONVEX

Math. Cardei P.
INMA Bucharest / Romania
petru_cardei@yahoo.com

Keywords: *optimization, rows, direction, farm, machinery*

ABSTRACT

This article presents an alternative calculus for the optimal trajectory of agricultural equipment working on parallel rows, by shuttle movement method, on a flat plot that can be modelled mathematically as a convex plan polygon. The objective function has only one argument: the angle between the polygon reference side and the direction trajectories of the working machine. By trajectories we understand the centre lines of working rows, considered straight. Initially, the objective function was considered the length of the path travelled. Subsequently we demonstrated that, with good approximation, the length of the path actually worked (inside the plot) varies little, with the trajectory angle and the polygon reference side. Then, in the end, I chose as objective function the number of turns. The article presents the method and two tests of it; the first one on an imaginary case and the second test on a real one. Finally, it is shown that if you know the coordinates of convex polygon vertices that mathematically shapes the plot, then, using this method we can determine the optimal orientation of the working rows, this way minimizing the number of turns and consumption. The minimization of the number of turns at the rows heads also leads to the increasing the working capacity. Finally, we analysed the possibilities of expansion and development of the method. The applications regard all farmers having lands worked in rows, for the moment only on flat land or very small slope and on convex plots.

REZUMAT

In acest articol se prezinta o varianta de calcul pentru traiectoria optimala a unui utilaj agricol care lucreaza pe randuri paralele, prin metoda de deplasare suveica, pe o parcela plana care se poate modela matematic ca un polygon plan convex. Functia obiectiv are un singur argument: unghiul dintre latura de referinta a poligonului si directia traiectoriilor utilajului in lucru. Prin traiectorii intelegem liniile mediane ale randurilor de lucru, considerate dreapte. Initial, s-a luat functia obiectiv ca fiind lungimea traseului parcurs. Ulterior am demonstrat ca, cu o buna aproximatie, lungimea traseului in lucru efectiv (in interiorul parcelei) variaza slab, cu unghiul dintre traiectorie si latura de referinta a poligonului. Atunci, in final am ales ca functie obiectiv numarul de intoarceri. In articol se expune metoda, si doua teste ale acesteia, primul pe un caz imaginar, al doilea pe unul real. In final se arata ca, daca se cunosc coordonatele varfurilor poligonului convex care modeleaza matematic parcela, atunci, folosind aceasta metoda se poate stbili orientarea optimala a randurilor de lucru, astfel incat numarul de intoarceri sa fie minim si implicit sa se minimizeze consumurile. Minimizarea numarului de intoarceri conduce si la cresterea capacitatatii de lucru. In final se analizeaza posibilitatile de extindere si dezvoltare a metodei. Aplicatiile privesc pe toti producatorii agricoli cu terenuri lucrate pe randuri, deocamdata numai pe teren plan sau panta foarte mica, si pe parcele convexe.

INTRODUCTION

After the energy crisis (oil crisis) in the 70s, 20th century, the theory and practice of agriculture aggregates operation developed, on the same front, intensive and extensive methods leading to rationalization of consumption and finding energy alternatives to fossil resources.

Theorists have addressed a range of issues in order to reduce energy consumption: the optimization of the agricultural machinery structures, of their specific consumptions and the elaboration of optimal methods of agricultural land exploitation. The last issue also includes the one mentioned in the title of the article: optimal trajectories for operating agricultural aggregates. The literature of the years 1960 -1990 is very rich in such solutions [1], [2], [3], for example. Contemporary literature also offers solutions to these problems [9], [10], [11], [13], [14].

In recent decades, taking benefit of the modern computing techniques and the acquisition and interpretation of aerial images (plane, drone, satellite) appeared software products that optimize trajectories of operating agricultural machinery on plots of various shapes [4].

For agricultural areas, flat or small slope, finding optimal paths for parcels of some form remains open in respect to the solutions given by the literature of the years 1960-1990. The scientific works of that period referred explicitly to rectangular plots. The optimal trajectory is imposed not only by the form of the parcel, but also by the requirements of the agricultural technology and, not ultimately, by the possibilities of manoeuvre of machinery. This paper presents only a small step forward to solve the problem, step going from rectangular parcels to convex polygon ones. It is clear that many problems still remain, starting with flat parcels of concave polygon form. Furthermore, the ways agricultural machinery cover agricultural parcels should also be considered. The next step would be optimal trajectories calculation for parcels located on slopes. This issue will have to take into account the anti-erosion indications regarding agricultural works. The working trajectories will be, when possible, superimposed over the isocline. Based on these considerations, there are a number of possibilities that we don't address in this article. There are already solutions at software level to this problem, [11], which was expected, given the development of the complex GIS programs.

MATERIAL AND METHOD

Considering a convex polygon with N sides, with vertices denoted V_i, i=0,..., N-1. In a Cartesian reference system, XOY, the polygon vertices are points of given coordinates, $V_i(X_i, Y_i)$. Therefore, the polygon is defined through the finite sequence of its vertices:

$$\mathcal{P} = \{V_i, i = 0 \ldots N-1\}, \tag{1}$$

Vertices of the polygon are defined by the sequence of the coordinates:

$$X_P = \{X_i, i = 0 \ldots N-1\}, Y_P = \{Y_i, i = 0 \ldots N-1\}. \tag{2}$$

Using the vertices sequence, the edges sequence is generated:

$$\mathcal{L} = \left\{\overline{V_i V_{i+1}}, i = 0,..., N-1\right\} \bigcup \left\{\overline{V_{N-1} V_0}\right\}, \tag{3}$$

where the notation with upper bar represents the polygon side determined by the specified vertices.

Considering a reference length, b. All units of measure used belong to the International System of Units, so b is measured in meters. Thus:

$$Y_{\min} = \min_{i=0,...,N-1} \{Y_i\}, Y_{\max} = \max_{i=0,...,N-1} \{Y_i\}. \tag{4}$$

The following string (family) of parallel equidistant lines is considered:

$$\mathcal{E} = \left\{\delta_j \equiv \left(Y = Y_{\min} + \frac{b}{2} + jb\right), j = 0, j = 0,..., n-1\right\}, \tag{5}$$

where:

$$n = \left[\frac{Y_{\max} - Y_{\min}}{b}\right], \tag{6}$$

Where the square brackets represent the integer part function.

Further, I have determined the orientation of the convex polygon (1) relative to the network of horizontal lines, which makes the number of corridors covering the parcel to be minimum, when the polygon rotates rigidly around one of its points. In other words, we have to solve the following problem of optimum: over the network of the equidistant horizontal lines (the distance between them being *b*), network that includes the Ox-axis of the absolute reference system, is superposed the polygon (1). The polygon rotates rigidly around one of its points determining, at each rotation, a partition in a number of strips generated by two consecutive lines of the horizontal network and by their intersection with the polygon sides. Be α, the angle between the polygon edge V_0V_1 and the horizontal lines network. Then, the number of strips in which the rotated polygon, by α degree, is divided by the network of horizontal parallel lines, depends on the angle of rotation $n(\alpha)$. If, for example, the rotation is performed on an interval $[\alpha_{min}, \alpha_{max}]$, we try to find if there is at least an angle α, where $n(\alpha)$ takes a minimum value. The angle α takes values from 0 to 2π radians (360°) at the most. The problem of the optimum can have one or more solutions, or it can have no solutions.

Essentially, the application of this procedure consists in the orientation of the operating lanes of the agricultural machine, so the number of turns at the end of rows to be minimal. It is to be mentioned that the length of trajectory, in the working process of the agricultural machine, can vary very little depending on the orientation of the polygon in relation with the network of parallel lines. I consider a **convex** polygon, given by one of the equivalent forms (1), (2) or (3). I suppose there is a network of parallel lines equidistant, with the distance between each two neighbouring lines equal to a value which we'll assimilate later with the working width of the agricultural machine. The polygon will rotate over the lines network. For each position obtained, we'll calculate the required number of turns made by the agricultural machinery, by dividing the maximum vertical dimension by the working width. Above the convex polygon will be formed a mesh network, similar to those used to calculate the areas bounded by the graphs of real functions of real variable. This way, the approximate area of the polygon will be equal to the Darboux sum, lower or higher, [7], or Riemann sum, [7] which complies with the mesh standard equal with agricultural machine's working width.

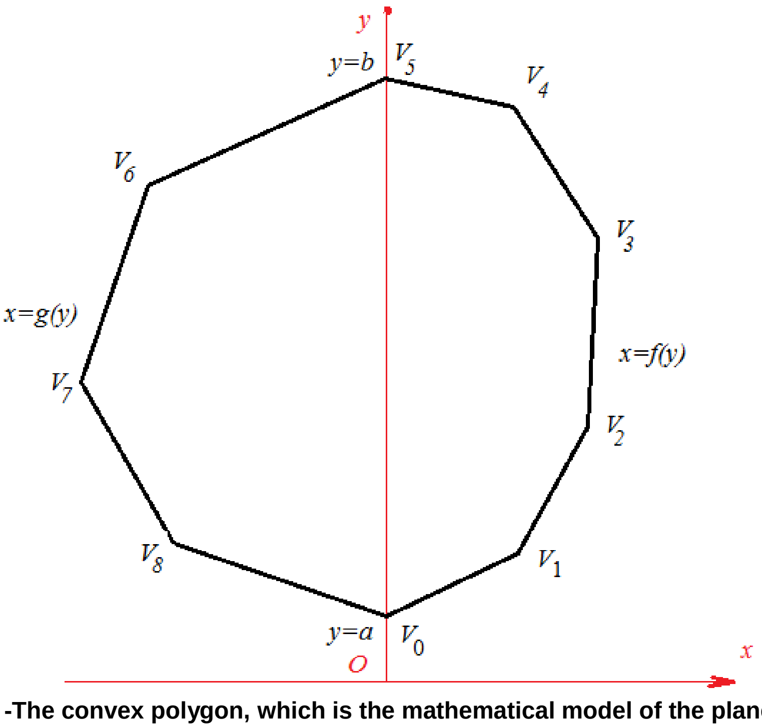

Fig. 1 -The convex polygon, which is the mathematical model of the plane plot

The lower Darboux sum which approximates the area of the polygon given in figure 1 is given by the formula:

$$A_{\inf}\left(f,g;\Delta_n\right)=\sum_{i=1}^{n}\left(y_i-y_{i-1}\right)\inf_{y\in[y_{i-1},y_i]}f(y)+\sum_{i=1}^{n}\left(y_i-y_{i-1}\right)\inf_{y\in[y_{i-1},y_i]}\left|g(y)\right|, \tag{7}$$

and the higher Darboux sum which approximates the same polygon area:

$$A_{\sup}(f,g;\Delta_n)=\sum_{i=1}^{n}(y_i-y_{i-1})\sup_{y\in[y_{i-1},y_i]} f(y)+\sum_{i=1}^{n}(y_i-y_{i-1})\sup_{y\in[y_{i-1},y_i]}|g(y)| \tag{8}$$

where:

$$\Delta_n=\{a=x_0<x_1<...<x_n=b\}, \tag{9}$$

it is a partition of the interval taken in these examples between *y* = *a* and *y* = *b* m. The two Darboux sums, delimiting the value of the polygon area:

$$A_{\inf}(f,g;\Delta_n)\le\int_a^b f(y)dy+\int_a^b|g(y)|dy=A\le A_{\sup}(f,g;\Delta_n), \tag{10}$$

and, passing to the limit:

$$\lim_{n\to\infty} A_{\inf}(f,g;\Delta_n)=\int_a^b(f(y)+|g(y)|)dy=A=\lim_{n\to\infty} A_{\sup}(f,g;\Delta_n), \tag{11}$$

where the functions *f* and *g* define the lines $V_0V_1V_2\ V_3V_4V_5$, respectively $V_0V_8V_7V_6V_5$, of the polygon given in figure 1. A[3] denotes the polygon area.
Also, the Riemann sums converge at the integral, which is equal to the polygon area:

$$R(f,g;\Delta_n)=\sum_{i=1}^{n}(y_i-y_{i-1})f(\xi_i)+\sum_{i=1}^{n}(y_i-y_{i-1})|g(\xi_i)|\underset{n\to\infty}{\to}A, \tag{12}$$

where ξ_i is any number ranging between y_{i-1} and y_i. If:

$$L_i=f(\xi_i)+|g(\xi_i)|, \tag{13}$$

and the working width gives the norm value which is constant:

$$b=y_i-y_{i-1},\ i=1,2,...,n, \tag{14}$$

then:

$$A\approx\sum_{i=1}^{i=n}bL_i, \tag{15}$$

therefore, the length of working path for working width *b* is:

$$\sum_{i=1}^{n}L_i\equiv L\approx\frac{A}{b}, \tag{16}$$

Consequently, the proposed method also allows estimation of the length of the path travelled in the working process if the agricultural machine's working width is given. The calculation takes into account that the machine works by shuttle movement method, [2] but it can be extended, maybe with small corrections, to the covering movement or other methods. The relationship is (16) already known [8].

[3] It is known that the transformation of rotation in space does not change the value of the polygon area.

RESULTS

First Application

I consider the convex polygon in Figure 2 in order to optimize the working trajectory of a farm machine working in rows by shuttle method. The polygon admits a symmetry axis. The initial position of the polygon reported to the network of equidistant horizontal lines is presented in Figure 2. The network orientation indicates the moving direction of the operating farm machine.

The process of searching optimal orientation corridors going over the surface is applied to the plan of the convex parcel in FIG. 2. The operation is suggested in Fig. 3. We obtain the graphical representation of function *number of turns* as a function of the polygon *angle of rotation* reported to the network of equidistant parallels with the distance between them equal to the agricultural machine's working width, Figure 4. The orientation of the $V_0V_1V_2V_3V_4V_5$ polygon in Figure 1, relative to the network of equidistant parallel lines is given by the angle between the direction of equidistant parallel lines network and the V_1V_2 edge of the polygon. In order to obtain the graphical representation in FIG. 4, the rotations were performed between 0 and 360 degrees, by one degree step.

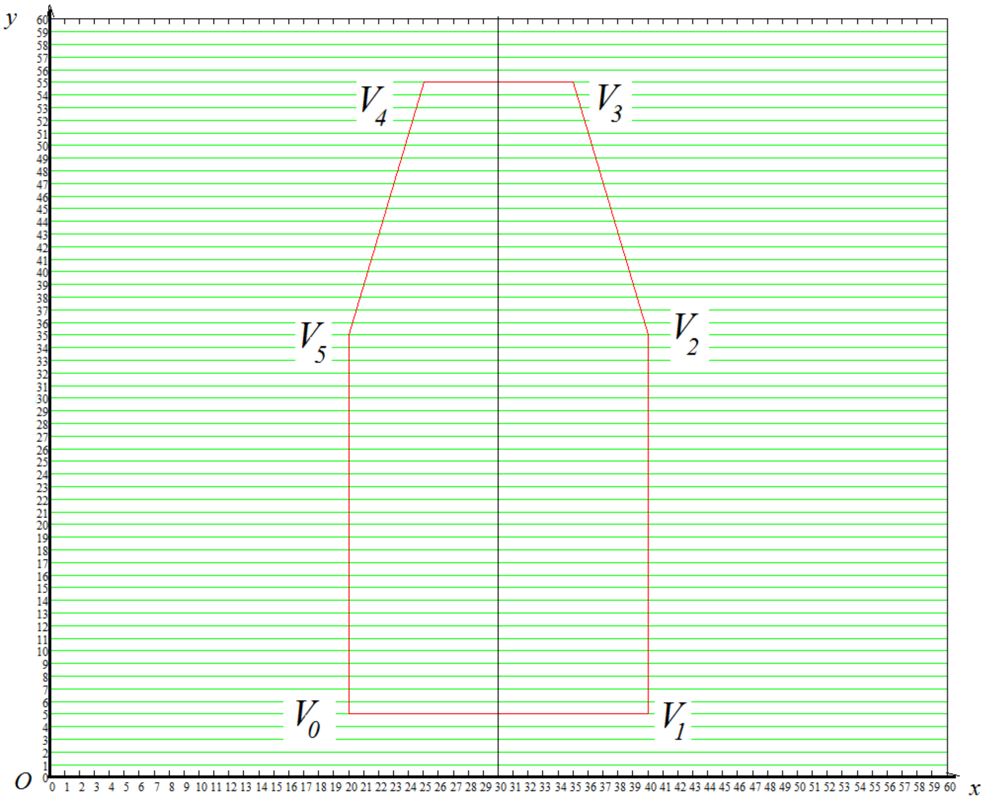

Fig. 2 - Convex polygon plan, with axial symmetry, tested for finding the optimal path of an agricultural machine in a working process on rows

Graphic representation of the number of returns dependence on the polygon angle of rotation reported to the lines of equidistant parallels network allows several conclusions:

-The graph shows a vertical symmetry axis passing through the angle of 180°, explained by the existence of the symmetry axis of this polygon;

-Given the symmetry observed above, the angle of rotation is sufficient to vary between 0^o and 180^o;

-If we refer to the entire range of rotation of between 0^o and 360^o, we see that the graph of the number of returns dependence on the polygon angle of reported to the orientation of equidistant parallels network, admits five points of minimum, out of which two are global (90^o and at 270^o) and three are local (0^o, 180^o and 360^o);

-The graph of the number of returns dependence on the polygon orientation reported to the lines of equidistant parallels network, also shows four points of maximum (all global because they the same value), corresponding to the orientation angles having the values 16^o 30', 163^o 30', 196^o 75', 343^o 30';

-Global minimum values are interesting as they give polygon orientation in relation to the network of equidistant parallel lines, for which the aggregate performs a minimum number of turns. In the case of the polygon in Figure 2, these orientations correspond to the case in which the reference edge of the polygon, makes an angle of 90º or 270º relative to the starting position, or 180º, respectively 360º, relative to the direction of the considered lines network. In Figure 3 the working positions with minimal number of returns, correspond to polygons drawn with thick lines (red and turquoise).

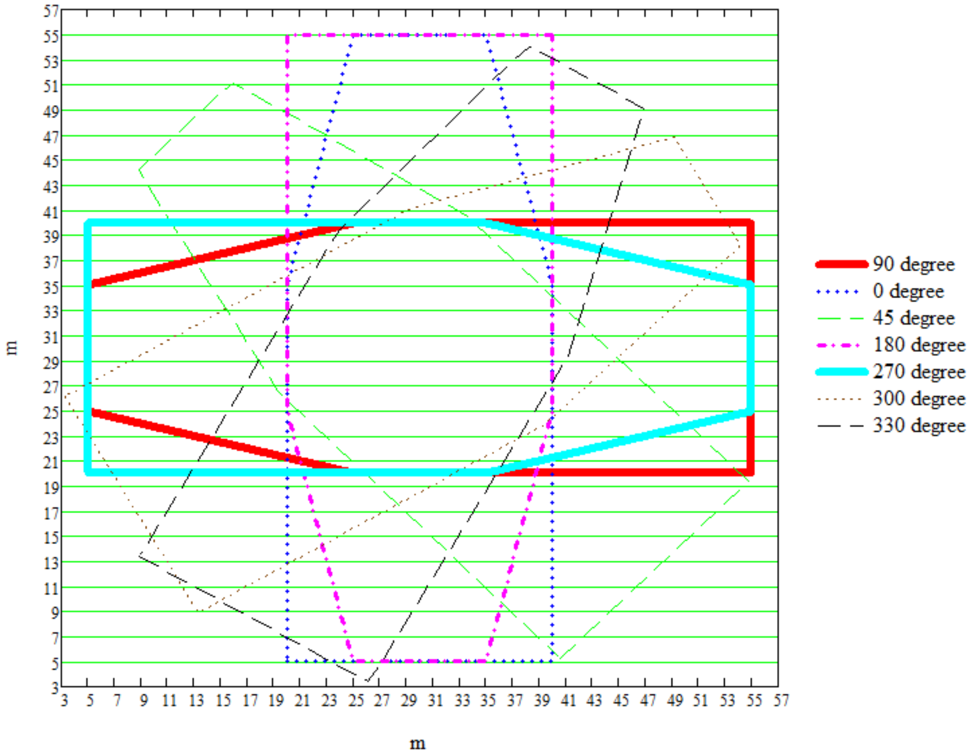

Fig. 3 - The scheme of the parcel rotation, superimposed over the network of equidistant parallel lines, each consecutive two parallels marking a working row.

In general, for any position of the polygon, the length covered by the operating machinery is calculated by formula (16). In this case, the distance of 900 m is obtained, corresponding to an area of 1800 m².

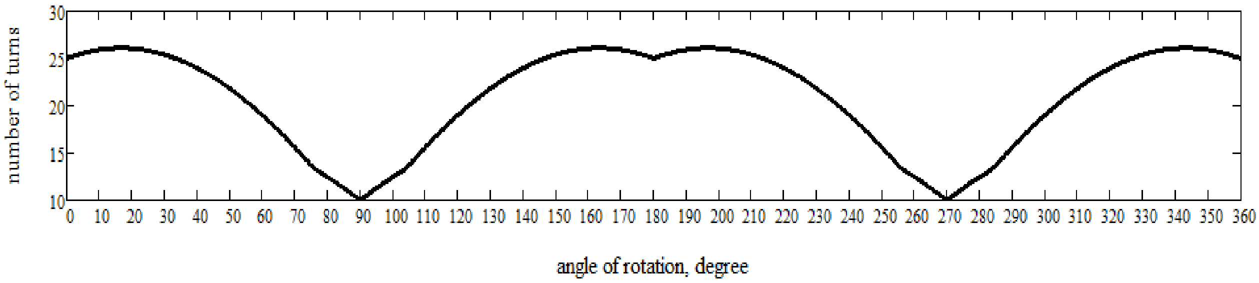

Fig. 4 - The dependence of agricultural machine's number of turns on the rotation angle of the polygon in relation to the direction of equidistant lines network

Second Application

To show how this method works on a real field (a real agricultural parcel), an example for a convex plot, selected from Dobrogea geographical area, Romania, is given. The plot is situated near the town Vulturu at a distance of 3690 m in a straight line to the south (slightly to the west). The reference coordinates of the plot are:

Table 1

Geographic coordinates and Cartesian local coordinates of the agricultural plot in Figures 5 and 6

Polygon top	Latitude	Longitude	East, UTM zone 35 N (WGS72), m	North, UTM zone 35 N (WGS72), m
A_0	44º 37' 04.53''	28º 14' 48.79''	598793.21	4941228.30
A_1	44º 37' 16.73''	28º 15' 13.40''	599329.79	4941613.06
A_2	44º 37' 05.09''	28º 15' 33.82''	599785.33	4941260.83
A_3	44º 36' 51.51''	28º 15' 24.52''	599586.83	4940838.64

Coordinate transformations were made by using the trial program: CoordTrans v2.3 - Franson, [12]. This program converts geographic coordinates in Cartesian coordinates considering the geographical location of the area on the globe.

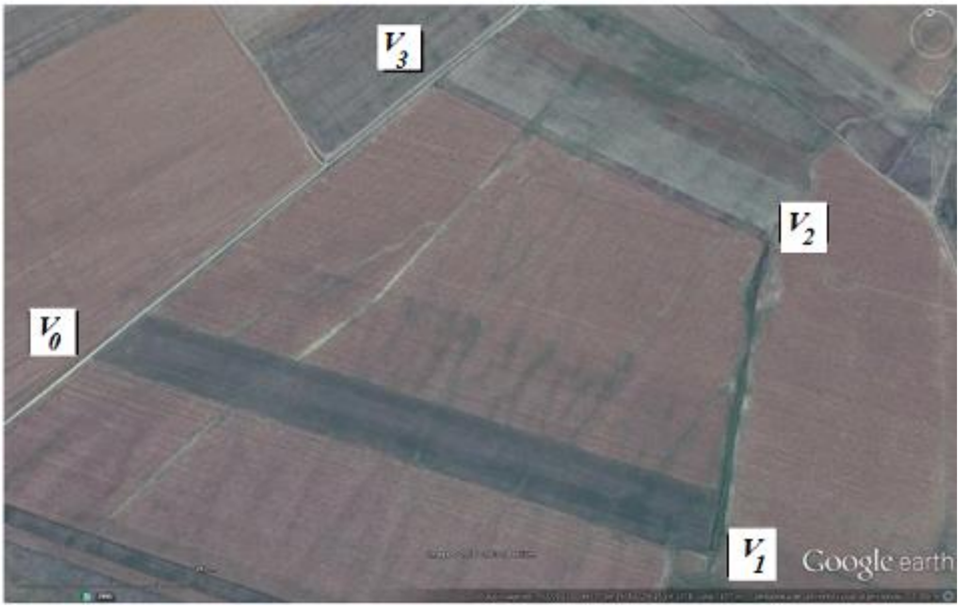

Fig. 5 - Locating the plot subject of this application on a Google Earth aerial map (detail)

In Figure 5 and 6 are given locations of the plot subject of this application on aerial maps from the archives of Google Earth. The plot in Figure 5, 6 and 7 do not have points or axis of symmetry. In Figure 7 is given the geometric model of the parcel, the geographic orientation, using Cartesian coordinates (N cardinal point at the top of the image). Null position angle of the polygon is given by the original direction of the edge V_0V_1. From this position, counter clockwise, the angles of rotation will be measured. I applied the method of searching the optimal orientation of the polygon and the same kinds of results as in application 1 have been obtained:

Fig. 6 - Locating the plot subject of this application on a Google Earth aerial map (overview of the nearest localities)

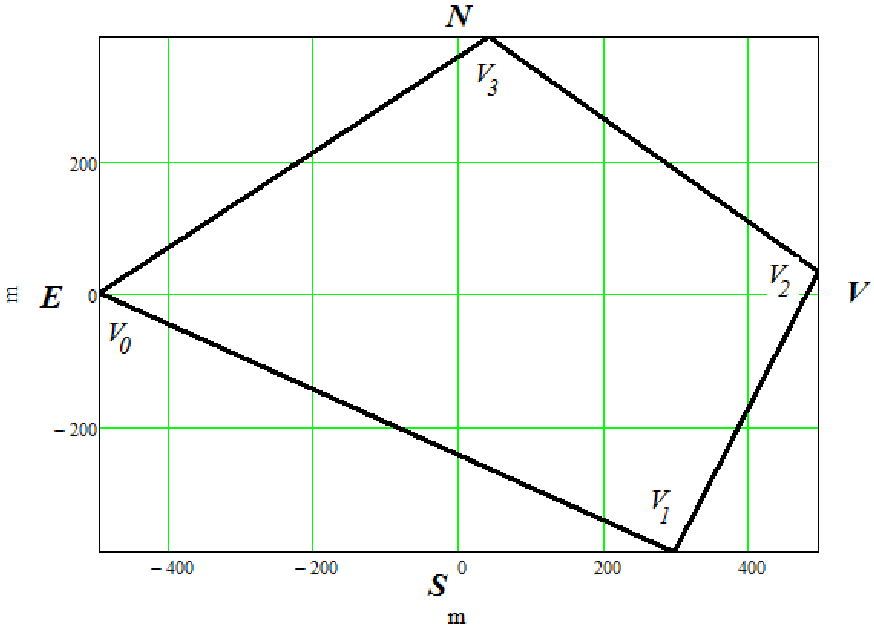

Fig. 7 - Convex polygon (geometric model of agricultural plot in Fig. 5 and 6), the subject of the calculation of optimal trajectories of agricultural equipment operating in rows.

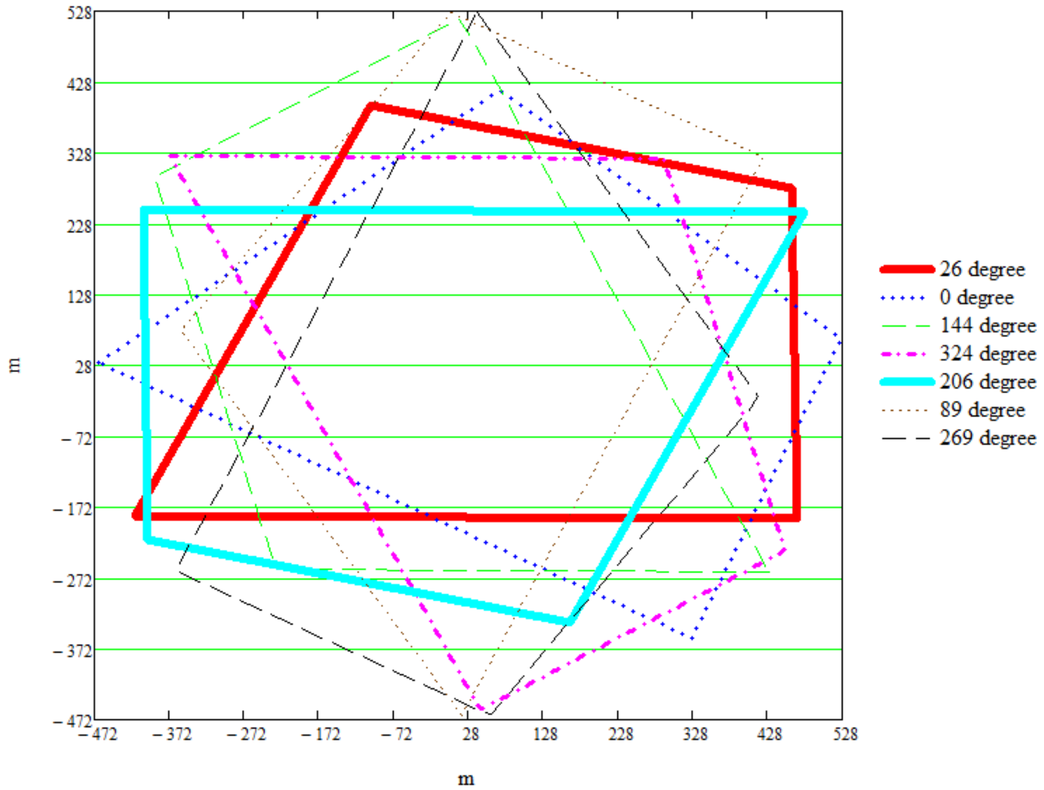

Fig. 8 - Polygon rotates in the position of the most important values of the graph in Figure 9

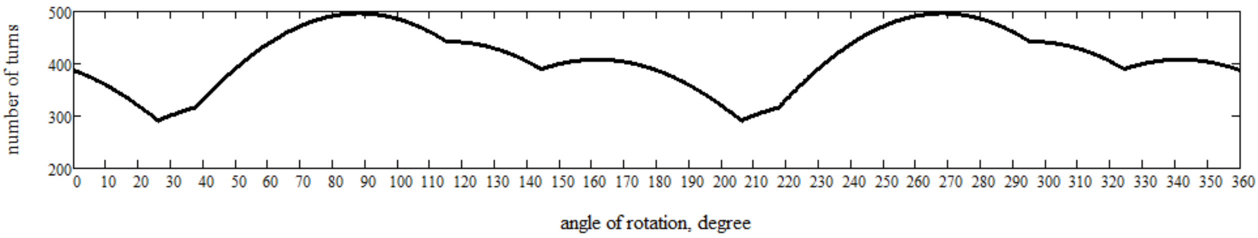

Fig. 9 - The graphical representation of the variation in the number of turns of the farm machine, depending on the polygon rotation angle, when the values of this angle belong to the interval [0°, 360°]

The scheme of the polygon rotation (fig. 8) and the graphical representation of the number of turns dependence on the angle between the reference edge of the polygon and the direction of the equidistant parallel lines network (Fig. 9). In Fig. 8 are represented the rotated positions of the polygon, at the most important values of the rotation angle read on the graph in Fig. 9. The angle of rotation had values between 0^o and 360^o. From the resulting graph (fig. 9), we can extract the following information:

-The graph admits the straight symmetry axis α = 180°, therefore a rotation of 180° is sufficient to obtain the result sought;

-There are two points of global minimum for α = 26^o, respectively α = 206^o, which are also the searched optimal points (corresponding to approximately 292 turns for the working width *b* = 2 m);

-There are also two points of local minimum (α = 144^o, 324^o = α), uninteresting because they reach values of the number of turns over 300. These points can be used only if the work cannot be done on the directions given by the global minima for different objective causes;

-There are two major directions to be avoided while the farm machine is operating because they lead to maximum values for the number of turns, consequently to maximum energy consumption, i.e. for α = 89^o, and α =269^o;

In Figure 8 is presented the rotated polygon with each of the important values on the graph in Figure 9, the angles of rotation being measured relative to the initial position of the polygon. We find out that optimal orientations are made if the orientation of the parallel lines network coincides with the orientation of the largest edge of the polygon (reference edge V_0V_1). In Figure 8, these positions of the polygon in relation to the network of parallel equidistant lines correspond with polygons drawn with thick continuous line. The two optimal positions differ through an angle of 180^o, which was to be expected given the symmetry noticed on the graph in Figure 9. Therefore, the method made possible obtaining an optimal orientation in working and, in addition, it can be appreciated that the length of the path travelled during operation is about 295,678 kilometres, for an area of approximately 591 356 m^2, i.e. a little over 59 ha.

As a confirmation, if we use Google Earth (image from 2013 archive) to identify the parcel, it can be noticed that, when shooting overhead, the plowing furrows were orientated exactly in the direction indicated by the above calculation.

CONCLUSIONS

The calculation method presented in this article is an extension of the classic calculation of working trajectories optimization for rectangular plots. The method is currently restricted only to agricultural plots that can be modelled mathematically by convex polygons.

The method has been checked for rectangular plots and has given the correct results. Moreover, for now, we can say (without a rigorous demonstration) that achieving an optimum in terms of the minimum number of turns for agricultural work performed through such processes is conditioned by choosing the machine moving direction, parallel to the longest edge (or edges, if they are more) of the polygon.

This method leads to the next useful results:

-Determining the optimal orientation for rectilinear working trajectories of a machine operating on parallel rows;

-The estimation, with good approximation, taking into account the working width of the machine, of the total length of trajectory in effective working;

-Calculating the number of turns required;

For this calculation we need the following data:

-Cartesian or geographical coordinates of the convex polygon vertices that mathematically shape the agricultural plot;

-If Cartesian coordinates of the polygon vertices are not available, then they must be calculated using the conversion programs available on free distribution networks;

-A computer program, relatively simple to construct, with graphics facilities which identify essential data of rotation and the optimal values, for example [6];

The coordinates of the polygon vertices that mathematically shape the plot can be taken using a GPS device or from the maps in the archives of GIS software (e.g. Google Earth) or the cadastral data.

The potential developments of this method must take into account some important steps such as the approach of other forms of land and environmental protection in general. Among the directions that could be addressed further, I mention:

-extending the method to concave polygons (parcels), maybe, at the beginning, by decomposing in convex polygons;

-extending the method to the curved paths (curved rows), generating bands covering a given polygon;

-another expansion of the method can be building an objective function consisting in two terms: the first is nonzero only in the stages in which the agricultural machine returns to row end; the second is nonzero only in actual working stages of the agricultural machine;

-in such objective functions average speeds and specific consumptions can be introduced, different for the two main working stages; more complete results are obtained including energy consumption, the working capacity and other important features. Optimality reassessment of the movement methods used in public or private agricultural sector can lead to significant fuel savings, reduction of work consumption and of the machine wear.

This tool can be used for recalculation of optimal working trajectory for all agricultural farms, while respecting the basic principles of agriculture and environment.

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INFLUENCE OF AGING HEAT TREATEMENT ON SOME MECHANICAL PROPERTIES OF THE AlZn5.7MgCu ALLOY THROUGH EXPERIMENTAL RESEARCHES

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INFLUENŢA TIPULUI DE TRATAMENT TERMIC DE ÎMBĂTRÂNIRE ASUPRA UNOR PROPRIETĂŢI MECANICE ALE ALIAJULUI AlZn5.7MgCu PRIN CERCETĂRI EXPERIMENTALE

Prof. PhD.Habil.Saracin I [1] Conf. PhD.Eng. Pandia O. [2] Lect.PhD. Eng.Neacsu M. [3] Ph.D. Eng. Ganea –Christu I.[4], PhD. Eng. Rădulescu D.L.[2]

[1]University of Craiova, Faculty of Agriculture, Romania, [2]University of Agricultural Sciences and Veterinary Medicine Bucharest / Romania, [3]Romania University of Dunarea de Jos, Galati, [4]INMA Bucharest / Romania

Tel: 0762142949; E-mail: ion_saracin@yahoo.com

Keywords: *aluminium alloy, heat treatment, mechanical characteristics.*

ABSTRACT

The paper presents the results of experimental research at laboratory scale on the influence of AlZn5.7MgCu alloy thermal processing mode.

Two types of aging heat treatment were studied, namely: a natural aging and an artificial aging treatment. For each of the two types of technological heat treatment, the change of the mechanical properties was monitored according to the parameters of the aging procedure.

The experimental research of this paper highlights the advantage of artificial aging as compared to natural aging, but this advantage must also be seen in terms of the costs implied by the two types of treatment.

REZUMAT

Lucrarea prezintă rezultatele cercetărilor experimentale la scară de laborator privind influenţa modului de procesare termică a aliajului AlZn5,7MgCu.

Au fost studiate două tipuri de tratamente termice de îmbătrânire şi anume: o îmbătrânire naturală şi o îmbătrânire artificială. Pentru fiecare din cele două variante tehnologice de tratament termic s-a urmărit variaţia proprietăţilor mecanice în funcţie de parametrii regimului de îmbătrânire.

Cercetările experimentale din această lucrare scot în evidenţă avantajul îmbătrânirii artificiale în comparaţie cu îmbătrânirea naturală, dar acest avantaj trebuie privit si prin prisma costurilor aferente celor două tipuri de tratament.

INTRODUCTION

There is a close relationship between the development of the aviation industry and the evolution of the materials it uses. It is well known that this top area of the technique requires advanced materials with special physical and mechanical properties.

AlZn5.7MgCu alloy is part of special aluminium alloys from Al-Zn-Mg-Cu system, of zicral type. These alloys have high mechanical characteristics and low density, which is why they are interesting for the aviation industry and automotive industry [1-6].

In the raw molded state in general, these alloys have a low mechanical strength and deformability which modifies very much by applying heat treatments [6].

Al-Zn-Mg-Cu alloys have a tensile strength which becomes greater as the precipitates formed after the aging process, natural or artificial, are more numerous, finer and more dispersed in the mass of the base solution (solid solution).

The phase transformations in the solid state occurring during thermal processing, if they are allowed in the alloy equilibrium diagram, represent an essential condition for making a heat treatment, by quenching, putting it in solution and artificial or natural aging, of an aluminium alloy. An alloy of this type can support an order-disorder reaction.

In the case of aluminium alloys with structural hardening, the increase of mechanical characteristics occurs on account of the complex interactions between the dislocations of the basic matrix and the precipitate particles arising in the alloys structure following aging.

The high strength of Al-Zn-Mg-Cu alloys is directly proportional to the increase of the amount of Zn or Zn + Mg content, thus generating metastable fine precipitates zones, rich in Zn and Mg, which represent the so-called GP zones [1].

The stages of the structure hardening mechanism after applying aging heat treatments are: forming the supersaturated solid solution through quenching by putting it in solution, forming Guinier - Preston areas during the aging process; first precipitates form a metastable zone (η'), then, as the temperature gradient is higher, these areas become stable (η), i.e. the formation of $MgZn_2$ precipitates [2].

MATERIAL AND METHOD

The materials for the experimental research are samples of the Al-Zn-Mg-Cu system alloy, whose chemical composition is shown in Table 1. The chemical composition of the alloy studied falls within the EN 573-3-2013 requirements [10].

Table 1

Chemical composition of the researched alloy [10]

Alloy \ Element	Zn	Mg	Cu	Si	Fe	Pb	Cr	Mn	Al
AlZn5,7MgCu	5.76	2.61	1.55	0.15	0.19	0.021	0.19	0.10	rest

In order to be used in the aviation industry or in the automotive industry, this alloy must acquire, after applying thermal processing regimes (natural or artificial aging), the mechanical properties stipulated in EN 485-2-2013 [11], which are shown in table 2.

Table 2

Alloys properties [11]

Alloy \ Element	Rm / MPa	$Rp_{0,2}$ / MPa	A_5 / %	HB
AlZn5,7MgCu	540	470	7	161

In this paper, the influence of some heat treatment regimes on the mechanical properties of the AlZn5.7MgCu alloy was experimentally researched.

Experiments have been conducted in two thermal processing technological variants: variant I, which is represented by the natural aging, and variant II, which is the artificial aging regime.

Ingots casting was performed on the casting system of SC Wagstaff from Alro Slatina S.A., Romania. Also at SC Alro S.A. was performed the ingots homogenization treatment at a temperature of 480 / ° C in an Olivotto semi-continuous furnace operating within the 460-610 / ° C temperature range.

Samples heating for hot-rolling at a temperature of 435 / °C, hot plastic deformation with a reduction rate of 25 / %, heating the samples at 500 / ° C for quenching through putting in solution as well as warming the samples to artificial aging temperatures were conducted in the Laboratory of Plastic Deformation and Heat Treatment of the Faculty of Engineering with "Lower Danube" University of Galati. These technological operations are common for both variant I and II.

The temperatures of artificial aging are: T_1 = 120C, T_2 = 140 / ° C, T_3 = 160 / ° C, T_4 = 180 / ° C, T_5 = 200 / ° C with the resistance time of: τ_1 = 4 / hours, τ_2 = 8 / hours τ_3 = 12 / hours, τ_4 = 16 / hours, τ_5 = 20 / hours for each temperature.

Research variant I studied, for a degree of hot plastic deformation ε = 25%, the influence of the resistance duration in the case of natural aging for τ_1 = 24 / hours, τ_2 = 72 / hours τ_3 = 168 / hours τ_4 = 360 / hours, τ_5 = 720 / hours τ_6 = 1080 / hours, τ_7 = 1440 / hours, on the mechanical properties studied.

Research variant II studied, for a degree of hot plastic deformation ε = 25%, the influence of temperature and resistance time in the case of artificial aging, on the mechanical properties studied.

The manufacturing from the homogenized ingots of the samples (test pieces) for carrying out the experiments, according to variants I and II, was made after metal cutting to the dimensions: length = 105 / mm, height = 7 / mm, width = 55 / mm. After the hot plastic deformation, the sample dimensions had the following values: length = 150 / mm; height = 5 / mm; width = 60 / mm.

RESULTS

After thermomechanical treatment, the samples were subjected to thermo mechanical testing and the mechanical characteristics were determined: *Rm*, $R_{p0.2}$, A_5, *HB*. On the basis of these results, there have been made the graphs of mechanical properties variation depending on the temperature and aging time.

The graphical representation of mechanical properties variation with natural aging time, according to variant I, is shown in Figures 1 and 2.

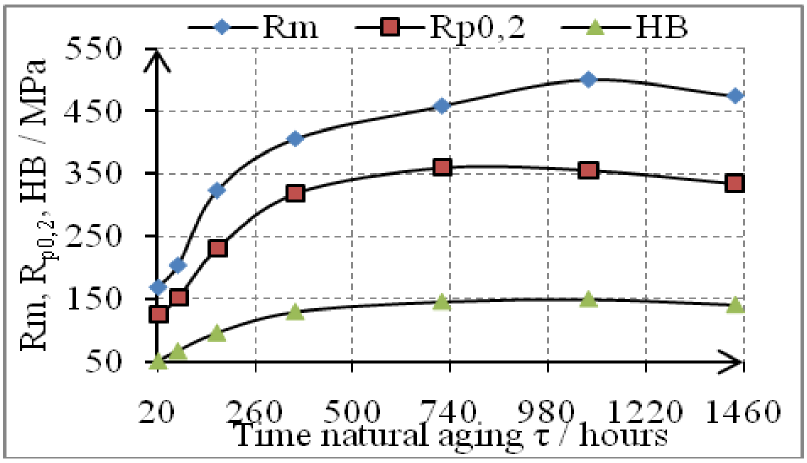

Fig. 1 - Variation of Rm, Rp0.2, HB during natural aging

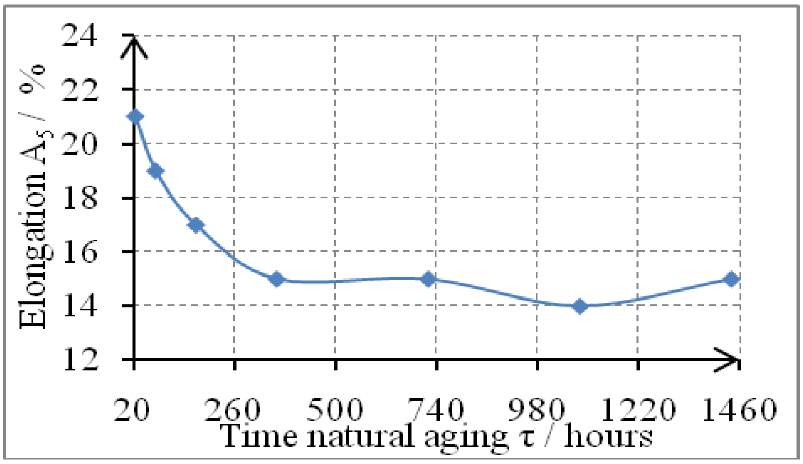

Fig. 2 - Variation of elongation at break with natural aging time

Figure 1 shows resistance properties variation according to natural aging time and it can be noticed that these mechanical characteristics increase as the natural aging time increases, up to a maximum value corresponding to a time of 1080 hours.

The graph in Figure 2 shows that the elongation at break decreases as the natural aging time increases and records a minimum at the time of 1,080 hours, followed by a slight increase.

For the tensile properties, as well as for elongation, this variation can be explained by the fact that the precipitates formed during the natural aging process reached a critical value of their size, after which their growth by coalescence followed.

More specifically, the growth of the large ones occurs at the expense of the small ones, and structurally is recorded a decrease of grain limits, which lowers the mechanical strength at the expense of plasticity.

In Fig. 3, 4, 5, 6 are shown the properties variations of the studied alloy, according to experimental research variant II.

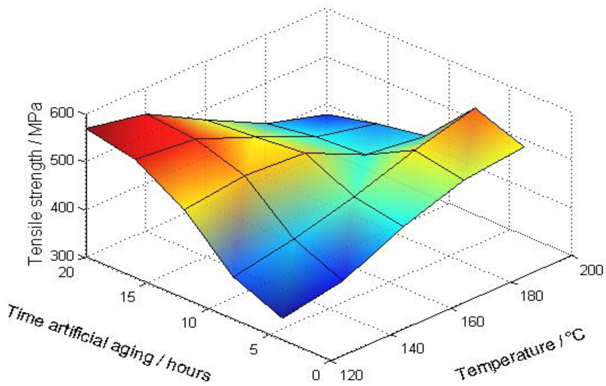

Fig. 3 - Mechanical resistance variation with artificial aging time and temperature

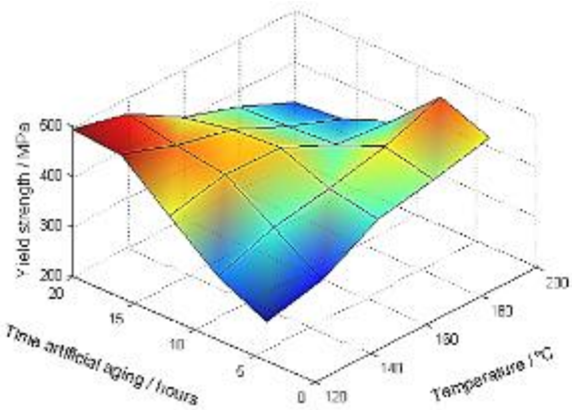

Fig. 4 - The variation in yield strength with artificial aging time and temperature

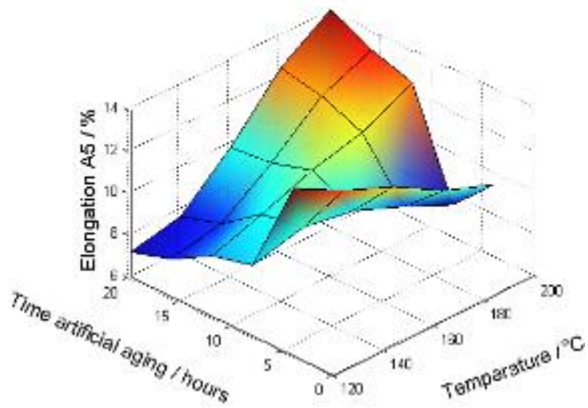

Fig. 5 -Variation of elongation at break with artificial aging time and temperature

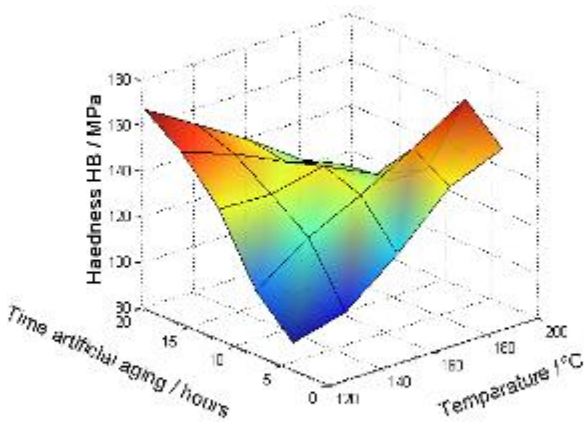

Fig. 6- HB hardness variation with artificial aging time and temperature

For properties *Rm*, $R_{p0.2}$, *HB* was found a growth of their values with the increasing of the duration of treatment at temperatures of 120 and 140 / ° C.

The thermal regime with temperatures of 180 to 200 / ° C and duration of 8 hours, led to maximum values of the mechanical characteristics.

As the aging time increases above this value, the mechanical properties decrease.

The temperature of 160 / ° C leads to mechanical resistance values that increase with the increasing of the treatment time, up to a period of 12 hours, after which a decrease in mechanical properties can be seen.

The variation of the elongation at break is inversely proportional to that of the strength properties. The highest value for A5 is obtained at 200 / ° C and a treatment time of 20 / hours.

Figure 7 shows the microstructure of the alloy that was submitted to natural aging for 729 hours, and where the formed precipitates on the basis of Al, Zn and Mg, leading to material hardening, are noticed.

Figure 8 shows the microstructure of the alloy after having been artificially aged at 140 / ° C for 8 / h. By comparing the two images, it can be seen that after artificial aging, the number of precipitates is bigger and they are more finely dispersed in the base matrix of solid solution α, as compared to those formed by natural aging.

This also explains the high values of the mechanical characteristics that were obtained from thermal processing according to variant II.

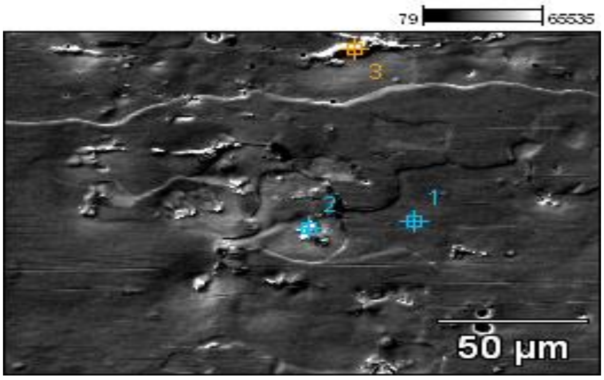

Fig. 7 - Natural aging microstructure (τ =720 / hours), 1509: 1 zoom

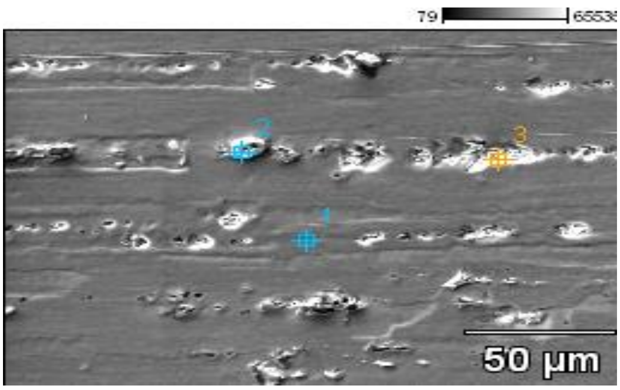

Fig. 8 - SEM electron microscopy of the studied material subjected to treatment variant II at 140 / ° C and a time of 8 / h, 1448: 1 zoom

CONCLUSIONS

After conducting experimental research the following conclusions can be drawn:

- the aging of quenched alloys leads to supersaturated solid solution decomposition with the emergence of secondary phases in a controlled dispersion and the solid solution getting closer to equilibrium;

- the type, size, distribution and amount of the precipitated particles in an alloy depend on the temperature, duration of aging and initial state of the microstructure;

- the mechanical properties of the alloy continuously vary with the temperature and duration of aging;

- increasing the temperature of aging or extending durations over a certain value decreases the resistance properties, but gives good dimensional and properties stability (over aging with precipitates coagulation);

- the allure of the properties variation curves at aging shows that the maximum values of one of the followed properties decreases as the temperature or duration rise above the optimum value; approximately the same values of a feature can be obtained either at higher temperatures and shorter durations, or at lower temperatures and longer durations);

- mechanical resistance varies inversely with elongation at break, so that to achieve high strength while maintaining a sufficient plasticity, moderate temperatures and extended durations are selected;

- of the two types of heat treatment researched, the best mechanical resistance properties were obtained after the artificial aging regime;

- the properties required by EN 485-2-2013 for the studied alloy are met for only some thermal processing parameter values in the variant II.

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APPLICATIONS OF FREE VIBRATIONS TO AGRICULTURAL MACHINERY FOR SEEDBED PREPARATION
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APLICAŢII ALE VIBRAŢIILOR LIBERE LA MAŞINILE AGRICOLE DE PREGĂTIT PATUL GERMINATIV

Prof.Ph.D.Eng. Biriş S.Şt.*[1)], Lect.Ph.D.Eng. Ungureanu N.[1)], As. Ph.D. Stud. Eng. Gheorghiţă N.E.[1)], Assoc.Prof. Ph.D. Eng. Covaliu I.C.[1)],Ph.D.Eng.Vlăduţ V.[2)], Eng. Oprescu M.R.[3)]
[1)] Politehnica University of Bucharest, Faculty ofBiotechnical Systems Engineering / Romania;
[2)]INMA Bucharest / Romania; [3)]Condor Comimpex S.R.L. / Romania
Tel: 0744756832; E-mail: biris.sorinstefan@gmail.com

Keywords: *Vibrating tillage tool, soil tillage, draft force, tillage energy*

ABSTRACT
In this paper was developed a comparative theoretical study on the functioning of a cultivator provided with non-vibrating working bodies (passive), respectively with vibrating working bodies, with free vibrations and forced vibrations, for which were developed mathematical models. The effects of using the vibrating working bodies lead to a better grinding of the soil, the self-cleaning of the working bodies, the increase of durability of working bodies, the reduction by 30-50% of the traction resistance.

REZUMAT
În această lucrare a fost elaborat un studiu teoretic comparativ privind funcţionarea unui cultivator prevăzut cu organe de lucru fără vibraţii (pasive), respectiv cu organe de lucru vibratoare, cu vibraţii libere şi vibraţii forţate, pentru care s-au dezvoltat modele matematice. Efectele utilizării organelor de lucru vibratoare duc la o mai bună mărunţire a solului, autocurăţare a organelor de lucru, creşterea durabilităţii organelor de lucru, reducerea cu 30-50% a rezistenţei la tracţiune.

INTRODUCTION
One of the main causes contributing to increasing drag of the working bodies of machinery for soil processing, and thus of energy consumption, is the friction that occurs between the active surfaces of the working bodies and soil(*Kattenstroth et al., 2009*).

There are several methods to reduce such frictions, such as: advanced grinding of the active surfaces of the tools for soil processing, coating the active surfaces with materials with low friction coefficient, the application of an air cushion between the active surfaces and the processed soil, the application of electro-osmosis principle for the circulation of watering the soil towards the active surface of the tool to lubricate it, the use of rotating working bodies etc.(*Fenyvesi and Hudoba, 2009*; *Kattenstroth et al., 2009; Marín Cabrera et. al., 2011*).

The possibility of using vibrations when performing the work process of soil processing machinery leads to: decreased energy consumption in carrying out the work, qualitative improvement of technical agricultural processes, and increased productivity of agricultural machinery, simplifying the design of agricultural machinery, universality of certain assemblies or subassemblies of agricultural machinery (*Fenyvesi and Hudoba, 2009*).

It is known that machinery for soil processing are the most important energy consumers. If their working bodies are passive, i.e. they do not have own movement but execute the work during aggregate travelling with absolute speed equal to the speed of transport, the energy derived from the source (propulsion system) is transmitted to the soil in just one way, respectively through continuous and uniform distribution of the stresses on the frontal surfaces of the working bodies in contact with the soil.

For amplification of energy transfer to the material to be processed (agricultural soil) can be made the activation of the working bodies either by printing of a rotary movement or by their vibration (in the presence or in the absence of elastic forces). The main effect of the application of vibration is the decrease of drag resistance, but the amount of energy to be transmitted to the material to be processed is usually high, comparable to the case of passive working bodies (*Chandon and Kushwaha, 2002*).

Various theoretical researches (*Chandon and Kushwaha, 2002; Razzaghi and Sohrabi, 2016;Setiawan and Setiawan, 2010*), and also experimental researches (*Dubrovskii A, 1977;Hendrick and*

Buchele,1963; *Lejman et. al., 2015; Marín Cabrera et. al., 2011*), show that the use of vibrating working bodies can lead to the considerable decrease of traction force, due to numerous factors, such as: parameters of vibration, speed of machinery, physical-mechanical properties of the soil etc.

The necessity to correlate the vibration parameters with the factors influencing the working process has led to the implementation, in vast majority, of all technical solutions that provide the use of forced vibration.

From the studies performed so far it results that there is possible to use the principle of free vibrations especially in case of cultivators and chisels, for whose construction are used elastic point supports which, during the working process, produce vibrations due to the heterogeneity of the soil and to the micro-relief, thus increasing the effectiveness of machinery.

Elastic coupling of the working body can be made in two manners (*Dubrovskii A, 1977*):

- between the working body and the frame of machinery is arranged an elastic support;
- between the working body and the frame of machinery is arranged a rigid support, its catch on the frame is hinged, allowing the oscillation in the forward direction, the initial position of the support being maintained by a spring that deforms with different values depending on the variation of soil resistance.

MATERIAL AND METHOD

By performing a comparative analysis on the operation of the cultivator provided with non-vibrating working bodies, respectively with vibrating working bodies (with free vibration and forced vibration),it can be highlighted the issues to be further taken. In the case of the cultivator with non-vibrating working bodies, soil resistance to the movement of the working body is given by the following equation(Fig. 1) (*Dubrovskii A, 1977*):

$$\overline{R}'_N = \overline{R}_N + \overline{F}_f \tag{1}$$

where: $\overline{R}_N$ - is the normal force on the active surface of the working body;

$\overline{F}_f$ - is the frictional force between the working body of the tool and soil.

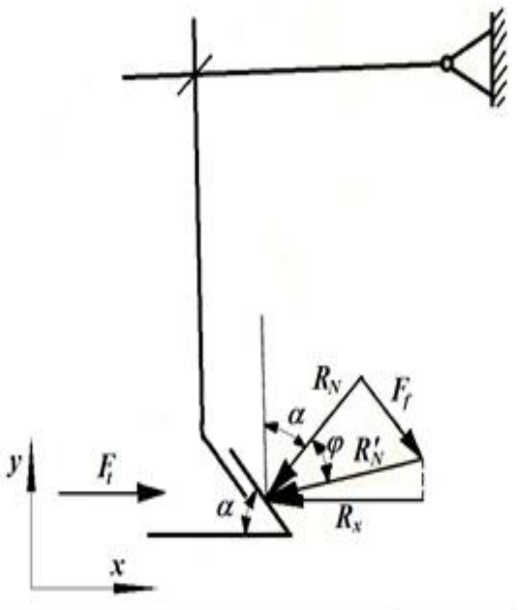

Fig.1 –Forces arising from the interaction of the non-vibrating working body and the soil (*Dubrovskii A, 1977*)

R_x component after the forwarding direction is equivalent to the traction force F_t. From Figure 1 it can be written the following equation (*Dubrovskii A, 1977; Dubrovskii A, 1956*):

$$\overline{R}_x = |\overline{R}'_N| \cdot \sin(\alpha + \varphi) \tag{2}$$

respectively:

$$R_x = |\overline{R}_N| \cdot \sin\alpha + |\overline{F}_f| \cdot \cos\alpha \tag{3}$$

where: α – is the angle of soil displacement and grinding;

φ –is the angle of external friction between the tool and soil.

The normal to the active surface of the working body has its gradient direction, respectively:

$$\overline{R}_N = \lambda \cdot \operatorname{grad} f(x,y,z) \tag{4}$$

where: λ – constant;
$f(x,y,z)$ –is the equation of active surface of the working body.

$$\operatorname{grad} f = \frac{\partial f}{\partial x}\bar{i} + \frac{\partial f}{\partial y}\bar{j} + \frac{\partial f}{\partial z}\bar{k} \tag{5}$$

$$|\operatorname{grad} f| = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2 + \left(\frac{\partial f}{\partial z}\right)^2} \tag{6}$$

Frictional force can be determined knowing the value of the coefficient of external friction μ, thus:

$$\overline{F}_f = \mu \cdot \overline{R}_N = \mu \cdot \lambda \cdot \operatorname{grad} f \tag{7}$$

and, given equation (3) it results:

$$R_x = \lambda \cdot |\operatorname{grad} f| \cdot (\sin\alpha + \mu \cdot \cos\alpha) \tag{8}$$

From equation (8) it results that the traction resistance is mainly dependent on the shape of the active surface of the working body (α, $|\mathit{grad}\, f|$) and the properties of the processed soil (λ, μ).

It has been found experimentally that with the variation of travel speed of the machinery (v), the component R_x also changes, respectively:

$$R_x(v) = R_x + \Delta R_x = (\lambda + \Delta\lambda) \cdot |\operatorname{grad} f| \cdot [\sin\alpha + (\mu + \Delta\mu) \cdot \cos\alpha)] \tag{9}$$

But, resistance R_x also varies due to the non-heterogeneity of soil and micro-relief, being a random function of time (Fig. 2), respectively:

$$R(t) = R_x + \Delta R(t) \tag{10}$$

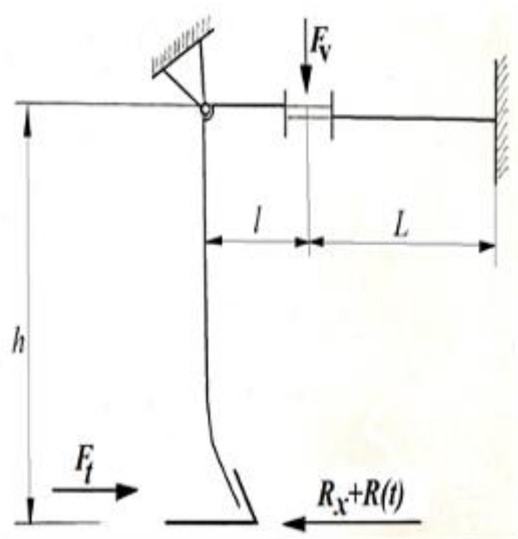

Fig. 2–Case of the vibrating working body with elastic support (*Dubrovskii A, 1977*)

Variations of R_x lead, in the case of vibrating working bodies with elastic support, to vibrations maintained due to the energy accumulated by the support. This energy is described by(*Dubrovskii A, 1956*):

$$E_S = k \cdot \frac{z^2}{2} \tag{11}$$

where: k – is the elastic constant of the support of working body, and z – is the vertical movement of the support.

It is known that:

$$k = \frac{3 \cdot E \cdot I}{L^3} \tag{12}$$

where: E – is the elastic modulus of the support's material, I – moment of inertia of the support's section, L – length of the support.

From the equation of moments in relation to the joint (Fig. 2), it results that the force acting on the end of the elastic support (F_V) has the expression:

$$F_V = \Delta R(t) \cdot \frac{h}{l} \tag{13}$$

But, given that $F_V = k \cdot z$, from equation (13) it results:

$$z = \Delta R(t) \cdot \frac{h}{k \cdot l} \tag{14}$$

And the expression of energy accumulated in the support (equation 11) becomes (*Dubrovskii A, 1956*):

$$E_S = \frac{\Delta R^2(t) \cdot h^2 \cdot L^3}{6 \cdot l^2 \cdot E \cdot I} \tag{15}$$

resulting that the energy depends primarily on the operating conditions (ΔR (t)) and the construction of the elastic support, factors influencing the parameters of obtained free vibration.

RESULTS

Equation (15) allows the calculation of the energy accumulated in the support of the working body depending on the working conditions, the material of which the support is manufactured and its parameters of construction and assembly.

It can be seen that as the height of the tool support is higher, as the length of the support arm is greater and the variation of traction resistance is higher, the energy accumulated in the support of the working body is higher and the availability of occurrence and generation of free vibrations is greater.

The moment of inertia of the section of the working body support, and the modulus of elasticity, have a proportional inversely influence to the energy accumulated in the support. In Figures 3 and 4 are presented these qualitative and quantitative dependencies of the energy accumulated in the support, depending on the size of variation of soil resistance to processing, for different cross sections of the support - moments of inertia (I1<I2<I3<I4).

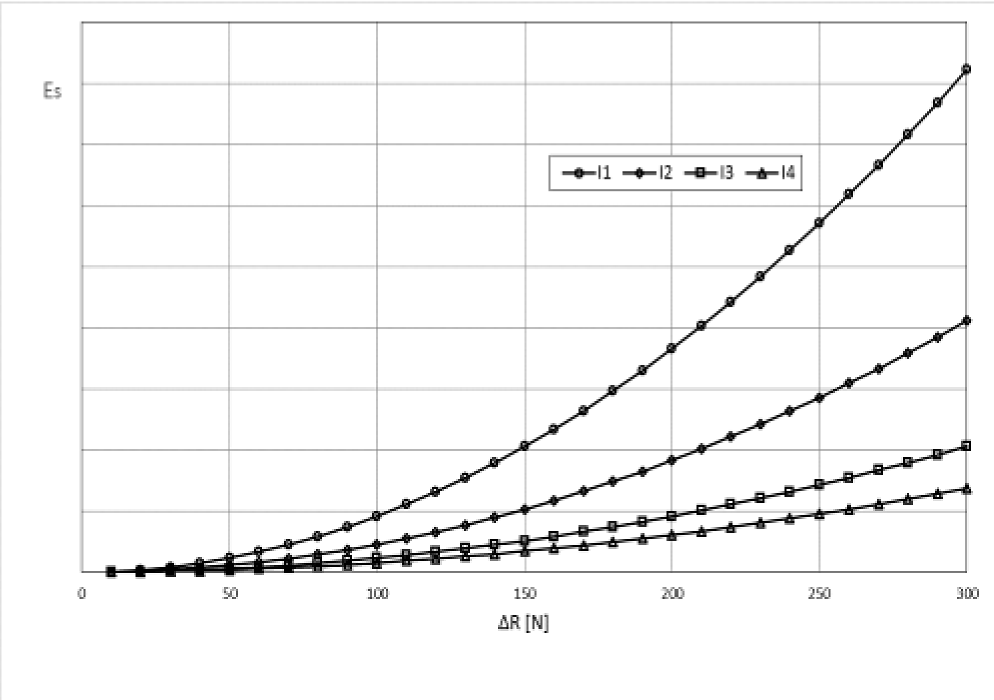

Fig.3–Dependence on energy accumulated in the elastic support depending on the size of variation in soil resistance during processing

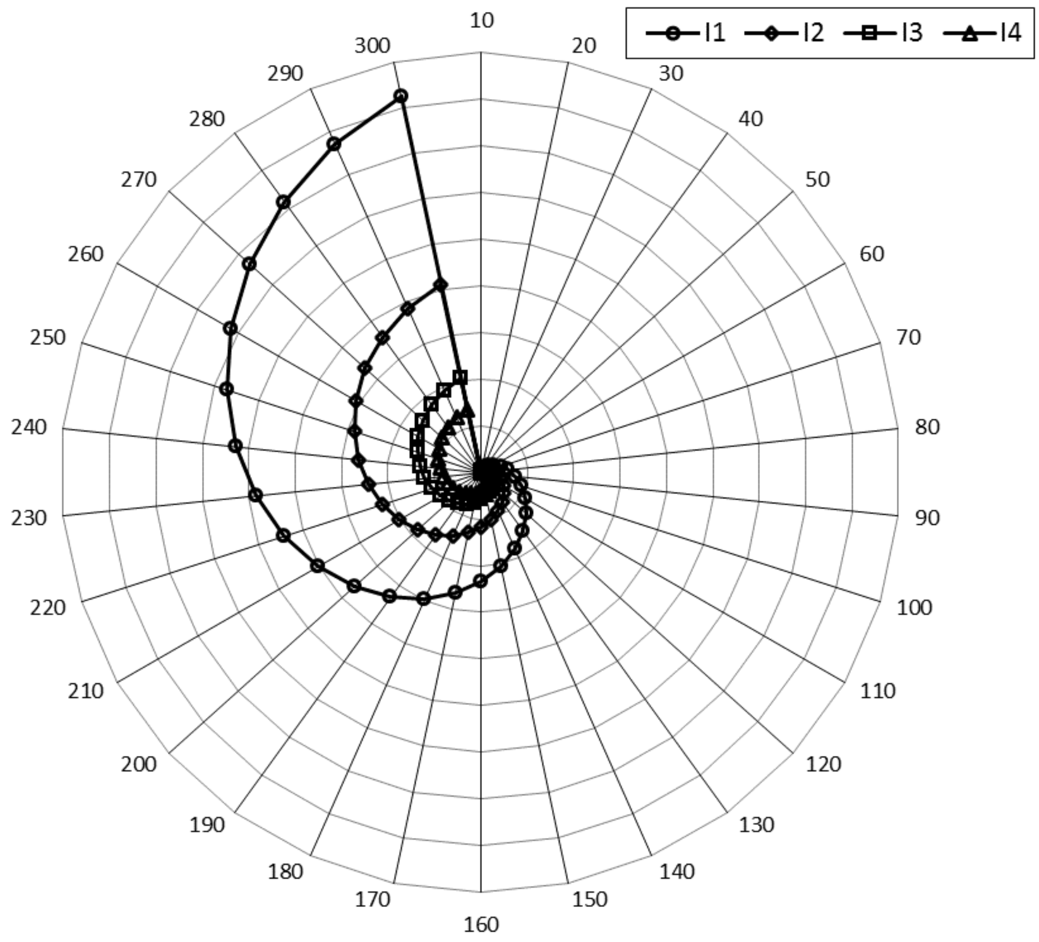

Fig.4–Representation of the dependency of the energy accumulated in the elastic support and the size of variation in soil resistance during processing

CONCLUSIONS

- The use of vibrating working bodies in cultivators leads to obtaining works with values of agrotechnical indices superior to those obtained when working with non-vibrating working bodies (soil grinding is better and there occurs the phenomenon of self-cleaning of the blade on the weeds).
- The life span of the knives without regrinding increases 2-4 times when applying vibrations.
- Traction resistance is reduced by 30-50% in the case of vibration with 480-1380 osc/min, the reduction being most obvious in soils with high resistance and when increasing amplitude and frequency of vibration or in the case of reduction of forward speed of the aggregate.

ACKNOWLEDGEMENT

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CONSIDERATIONS REGARDING RECIRCULATING ACVACOLE SYSTEMS / *CONSIDERATII PRIVIND SISTEMELE ACVACOLE RECIRCULANTE*

Phd. Stud. Eng. Andrei S., Phd. Stud. Eng Laza Evelin, PhD. Eng. Păun A., Eng. Marian M.
INMA Bucharest / Romania
E-mail: Andrei_sg85@yahoo.com

Keywords: *aquaculture, RAS, mechanical filtration, biological filtration*

ABSTRACT

The increasing demand for acvacole products contributed to worldwide aquaculture development, which led to the implementation of fish growing super-intensive systems. Recirculating acvacole systems (RAS) represent the most viable solution for acvacole products growth and development due to the possibilities of monitoring and control all parameters that can influence biological material growth and development. The technologies included in a RAS contribute, in a decisive way, to the proper functioning of the system, thus providing compliance with applicable regulations both in terms of quality of products which are offered for consumption, but also reducing the amount of waste released into the environment.

REZUMAT

Cerinta tot mai mare de produse acvacole a contribuit la dezvoltarea acvaculturii pe plan mondial, fapt ce a condus la implementarea de sisteme superintensive pentru creşterea peştilor, protejand in felul acesta in felul acestincercand sa se protejeze resursele naturale. Sistemele acvacole recirculante (SAR) reprezinta solutia cea mai viabila in cresterea si dezvoltarea produselor acvacole datorita posibilitatilor de monitorizare si control a tuturor parametrilor ce pot influenta cresterea materialului biologic. Tehnologiile pe care le inglobeaza un SAR, contribuie intr-un mod hotarator la buna functionare a sistemului, asigurand in felul acesta respectarea normelor in viguare atat in ceea ce priveste calitatea produselor ce sunt oferite spre consum, dar si reducerea cantitatii de deseuri evacuate in mediul inconjurator.

INTRODUCTION

Due to intense exploitation of planet acvacole resources it was necessary to find a solution to obtain acvacole products that meet market requirements and protect natural resources. Aquaculture is the field in charge with finding these solutions. Since the demand for acvacole products has been very high in the past two decades, aquaculture has gone through some changes so that its output surpassed the production from fish capture or other areas (FAO, 2001).

Aquaculture had the fastest growth in the field, increasing by 9.1% compared to the 1.2% production obtained from fish capture. However, it is necessary for fish production obtained from aquaculture to grow 5 times in the coming years in order to meet the increasing demand for meat consumption [4].

Fish growing in recirculating acvacole systems

Within these acvacole systems are used waste water treatment installations. After waste water treatment, it is reintroduced in culture basins, as it can be seen in fig. 1 [6]. This way, water resources are used more efficiently due to low water consumption [5], [6].

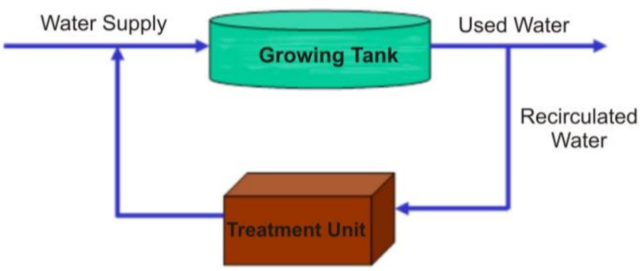

Fig. 1 - Functioning procedure of a RAS [6]

Due to the possibility to reuse water within the system, the necessary of land is much lower compared to pond type traditional systems. It is very important to mention that a RAS system offers the possibility to a larger control on culture environment and a better management of the waste released in environment, increasing in this way the system productivity.

MATERIAL AND METHOD

The main objective aimed in a RAS is to ensure as favourable as possible environmental conditions to meet eco-physiological characteristics specific to each species culture.

Although the technical equipment used for the performance of a RAS is costly, we can say that there are several important reasons that justify their use in acvacole systems, namely that we are able to obtain the product in continues flow throughout the year, including having possibility to locate farm in areas with limited water resources and proximity to markets, thereby reducing transportation time [5].

The main advantages of a recirculating acvacole system are related to: the use of small amounts of water, use of a reduced space, the ability to control water temperature, the ability to control water quality, functioning of the system independent of weather conditions [8].

RAS functions

The essential functions of a RAS are:
- providing the necessary space for fish material, optimum water flow conditions, the pollution degree (density);
- protecting the fish stock material of infections or other pathogens;
- ensuring the fish physiological needs (particularly oxygen and food);
- removing the metabolic compounds from water mass (excrements, ammonia and carbon dioxide);
- removing unused food (solid and dissolved organic compounds);
- maintaining water temperature and quality parameters at an acceptable level.

The most common equipment in an RAS is presented in figure 2 [6].

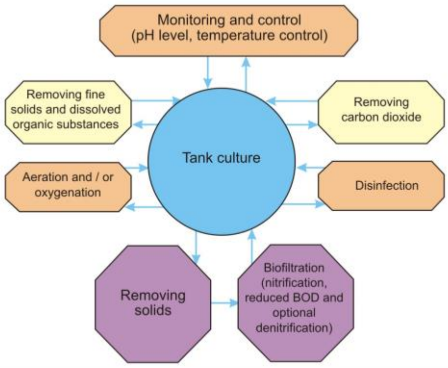

Fig. 2 - Necessary equipment for a recirculating acvacole system (adaptation Losordo, 1998) [6]

A well-structured acvacole system must include equipment that is capable of removing solids in suspension in the water mass, removing carbon dioxide, introducing oxygen into the system, monitoring the concentrations of ammonia, nitrates and nitrogen, pH and bacterial pathogens in equal proportion to their rate of propagation.

RESULTS

Components of recirculating acvacole systems

In a recirculating acvacole system (RAS) for the fish material growth and development to take place in good conditions, there must be a variety of equipment such as: mechanical and biological filtration equipment, recirculation pumps and basins for fish and other auxiliary equipment necessary for the improvement of water quality in the system. Water quality within a RAS is determined by its concentration in dissolved oxygen, unionized ammoniacal nitrogen, nitrites and carbon dioxide. The levels of pH, concentration in nitrates and alkalinity are also important parameters for water quality assessing.

• **Recirculation pumps:** all acvacole recirculating systems require the presence of a shunt in order to carry out water circulation within the system, to transport oxygen in pipelines and to remove waste from storage tanks. Using water recirculation pumps water is raised to the desired level and then it is circulated within the system. One of the main conditions in designing a RAS is to choose the correct type of pump or pumping system, due to the need to have a correlation between system requirements and maximum operation efficiency of the pump. Any discrepancy between what is required and what a pump or a pumping system can provide will increase the costs of pump operation and maintenance. When choosing pumps to circulate water within RAS a special importance must be given to the following details such as working pressure, flow of water to be pumped into the system, the degree of purity of the water and the size of hydraulic losses in the network [2], [19].

In RAS, three types of water recirculation pumps are currently used: centrifugal pumps, axial pumps and airlift pumps.

- **Centrifugal pumps:** are sold in a wide range of models that meet the requirements for pressure and flow established by the beneficiaries of acvacole systems and not only. For typical applications in RAS, which require a high flow pump and small pumping height, centrifugal pumps would rather be used because they do not require high electric energy consumption [13].
- **Axial pumps** are another type of pumps widely used in recirculating systems, because they have better pumping efficiency than centrifugal pumps. It is used mainly where is needed high flow rate and low pressure [13].

- **Ventilation and oxygenation systems:** of water in a recirculating system plays an important role because in conditions of poor oxygenation of water, fish is exhibited to stress, such as the tendency to agglomerate in areas where the stream is stronger, it breathes at the surface, tends to leave the unfavourable environment, breathing accelerates and eventually death occurs with fish jerking movements, alternating with calm [13].

Another important aspect is to ensure optimal concentrations of oxygen within filters provide a good functioning of biological film; nitrification process is slower nitrification process until stoppages in nitrification bacteria.

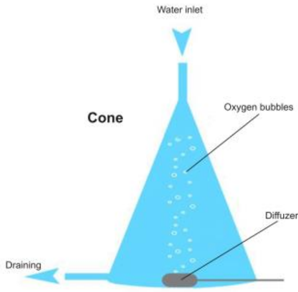

Fig. 3 – Cone type oxygenator functioning mode[12]

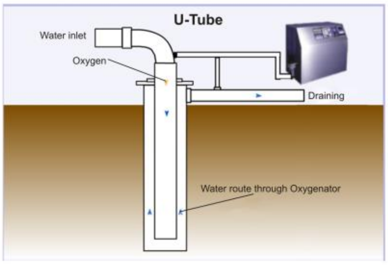

Fig. 4. Oxygenator U type- and oxygen in water circuit inside the apparatus [12]

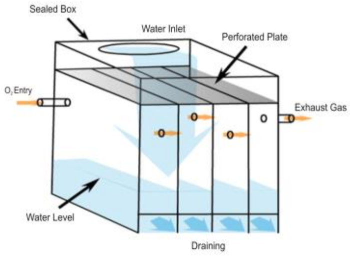

Fig. 5- Low Head Oxigenator (LHO) [12]

- **Mechanical filters:** represent the primary process of removing solid particles in suspension in RAS water mass. Currently, worldwide there aren't any farms which recirculate water removed from basins not to use micro-filters which are equipped with sieves with apertures in size of 40-100 microns [16].
- **Biofilters:** filtering equipment together with biological filtration and mechanical equipment intended for treatment with UV radiation is one of the essential components of the wastewater treatment department within a recirculating system. The use of biofiltering equipment is intended to remove from recirculating water mass the substances that are toxic for fish material, with the help of nitrification bacteria present in biological filters.
- **Culture basins:** can be found in an acvacole recirculating systems are of various shapes and sizes, generally densely populated basins, so as to ensure fish stocks, thereby requirements related to the necessary field are highly reduced in comparison with traditional aquaculture [5]. Basin types within a RAS are generally circular, rectangular or oval as constructive shape, as it can be seen in figure 6 [13]. In basins design the rest of the equipment in the system must also be taken into account, but especially the biofilter size.

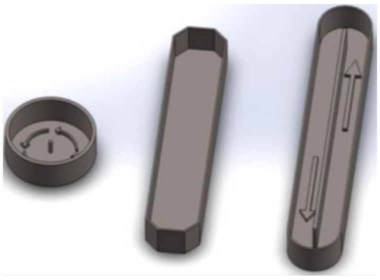

Fig. 6 - Basin types encountered in aquaculture [13]

- **UV treatment system:** is known that some bacteria can be destroyed by sunlight. In the last decade of the nineteenth century, it was confirmed that the ultraviolet portion of the solar radiation spectrum is responsible for the bactericidal action of light. UV disinfection operates on the base of light application with a wavelength of 254 nm wavelength which is capable of destroying biological organisms DNA [22]. UV wastewater treatment systems from RAS, due to the principle of operation, are divided into two categories: UV systems in closed reactors, figure 7 [19] and UV open channel systems, figure 8 [20].

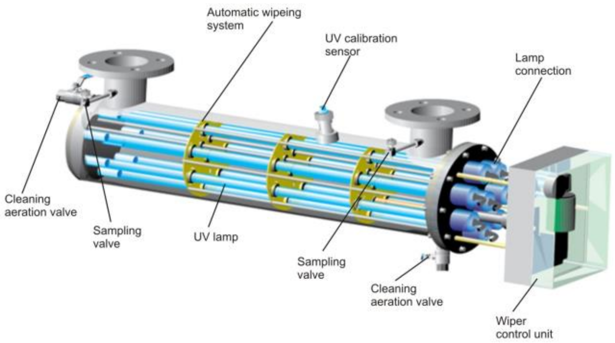

Fig. 7 - UV treatment system in closed reactor [19]

Fig. 8 - UV treatment system in open channels [20]

Control of the main physico-chemical parameters of aquaculture water

In a recirculating system, the requirements regarding water quality can vary considerably depending on a number of factors such as: culture species, water source, water speed inside the system, the density of fish, the maturity of fish and not least the exposure to stress. The way in which the quality of water used in aquaculture is managed depends not only on the process of fish growth and development but also their survival [10].

General water quality requirements within a recirculating system are presented in Table 1 [2]

Table 1 [2]

General water quality requirements within recirculating systems

Components	Recommended value
Temperature	Optimal limit for the species grown - variations lower than 1°F
Dissolved oxygen	Saturation of 60% or more, usually 5 mg/l or more. For warm water fish even more than 2mg/l in biofilter affluent
Carbon dioxide	Less than 20 mg/l
pH	7.0 to 8.0
Total alkalinity	50 to 100mg/l for $CaCO_3$
Total hardness	50 to 100mg/l for $CaCO_3$
Unionised ammonia	Less than 0.05 mg/l
Nitrites	Less than 0.05 mg/l
Salinity	0.02 to 0.2%

Physical factors

- ***Temperature:*** is defined as the degree of heating and cooling of a living organism, which is either in the water or on land, according to (Lucinda and Martin, 1999) [1]. This is the physical factor that can influence all biological and chemical processes within a RAS. A recirculating system must be able to control water temperature, in order to develop and capitalize the fish material [10]. The temperature inside a recirculating system must be maintained in an optimum range, specific to the culture species.

Turbidity: Water turbidity depends on the amount of organic or inorganic substances suspended in the water mass which interferes with the light that penetrates the water column, and not least, it also depends on the height of the water column. Bigger the amount of suspended material is, more pronounced the degree of water turbidity and lower presence of light in the water mass is [21].

A management activity in aquaculture is represented by a monitoring, as serious as possible, of water turbidity, because using this parameter, water quality can also be evaluated. It is recommended that in recirculating systems the concentration of suspended solids in the water mass be no higher than 15 mg/l.

Chemical parameters

- ***Water pH:*** water pH can determine whether it is acidic or alkaline; to be more explicit, the pH is that chemical parameter indicating the hydrogen ion concentration in the water and it is defined as the negative logarithm of the hydrogen concentration in the water (-log [H +]). It is important to mention that water pH is a parameter affecting in turn other quality parameters of the water in the system, as for example carbon dioxide – CO_2 and unionized ammonia – NH_3, shown in Figure 9 [21] . That is why pH is an extremely important parameter that must be rigorously monitored and controlled.

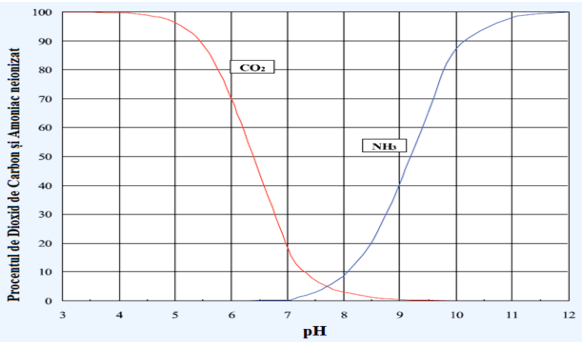

Fig. 9 - pH influence on carbon dioxide and unionized ammonia [21]

- ***Alkalinity:*** is an extremely important factor, because it represents the ability to neutralize the acidity of a solution; alkalinity depends on the concentration of bicarbonate, carbonate, hydroxide and hydrogen ions [16]. Alkalinity plays a very important role in the nitrification process and, according to Gujer and Boller (1984), maintaining an alkalinity of at least 50 mg/l concentration of calcium carbonate - $CaCO_3$ during nitrification may prevent water pH instability, while Malone et al. (1993) recommend a level of 100 mg/l alkalinity of calcium carbonate $CaCO_3$ [14]. Due to the high density of fish in a recirculating system, there may be fluctuations in the water pH level, fluctuations to be monitored and controlled by adding buffer solutions in order to increase the alkalinity level of the water in the system. If water pH tends to go out of the optimum range, by adding sodium bicarbonate in proportion of 17-20% of the daily feed rate (Masser Michael P. et al, 1999) state that it is sufficient for maintaining the pH and alkalinity within the optimum range, as it can be seen in Figure 14 [11].

- ***Dissolved oxygen (DO):*** in all acvacole systems dissolved oxygen (DO) concentration in water is considered the first limiting factor responsible for fish growth and welfare, which must be maintained at a safety level since it is responsible for ensuring fish breathing in the acvacole system. The dissolved oxygen concentration in water is expressed as milligrams of oxygen per litre of water (mg/l).

0-2 mg / L: oxygen level is insufficient to sustain aquatic life.
2-4 mg / L: oxygen level is low, only a few fish and aquatic insects can survive.
4-7 mg / L: oxygen level is good for many aquatic animals, but it is low for cold water fish.
7-11 mg / L: oxygen level is very good for most fish.

With regard to oxygen consumption by the fish in the RAS, this depends on a number of factors, such as: their size, intensity of feeding, metabolic activity and temperature. Juvenile fish use a much larger amount of oxygen as opposed to the adult fish, as a result of more intense metabolic activity [10].

One of the factors influencing the maximum oxygen content in the water is given by water temperature. In table 2 [11], it can be seen that there is an inverse correlation between temperature and DO (dissolved oxygen) in the water. The higher the water temperature, the lower the amount of oxygen that can be dissolved in water at a given time and, vice versa, the lower the water temperature, the higher the oxygen concentration in the water.

Table 2 [11]

Temperature [°C]	DO [mg/l]
10	10.92
12	10.43
14	9.98
16	9.56
18	9.18
20	8.84
22	8.53
24	8.25
26	7.99
28	7.75
30	7.53
32	7.32
34	7.13
36	6.95

Low concentrations of oxygen dissolved in the water mass are more responsible for the high level of fish material mortality, either directly or indirectly, than all other problems combined. [10]

- ***Control of nitrogen waste:*** the main source of ammonia in culture basins within a RAS is generated by fish material excretion processes [10]. Total ammoniacal nitrogen (TAN) within acvacole systems includes two forms: unionized (NH3) and ionized (NH4+). Unionized ammonia is extremely toxic to fish, therefore it must be removed rapidly from the system [5]. Total ammoniacal nitrogen (TAN) concentration in its ionised and unionized forms varies depending both on the pH and the temperature of the water in the system; if pH and temperature increase at the same time, the concentration of TAN in the unionized form also increases, as shown in Figure 10. A frequent exposure of the fish material to a concentration of ammonia in the unionized form of 0.02 mg/l can make the growing process proceed very slowly and all sorts of diseases may appear [9].

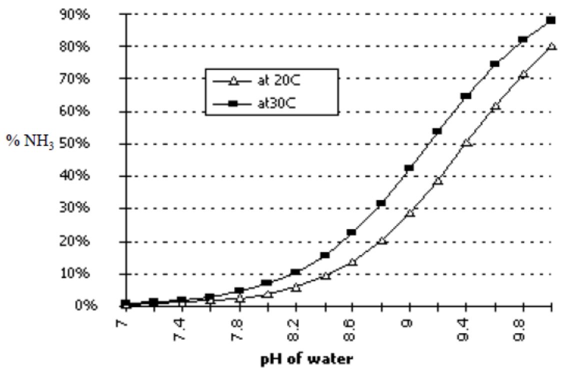

Fig.10. Relation between pH and NH_3 [9]

- ***Carbon dioxide:*** in acvacole systems is generated in fish breathing process; its presence in culture basins is not a particular problem for the system as long as there is a sufficient concentration of dissolved oxygen in the water. However, the concentration of carbon dioxide in the system must not exceed 20 mg/l, not to endanger fish living conditions. According to (Basu, 1959), the concentration of carbon dioxide in the range of 20-40 mg/l is highly toxic for fish because it slows down the carrying capacity of the blood. The concentration of carbon dioxide according to Summerfelt (1993) may rise until reaching a toxic level within a RAS using pure oxygen injection equipment, caused by a low gas exchange and the high density of fish in the basins [4].

- ***Salinity:*** is the total concentration of ions dissolved in water, the following compounds having a major contribution: calcium, sodium, potassium, bicarbonate, chloride and sulphate. Salinity is expressed as parts per thousand (ppt salt grams per water kilogram). Normally, salt concentration in the fish body is 0.5% higher than salt concentration in the water surrounding it. Salinity plays an important role in culture species growth through the osmoregulation of body minerals with the water in culture basins [20]. It is important to mention that speeding up the acclimatization process by adding salt rapidly may have undesirable effects, first of all on the biological filter, decreasing filtering efficiency [11]. To reduce the stress that appears among culture species and also to reduce the energy consumed by osmoregulation, the salinity level in acvacole systems should be maintained between 2-3 ppt [23].

CONCLUSIONS

As long as the demand for acvacole products is raising on national and international market, in the following years a series of investments are expected in order to support and develop new recirculating acvacole systems.

Recirculating acvacole systems can be successfully implemented in areas with limited water resources and due to water reuse capacity and a more reduced need for land compared to traditional acvacole systems.

Recirculating acvacole systems are considered optimum solutions to increase productivity of aquaculture products as a result of not being influenced by outdoor climate conditions, but also due to the advanced equipment available, equipment that can control both water quality in the system and the amount of waste to be removed.

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INFLUENCE OF RYE FLOUR DURING THE KNEADING OPERATION – A REVIEW / *INFLUENŢA FĂINII DE SECARĂ ÎN TIMPUL OPERAŢIEI DE FRĂMÂNTARE - REVIEW*

As. Ph.D. Stud. Eng.Munteanu M. G.[*1)], Prof. Ph.D. Eng. Voicu Gh.[1)], Lect. Ph.D. Eng. Ionescu M.[1)], Lect. Ph.D. Eng. Stefan E. M.[1)], Lect. Ph.D. Constantin Al. G.[1)], As. Ph.D. Stud. Eng. Zăbavă B. Şt.[1)]
[1)] University Politehnica of Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
Tel: 0767236522; E-mail: munteanumaya@yahoo.com

Keywords: *wheat flour, rye flour, rheological properties, farinograph curves*

ABSTRACT

In order to establish the flours quality, determinations are made to obtain the farinograph characteristics of bread dough. One of the most popular devices for determining the quality of flour is the farinograph. The Farinograph measures and registers the mechanical strength of the dough during kneading, highlighting the farinograph characteristics by a curve named farinogram. Thus, on a farinogram the following parameters can be read: flour water absorption, dough development time, dough stability, dough softening degree and farinograph quality number (FQN). This paper presents results of experimental research on the rheological characteristics of dough made of wheat flour mixtures FA-480 and FA-650 with rye flour in different amounts. (Munteanu et al., 2015)

REZUMAT

In vederea stabilirii calitati fainurilor, se fac determinari pentru obtinerea carateristicilor farinografice ale aluaturilor de panificatie. Unul dintre cele mai raspandite aparate pentru determinarea calitatii fainii, il reprezinta Farinograful. Farinograful măsoară şi înregistrează rezistenţa mecanică a aluatului în timpul procesului de frământare, evidenţiind caracteristicile farinografice printro curbă numită farinogramă. Astfel, pe farinogramă pot fi citiţi următorii parametrii: capacitatea de hidratarea a făinii, timpul de dezvoltare al aluatului, stabilitatea aluatului, gradul de înmuiere al aluatului şi indicele farinografic. În lucrare se prezintă rezultatele unor cercetări experimentale privind caracteristicile reologice ale aluaturilor din amestecuri de făină de grâu FA-480 si FA-650 cu făină de secară în procente diferite. (Munteanu et al., 2015)

INTRODUCTION

In the last decades, researches using different ingredients in the manufacture of bakery products have experienced a spectacular growth due to advances in research of the dough rheological properties. (Luchian, 2012).

The physico-chemical, rheological and technological properties influence the mixing process and dough processing by the operating modes adopted by the machines on the technological flow and by the used recipe ingredients (additions of ingredients and additives). (*Munteanu et al., 2016*)

Rheological characteristics of dough influence bread volume and shape, elasticity of the core and crust, maintaining of the freshness. When the dough has high enough elasticity and extensibility powdery bread results, with developed volume and core having pores with thin walls. If the dough is too tough (tenacious), undeveloped bread is obtained, with dense core; if the dough is excessively extensible the bread becomes flattened, has low volume and coarse porosity. (*Luchian, 2012*).

Empirical methods for determining the rheological properties are purely descriptive, the parameters obtained from the sample subjected to analysis being dependent on test conditions imposed (amount of flour subjected to analysis, the geometry of the mixer unit, operating parameters of the device, etc.). However, they are easy to interpret and may represent an important milestone in assessing the quality of analysed flour (Codina, 2010)

One of the best known and widely used methods to determine the rheological properties of dough is farinograph method (AACC 54-21, ICC 115/1, ISO 5530-1). (*Munteanu et al., 2015*)

Farinograph renders information on the changes of the dough rheological properties during the kneading of dough with constant consistency. This information is related to the ability of flour hydration, development time, stability, dough softening. (*Danciu, 2012)*

Knowledge of the dough farinographic characteristics helps achieving optimal technological mixtures of flours from different varieties from which quality bread can be obtained. Dough properties influence the quality of bakery products. Knowing the rheological properties of dough (gluten) we can assess the quality of an assortment of flour proteins. The addition of wheat flour proteins (soy protein, mushrooms, whey) recorded significant changes of dough farinograph parameters: hydration capacity, development time and dough rise stability. (Munteanu et al, 2015)

MATERIAL AND METHOD

To highlight the farinograph characteristics of wheat and rye flours, Voicu et al. and Munteanu et al., determinations were made with Brabender Farinograph-E (Figure 1) under standard methodology for testing the quality flours AACC 54-21, ICC 115/1, ISO 5530-1.

The working principle of the farinograph is based on the resistance subjected by the dough on the mixing shaft. The resistant moment on the mixing shaft has an increasing variation when mixing the components, hydrating particles of flour, dough formation and development, up to a maximum value close to the value of the dough consistency standards. Then, the variation of the shaft moment, respectively consistency of the dough, remains approximately constant during the stability phase of the dough which can be maintained for longer or shorter period of time, depending on the flour characteristics. Graphic recording of the moment (consistency of the dough) during kneading with farinograph is called farinogram (Figure 2). (*Voicu Gh et al., 2012, Munteanu et al., 2016*)

Fig.1 – Farinograph - Brabender

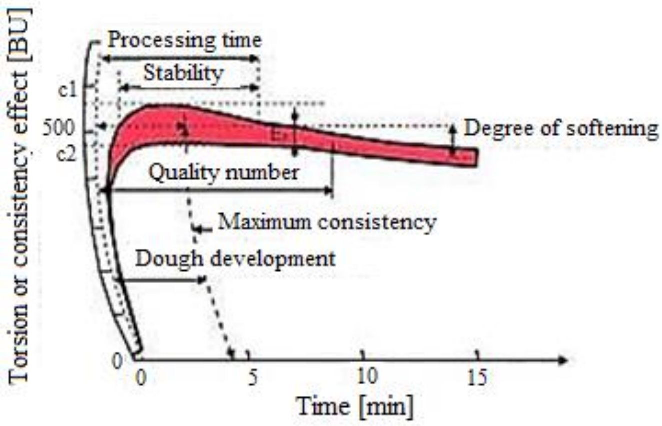


Fig. 2 - Farinograph curve (Codina, 2010, Voicu et al., 2012)

On the farinograph curve the following parameters can be read:

- *Hydration capacity* of the flour representing the percentage of water compared to the flour for obtaining a standard consistency of the dough (UB 500);

- *Development time (*formation) of the dough is the time (in minutes) for the formation of gluten, meaning until the consistency of UB 500*;*

- Dough *stability* is the time that the farinograph curve keeps in line of normal consistency;

- *The softening of the dough (*the tolerance to kneading) is represented by the difference between 500 UB consistency and the consistency that has reached a curve after 12 minutes from reaching standard consistency;

- *Value index of the flour FQN* is an index for measuring the quality of the flour and measures the farinograph curve horizontally (in minutes) from the vertical axis of the consistency of the dough to the point where the centre line of the curve meets the horizontal line lowered by 30 UF from the consistency peak, multiplied by 10. If the number is bigger, it means that the flour is stronger. *(Voicu Gh. Et al., 2009).*

All these rheological characteristics of dough serve to determine the appropriate flour mixtures, the composition of the manufacturing recipes, as well as setting the system parameters of the bread-making technology, so as to obtain the corresponding bread properties. (Voicu Gh. Et al., 2009)

The determinations were made in 2011 and 2015, in the Department of Biotechnical Systems, "Politehnica" University of Bucharest. For determinations were used more types of flour: white wheat flour type 650 (FA-650), commercially purchased used in mixture with rye flour produced at the mill SC ILSA SA Calarasi, Romania, from 2014 production of wheat from and flour type FA-480, purchased from the bread factory “Spicul”, Rosiori de Vede, Romania, obtained from the 2010 production of wheat, mixed with various percentages of rye flour purchased from the market.

Farinographic characteristics were determined for the three types of flour, but also for their mixture (90% FA-480 + 10% rye flour, 80% FA-480 + 20% rye flour, 70% FA-480 + 30% rye flour 60% FA-480 + 40% of rye flour, 50% FA-650 + 50% of rye flour).

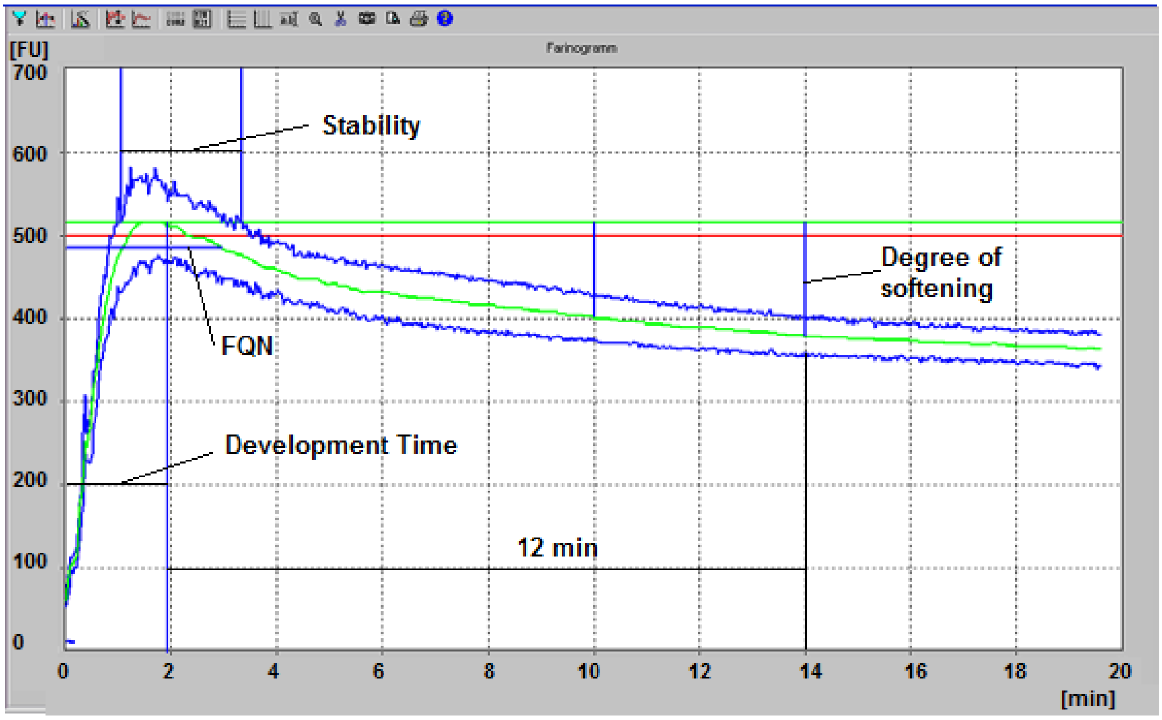


Fig. 3 - Example of wheat flour farinogram of

RESULTS

Experimental curves obtained for the flour mixtures mentioned are shown in Fig. 4 and Fig. 5 and farinograph characteristics are presented in Tables 1 (Gh Voicu et al, 2012) and 2 (Munteanu M. et al, 2015).

Table 1

Farinograph parameters of dough from wheat flour mixed with FA-480 rye flour

Farinograph characteristics	FA-480	10% Rye flour	20% Rye flour	30% Rye flour	40% Rye flour
Water absorption, (%) Correction for 500 FU	60.0 61.4	62.8 62.9	65.5 65.1	67.0 67.0	67.7 67.5
Development time, min	1.8	1.9	2.0	2.0	2.2
Dough stability, min	1.5	1.4	1.3	1.9	1.9
Degree of softening, FU After 10 minutes After 12 minutes (ICC)	 110 122	 85 83	 63 63	 48 65	 32 65
Farinograph Quality Number	26	29	34	50	100

Table 2

Farinograph characteristics for FA-650, rye flour and flour mixture

Farinograph characteristics	**FA-650**	**Rye flour**	**FA-650 and rye flour mixture**
Water absorption, (%) Correction for 500 FU	66.3 67.0	59.7 59.0	64.6 63.5
Development time, min	2.2	1.7	2.0
Dough stability, min	10.9	0.4	1.3
Degree of softening, FU After 10 minutes After 12 minutes (ICC)	 33 38	 198 214	 57 93
Farinograph Quality Number	48	21	77

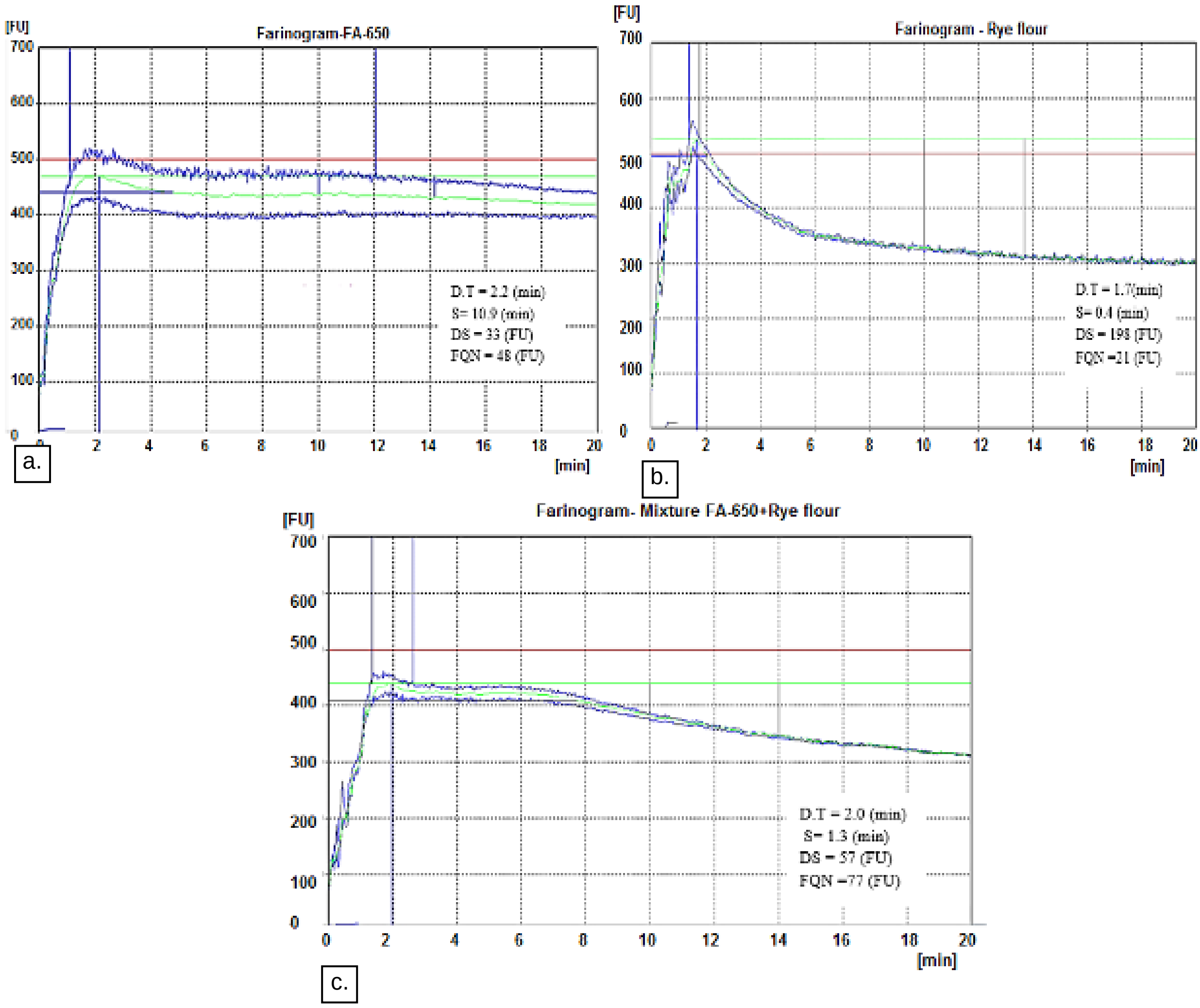


Fig. 4 – Farinogram curves obtained for FA-650, rye flour and mixture of 50% FA-650 + 50% rye flour

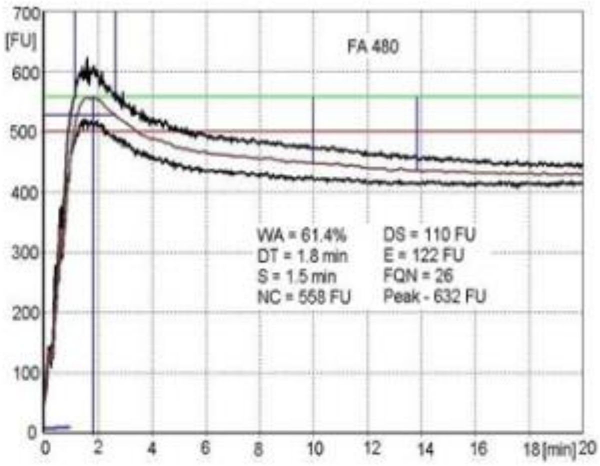
From farinograph curves analysis results that there is a slight growth trend of dough development time with increasing percentage of rye flour added, but the differences are insignificant.

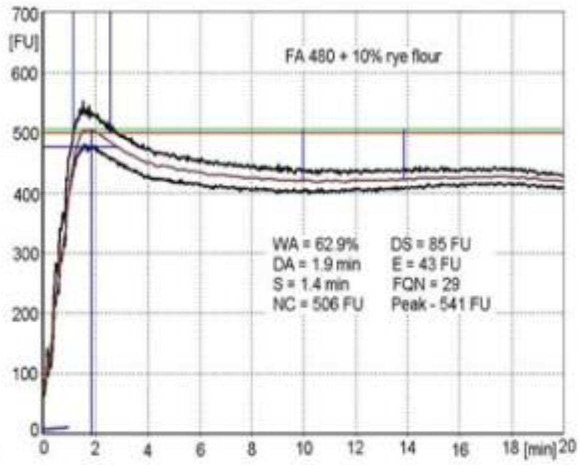
Regarding the dough stability time during kneading, it drops a little for the dough with a content of 10% and 20% rye flour and grows a little more for dough with 30% and 40% rye flour. (Voicu Gh., Et al, 2012)

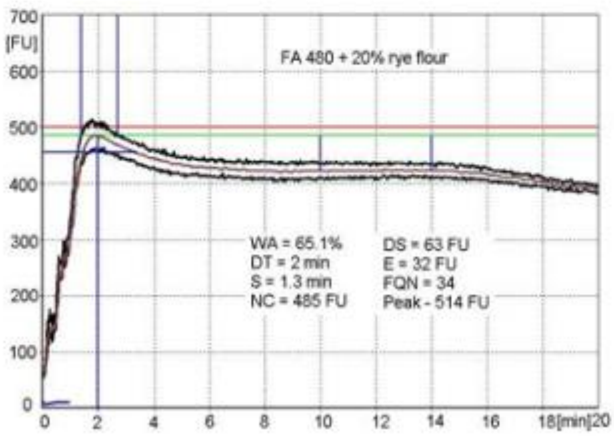
By comparison with wheat flour, the rye flour develops dough with rheological characteristics significantly different (see Figure 4 b). If development time is only 1.7 minutes, the stability time of rye flour dough is 0.4 minutes, which shows a very low flour, especially since the degree of softening is very high (214 UF after 12 minutes from the achievement of the maximum consistency) and farinograph index has a low value (FQN = 21). If it forms a dough of wheat flour and rye flour (in equal proportions), then rheological characteristics, respectively farinographic characteristics, of the obtained dough are improved, although they don't reach the values shown by the simple dough, only from wheat flour. This one shows a development time of about 2 minutes, respectively a stability time of 1.3 minutes. (Munteanu M. et al, 2015)

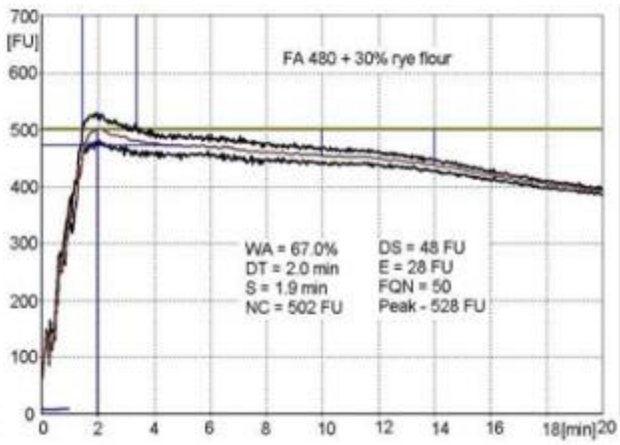
As mentioned in the scientific literature, the degree of softening (at least on the curves plotted using farinograph Brabender) shows a decreasing trend with an increasing percentage of rye flour added, but it should be noted that the dough becomes sticky and emerges hard on the sides. (Voicu Gh., Et al, 2012)

About the power of the flour measured by the index FQN, it can be seen that it gets bigger by increasing the percentage of rye flour added, even doubling with the change of rye flour from 30% to 40%, mixed with wheat flour. (Voicu Gh., Et al, 2012)









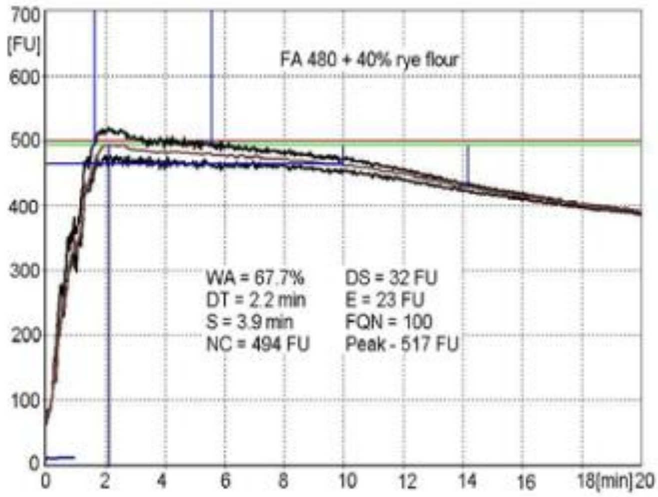


Fig. 5 - Farinograph curves obtained from experimental determinations with Brabender farinograph

CONCLUSIONS

Knowledge of physical and rheological parameters of baking flours, in general, and of the dough, in particular, is useful for specialists and for workers in the field, both for assessing the technological and functional parameters of the machines that process the flour dough, as well as for setting technological parameters of baking process. (Voicu Gh. Et al, 2009)

The quantity of rye flour introduced in mixture influences the farinographic characteristics of the dough.

Rye flour, even if it is frequently used by the manufacturers of bread, adversely affects the farinographic characteristics of the dough.

The increase of rye flour amount in the dough leads to a decreasing of dough development time at kneading and its stability period, even if FQN farinograph index (which gives indications about the flour strength) increases. (Munteanu M. et al, 2015)

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DISC HARROW VIBRATION ANALYSIS
/
ANALIZA VIBRAŢIILOR UNEI GRAPE CU DISCURI

Prof. Ph.D. Eng. Craifaleanu A.*[1], Assoc. Prof. Ph.D. Eng. Orăşanu N.[1], Prof. Ph.D. Eng. Dragomirescu C.[1]
[1] University "Politehnica" of Bucharest, Department of Mechanics;
Tel: (004)021.402.92.50; E-mail: ycraif@yahoo.com

Keywords: *free vibration, Euler Bernoulli beam, eigenfrequencies, supported ends*

ABSTRACT

The paper analyses the free vibrations of a disc harrow. The vibration eigenfrequencies and eigenmodes are determined by two methods: the exact method, considering a simplified model, with the mass of the discs uniformly distributed over the length of the axle, and the approximate method of discretization. In order to verify its accuracy, the approximate method is also applied to the simplified model. The results obtained by the two methods are compared. Both cases of undamped and damped vibrations, respectively, are studied.

REZUMAT

Lucrarea analizează vibraţiile libere ale unei grape cu discuri. Pulsaţiile şi modurile proprii de vibraţie sunt determinate prin două metode: metoda exactă, considerând un model simplificat de bară omogenă, cu masa discurilor distribuită uniform pe lungimea axului, respectiv metoda aproximativă a discretizării. În vederea verificării preciziei sale, metoda aproximativă este aplicată şi modelului simplificat. Rezultatele obţinute prin cele două metode sunt comparate. Se studiază atât cazul vibraţiilor neamortizate, cât şi cel al vibraţiilor amortizate.

INTRODUCTION

The active organ of a disc harrow consists of a beam simply supported at its ends, on which a number of discs are fixed (Fig. 1). The system performs bending vibrations that can affect considerably the functioning of the device. Consequently, knowing the characteristics of these vibrations already from the design phase is necessary from technical, as well as economic reasons.

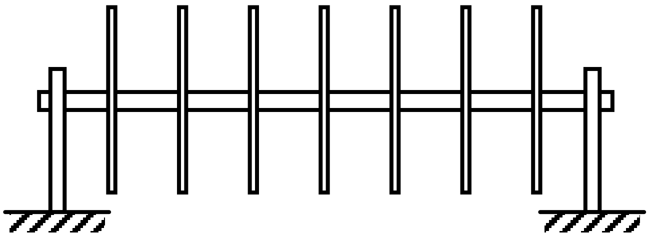

Fig. 1 - Model of a disc harrow

The study of the undamped and damped free vibrations is made in the present paper by two methods:

1) the *exact method*, applied by modelling the organ as a homogeneous beam, with the geometrical and elastic characteristics of the axle, but with the mass of the whole system – axle and discs – uniformly distributed over the length of the axle;
2) the *approximate method of discretization*, which consists in modelling the system as a beam with negligible mass, on which a number *n* of equal concentrated masses are fixed, considering also the masses of the discs in the corresponding sections; in order to verify its accuracy, the approximate method is also applied to the simplified model.

The exact method applied to the undamped free vibrations is known from the literature (*Den Hartog, 1947; Meirovitch2001; Rao, 2011*) and is based on the model of the elastic Euler-Bernoulli Beam, for which the relation between the normal stress σ and normal strain ε is given by Hooke's law (*Timoshenko, 1948*),

$$\sigma = E\varepsilon , \qquad (1)$$

where E is Young's modulus.

A generalization of this method was proposed by the authors of the present paper for the study of the damped free vibrations of a viscoelastic beam (*Craifaleanu, Orăşanu and Dragomirescu, 2015*), for which the relation between the normal stress and normal strain takes the form

$$\sigma = E\varepsilon + \mu\dot{\varepsilon}, \tag{2}$$

where μ is a viscosity coefficient.

The approximate method of the discretization consists in replacing the continuous system by a discrete one, with n concentrated masses. The use of this method for the study of various types of bending vibrations was illustrated in a number of papers (*Craifaleanu, et al., 2014; Craifaleanu, Orăşanu and Dragomirescu, 2015; Craifaleanu and Dragomirescu, 2015; Orăşanu and Craifaleanu, 2011, Orăşanu and Craifaleanu, 2012; Orăşanu and Dragomirescu; 2015*). In some of these references, the accuracy of the method has been verified by comparing the theoretical results with experimental ones.

Other approaches of the same problem can be found in (*Di Lorenzo, et al., 2012;* Vrabie*, et al., 2009*).

MATERIAL AND METHOD

Exact method

The differential equation of the bending vibration of the homogeneous viscoelastic Euler-Bernoulli beam is (*Di Lorenzo, et al., 2012*)

$$\frac{\partial^4 w}{\partial x^4} + \kappa\frac{\partial}{\partial t}\left(\frac{\partial^4 w}{\partial x^4}\right) + \gamma\frac{\partial^2 w}{\partial t^2} = 0, \tag{3}$$

where w is the deflection and, using the linear density, ρ_l, as well as the geometrical moment of inertia of the cross-section, I,

$$\kappa = \frac{\mu}{E}, \quad \gamma = \frac{\rho_l}{EI}. \tag{4}$$

The exact method for the integration of equation (3) leads to solutions of the form (*Craifaleanu, Orăşanu and Dragomirescu, 2015*)

$$w = \mathrm{Re}(\hat{w}), \tag{5}$$

where the complex deflection

$$\hat{w} = \hat{X}(x)e^{\lambda t} \tag{6}$$

was introduced.

In the same reference it was shown that the coefficient λ takes the complex or real values

$$\lambda_{1,2} = -\frac{\kappa r^4}{2\gamma} \pm \sqrt{\frac{\kappa r^8}{4\gamma^2} - \frac{r^4}{\gamma}} \tag{7}$$

while the shape functions take the form

$$\hat{X}(x) = \hat{K}_1 e^{\eta x} + \hat{K}_2 e^{-\eta x} + \hat{K}_3 e^{i\eta x} + \hat{K}_4 e^{-i\eta x} = \hat{C}_1 \cosh \eta x + \hat{C}_2 \sinh \eta x + \hat{C}_3 \cos \eta x + \hat{C}_4 \sin \eta x, \tag{8}$$

where the real parameter η and the complex coefficients $\hat{K}_j, \hat{C}_j\ (j = 1,2,3,4)$ depend on the boundary conditions.

For a beam of length l, simply supported at both ends, the boundary conditions are

$$\hat{X}(0) = 0, \quad \hat{X}''(0) = 0, \quad \hat{X}(l) = 0, \quad \hat{X}''(l) = 0. \tag{9}$$

By replacing the last expression (8) in relations (9), the following homogeneous system of linear equations results:

$$\begin{cases} \hat{C}_1 + \hat{C}_3 = 0 \\ \hat{C}_1\eta^2 - \hat{C}_3\eta^2 = 0 \\ \hat{C}_1 \cosh \eta l + \hat{C}_2 \sinh \eta l + \hat{C}_3 \cos \eta l + \hat{C}_4 \sin \eta l = 0 \\ \hat{C}_1\eta^2 \cosh \eta l + \hat{C}_2\eta^2 \sinh \eta l - \hat{C}_3\eta^2 \cos \eta l - \hat{C}_4\eta^2 \sin \eta l = 0. \end{cases} \tag{10}$$

This system admits non-trivial solutions if its determinant is null, which leads to the characteristic equation

$$\sin \eta l = 0. \tag{11}$$

It follows next

$$\hat{C}_1 = 0,\quad \hat{C}_2 = 0,\quad \hat{C}_3 = 0,\quad \hat{C}_4 = \hat{\nu}, \tag{12}$$

where $\hat{\nu}$ is a complex parameter which is determined from the initial conditions.

It can be remarked that the real part of the shape function $\hat{X}(x)$ is proportional to the imaginary part.

Approximate method

The discretized system in Figure 2 is considered.

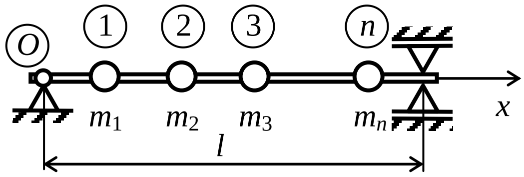

Fig. 2. Discretized model of a disc harrow

The masses in the sections without discs are

$$m_i = \frac{m_a}{n}, \tag{13}$$

while the masses in the sections of the discs are

$$m_i = \frac{m_a}{n} + m_d, \tag{14}$$

where m_a is the mass of the axle, while m_d is the mass of a single disc.

It was shown in (*Craifaleanu, Orăşanu and Dragomirescu, 2015*) that the differential equations of the damped free vibrations of the system are described by the matrix system

$$[\delta][M]\{\ddot{w}\} + \kappa\{\dot{w}\} + \{w\} = \{0\}, \tag{15}$$

or, equivalently,

$$\{z\} = [A]\{\dot{z}\}, \tag{16}$$

where

$$[A] = \begin{bmatrix} -\kappa[I] & -[\delta][M] \\ [I] & [0] \end{bmatrix}, \tag{17}$$

$$\{z\} = \begin{Bmatrix} \{w\} \\ \{\dot{w}\} \end{Bmatrix}, \tag{18}$$

$$[M] = \begin{bmatrix} m_1 & 0 & \ldots & 0 \\ 0 & m_2 & \ldots & 0 \\ \ldots & \ldots & \ldots & \ldots. \\ 0 & 0 & \ldots & m_n \end{bmatrix}, \tag{19}$$

while $[0]$ and $[I]$ are the null matrix and the identity matrix, respectively, of *n*-th order.

Matrix $[\delta]$ in expression (17) is the matrix of the influence coefficients (*Meirovitch, 2001; Silaş, 1968*). For the beam simply supported at both ends, the influence coefficients are

$$\delta_{i,j} = \delta_{j,i} = \frac{x_i(l - x_j)}{6EIl}\left[l^2 - x_i^2 - (l - x_j)^2\right] \quad \text{if} \quad x_i < x_j, \tag{20}$$

where x_i and x_j are the abscissas of sections "i" and "j", respectively.

If matrix $[A]$ has no multiple eigenvalues, the solutions of the differential system (16) are of the form

$$\{z\} = \{a\}e^{\lambda t}, \tag{21}$$

Where λ are the eigenvalues (real or complex conjugated) of matrix $[A]$, while $\{a\}$ are the corresponding eigenvectors (also real or complex conjugated).

Matrix equation (15) shows that the studied system has proportional damping (*Meirovitch, 2001; Silaş, 1968*), therefore the real part and the imaginary part of the first n elements of the $2n$-dimensional vector $\{a\}$ can be interpreted as modal coefficients of the damped vibration.

RESULTS

A disc harrow with the following characteristics was analysed: steel axle with 50 x 50 mm square section, length $l = 2\,\mathrm{m}$, density $\rho = 7850\,\mathrm{kg/m^3}$ and Young's modulus $E = 210\mathrm{x}10^9\,\mathrm{N/m^2}$; 7 discs fixed at a distance of $250\mathrm{mm}$ one from the other.

The first 10 circular eigenfrequencies and eigenvalues obtained for the undamped system and for the damped one, respectively, for various values of parameter κ, are presented in Tables 1-5. In each case, the simplified model (homogeneous beam) was studied with both exact and approximate method, while the real model (beam with discs) was studied only with the approximate method.

The first two eigenmodes are illustrated in Figures 3 and 4. At the representation scale, all the studied cases led to practically identical curves for the same eigenmode.

Table 1

Circular eigenfrequencies of the undamped system

i	Simplified model, exact method	Simplified model, approx. method	Real model, approx. method
1	106.7195	106.7168	101.82
2	426.8781	426.8674	407.3519
3	960.4757	960.4516	916.3861
4	1707.512	1707.47	1626.267
5	2667.988	2667.921	2524.008
6	3841.903	3841.806	3559.309
7	5229.257	5229.125	4555.915
8	6830.05	6829.878	11734.32
9	8644.281	8644.063	12499.23
10	10671.95	10671.68	14490.62

Table 2

Eigenvalues of the damped system with $\kappa = 0.00001$

i	Simplified model, exact method	Simplified model, approx. method	Real model, approx. method
1	- 0.0569 $\pm$ 106.7195 *i*	-0.0569 $\pm$ 106.7168 *i*	-0.0518 $\pm$ 101.82 *i*
2	-0.9111 $\pm$ 426.8771 *i*	-0.9111 $\pm$ 426.8664 *i*	-0.8297 $\pm$ 407.351 *i*
3	-4.6126-960.4646 *i*	-4.6123 $\pm$ 960.4405 *i*	-4.1988 $\pm$ 916.3765 *i*
4	-14.578 $\pm$ 1707.4502 *i*	-14.5773 $\pm$ 1707.4073 *i*	-13.2237 $\pm$ 1626.213 *i*
5	-35.5908 $\pm$ 2667.7507 *i*	-35.589 $\pm$ 2667.6837 *i*	-31.8531 $\pm$ 2523.8067 *i*
6	-73.8011 $\pm$ 3841.194 *i*	-73.7974 $\pm$ 3841.0976 *i*	-63.3434 $\pm$ 3558.7453 *i*
7	-136.7256 $\pm$ 5227.4689 *i*	-136.7188 $\pm$ 5227.3377 *i*	-103.7818 $\pm$ 4554.7324 *i*
8	-233.2479 $\pm$ 6826.0656 *i*	-233.2361 $\pm$ 6825.8941 *i*	-688.4716 $\pm$ 11714.1084 *i*
9	-373.618 $\pm$ 8636.2035 *i*	-373.5992 $\pm$ 8635.986 *i*	-781.1532 $\pm$ 12474.7921 *i*
10	-569.4528 $\pm$ 10656.7486 *i*	-569.424 $\pm$ 10656.4794 *i*	-1049.8906 $\pm$ 14452.5378 *i*

Table 3

Eigenvalues of the damped system with $\kappa = 0.001$

i	Simplified model, exact method	Simplified model, approx. method	Real model, approx. method
1	-5.6945 ± 106.5675 *i*	-5.6942 ± 106.5648 *i*	-5.1837 ± 101.688 *i*
2	-91.1125 ± 417.0413 *i*	-91.1079 ± 417.0313 *i*	-82.9678 ± 398.8131 *i*
3	-461.2568 ± 842.47 *i*	-461.2336 ± 842.4552 *i*	-419.8817 ± 814.5323 *i*
4	-1457.7993 ± 889.0556 *i*	-1457.7261 ± 889.0933 *i*	-1322.3719
5	-5914.6888	-1203.4871	-1242.2252
6	-13681.3617	-1078.8605	-1094.5706
7	-26305.6084	-1039.5191	-1053.4677
8	-45627.1687	-1022.4091	-1007.3699
9	-73709.8482	-1013.754	-1006.4841
10	-112881.6297	-1008.9385	-1004.8083

Table 4

Eigenvalues of the damped system with $\kappa = 0.002$

i	Simplified model, exact method	Simplified model, approx. method	Real model, approx. method
1	-11.3891 ± 106.1101 *i*	-11.3885 ± 106.1074 *i*	-10.3673 ± 101.2909 *i*
2	-182.2249 ± 386.0298 *i*	-182.2158 ± 386.0222 *i*	-165.9356 ± 372.0228 *i*
3	-922.5136 ± 267.3617 *i*	-922.4673 ± 267.4349 *i*	-839.7635 ± 366.8253 *i*
4	-5278.8836	-552.3167	-559.0962
5	-13717.4065	-518.9155	-521.3312
6	-29011.6668	-508.7688	-510.2766
7	-54185.5939	-504.657	-506.1718
8	-92796.4444	-502.7088	-500.9111
9	-148945.5189	-501.6842	-500.8027
10	-227280.0331	-501.1024	-500.5967

Table 5

Eigenvalues of the damped system with $\kappa = 0.003$

i	Simplified model, exact method	Simplified model, approx. method	Real model, approx. method
1	-17.0836 ± 105.3433 *i*	-17.0827 ± 105.3407 *i*	-15.551 ± 100.6255 *i*
2	-273.3374 ± 327.8896 *i*	-273.3236 ± 327.8871 *i*	-248.9033 ± 322.4635 *i*
3	-2379.9164	-387.6282	-395.3868
4	-8399.6876	-347.1087	-348.6543
5	-21015.7759	-338.7059	-339.3592
6	-43944.7717	-335.8812	-336.3093
7	-81700.6771	-334.699	-335.1371
8	-139614.5986	-334.1311	-333.6027
9	-223836.974	-333.8305	-333.5707
10	-341338.0441	-333.6592	-333.5099

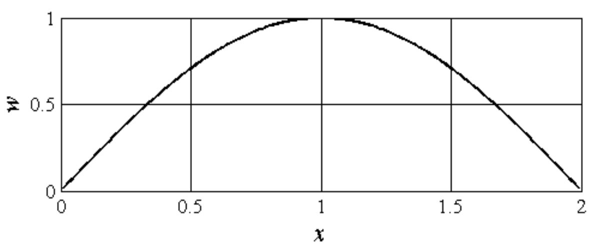

Fig. 3 - First eigenmode

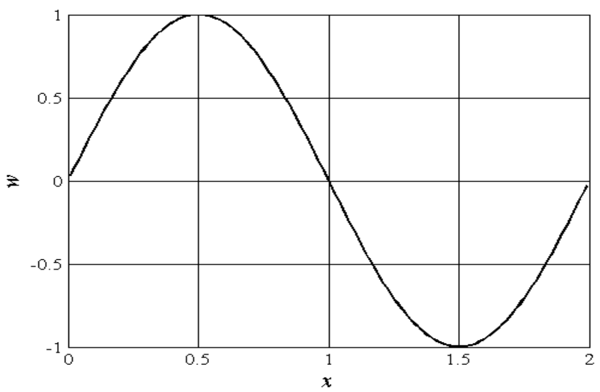

Fig. 4 - Second eigenmode

CONCLUSIONS

For the analysed values of parameter κ, the first eigenmodes are pseudo-periodic, since the eigenvalues of the matrix $[A]$ are complex. For higher modes, the motion tends to become aperiodic.

The close values obtained for the pseudo-periodic modes by the two methods applied to the simplified model prove the accuracy of the approximate method.

The same conclusion results by comparing the circular eigenfrequencies determined for the undamped system with the imaginary part of the eigenvalues determined for the damped system with the very small value 0.00001 of parameter κ.

The errors made by using the simplified model are in some cases of up to 10%.

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CONSIDERATIONS REGARDING FORESTRY SEEDLINGS PLANTING TECHNOLOGY / *CONSIDERATII PRIVIND TEHNOLOGIA DE PLANTARE A PUIEŢILOR FORESTIERI*

PhD. Stud. Eng. Mircea C.*, PhD. Eng. Ciupercă R., Eng. Bogdanof G., PhD. Eng. Vişan A.L., PhD. Eng.Ciobanu V.G., PhD. Stud. Eng. Persu C., PhD. Stud. Eng. Cujbescu D.
[1)]INMA Bucharest
Tel: 0766420952; E-mail: costinmircea@yahoo.com

Keywords: *planting, forestry seedlings, technology, equipment*

ABSTRACT

This article addresses foresters and entrepreneurs in agriculture field, interested in implementing in their units the technology of planting the forestry seedlings.

The present paper outlines the economic and productive effects produced by these mechanization technologies, highlighting their yield.

REZUMAT

Articolul se adreseaza silvicultorilor si intreprinzatorilor din domeniul agricol, interesati de implementarea in unitatile proprii a tehnologiilor de plantare a puietilor forestieri.

Prezenta lucrare contureaza efectele economice si productive produse de aceste tehnologii de mecanizare, scotand in evidente randamentul pe care acestea le produc.

INTRODUCTION

The Agency for Rural Investment Funding (AFIR) encourages establishing the group of producers in fruit growing field by extending the submitting deadline for investment projects within 9.1. Measure: “Establishing the fruit-growing producers groups in accordance with the National Plan for Rural Development for 2014 – 2020 period (PNDR 2020), until December 30, 2016. [6]

Budgetary amount set for 2016 session within PNDR 2020 for this sub-measure (sm) of the fruit growing sector is 2.2 million. [6].

The forest fund consists of the total area of forest land for afforestation, those serving the needs of crop production and forestry administration and unproductive lands included in the forestry management [1,5].

The total national forest area of Romania is of 6515 thousand ha and represent 27.3% of the country. The European average is 32%. [10]

Forest area includes land covered with forest vegetation consisting of shrubs and trees, which creates a specific environment of biological development, constituting directly productive forest composition, having a larger area of 0.25 hectares. [5]

Forestry crops can be artificial installed through:

- direct sowing
- direct cuttings.

Mechanical planting by forest seedlings machine (Figure 1), is more economical and more productive, contrary manual planting technology, the yield depending on the model and type of the used machine, by optimal exploitation of the machine and the soil preparation.

Fig.1 – Mechanical planting by forest seedlings machine [5]

MATERIAL AND METHOD

Forest seedlings machine are intended for works mechanizing of cultures establishing by plantations in placed land, with the soil well prepared in advance, loose and free of weeds.

On worldwide were conceived several seedling machines, namely:

- machines which are opening only in gullies in prepared soil, following that planting to be manually carried on;
- machines which open gullies in prepared soil and execute the planting by the help of an automatic feeding planting apparatus;
- machines which work the soil into strips of 0.6 m at a depth of 0.35 to 0.40 m, with simultaneous and manual feeding planting of the apparatus [4].

The way the planters are constructed, they provide mechanically executing of the following actions:

- gully opening at the necessary depth;
- catching and planting material distribution in gully in the same time with its fixation in the soil.

Some machines are equipped with watering equipment, planting and watering in same time each sapling.

In generally, planting machines can partially or totally perform the operations described above, by manually or automatic introduction of the material in planting apparatus.

Planting machines, in generally, have one or more planting sections.

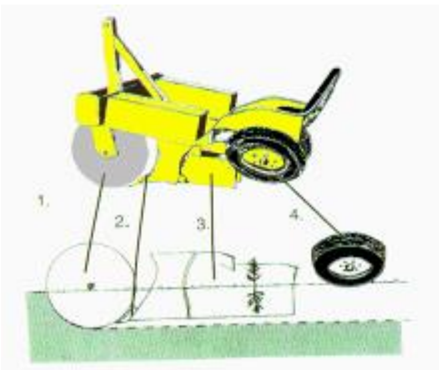

Fig.2 - Planting section [5]

To obtain a good yield, it is necessary to be fulfilled the following conditions:

-well soil loosening by deep plowing and cultivation, having mechanical planting evened area;

- the tractor has to carry planting machine aggregate in straight line and with indicated speed by the machine characteristics;

- forestry seedling planting machine to present setting possibilities of the distance among rows and the settings in function of seedling dimensions.

Planting machines work on the principle of the soil opening by a coulter, so that, the sapling may be placed in the created place. The compacting wheels push then the soil around the sapling and the machines goes on. Other machines are capable to plant different kind of plants: tubular, with short stem and open root.

RESULTS

Sapling mechanical planting is more accessible for farmers who want to establish forestry belts, orchards or fruit tree nurseries.

A Romanian specialists patent belonging to National Institute for Machines and Installations destined Agriculture and Food Industry – INMA brings new knowledge and help in performing these operations (fig.3) [3].

Fig.3 – MPF-1 Forestry sapling planting machine [3]

Technical characteristics of the machine are presented in table no. 1:

Table 1

TECHNICAL CHARACTERISTICS	
Machine type	carried
Energetic source	tractor of min. 65 CP
Coulter type	anchor
Size dimensions:	
– length, mm	2200
– width, mm	3050
– high, mm	2120
Mass, kg	1200
Number of planting sections, piece	1
Maximum planting depth, mm	300
Distance among saplings on the row (5 planting models), m	0,5; 0,75; 1; 1,5; 3
Planting mode	semiautomatic
Work speed, km/h	0,25-3

MPF-1 sapling planting machine, is destined to forestry mechanisation of agroforestry works of afforestation, perform to restoring forest fund in the lowlands and hills, establishing protection curtains, as well as for establishing fruit orchards or nurseries [8]

The machine performs the forest sapling of resinous deciduous and conifers having sizes between 25…70 cm, until max. 30 cm depth in processed soil in bands of about 60 cm or totally processed. [3]

Machine is of carried type on three points suspending mechanism of a tractor of 65 CP power (fig.4). [4]

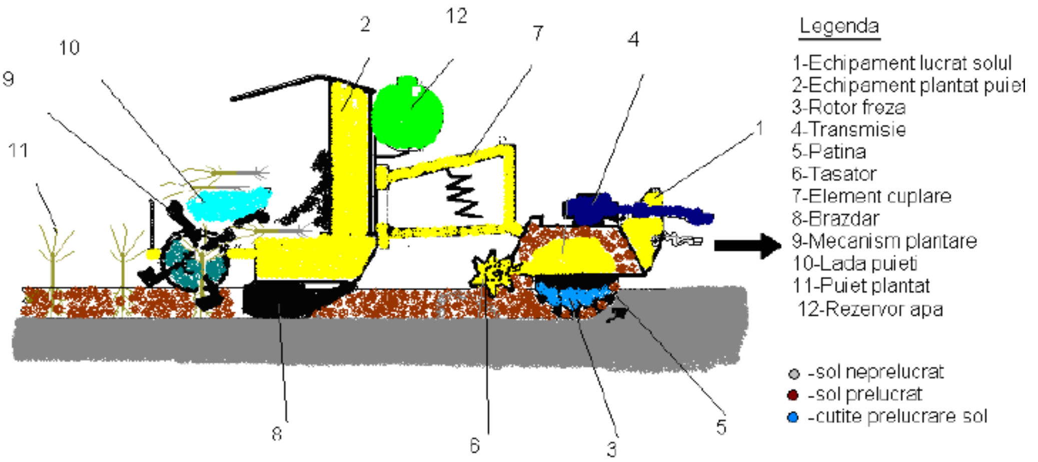

Fig.4 – Composing elements of forest sapling planting machine [9]

CONCLUSIONS

Forestry emerged and developed on the background of substantial reduction of the forestry areas and increasing the wood consumption.

Forest represents a rich source of products (wood, venison, fish, fodder etc.) and in the same measure offer multiple services on ecologic and social plans (protection and soil restoration, water, air, fauna and flora protection, cities protection, human health restoration, tourism development etc.) [7]

Average planting rates for manually one is about 300-500 saplings /day /man and in case of mechanical planting is about 500-3000 saplings/h.

Mechanical planting offers economic, social and environmental advantages as well as high yield, as follows:

- reduced fuel consumption, about 20%;
- reducing the necessary labour force, about. 35%;
- reducing physical effort, 10 times comparing to manually planting;
- allow framing in optimal planting, having effects on production increasing;
- productivity and efficiency ensuring of the afforestation by sampling mechanized application of planting having values between 500-3000 saplings/hour;
- ensuring sampling optimal development conditions during vegetation period.

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FINITE ELEMENT METHOD USE IN THE CALCULATION AND OPTIMIZATION OF THE ACTIVE PARTS OF MULCH FILMS APPLYING EQUIPMENT
/
UTILIZAREA MEF IN CALCULUL SI OPTIMIZAREA ORGANELOR ACTIVE ALE ECHIPAMENTELOR DE APLICAT FOLII DE MULCIRE

PhD. Stud. Eng. Gheorghe G., PhD. Stud. Eng. Persu C., PhD. Eng. Matache M., PhD. Eng. Mateescu, M., PhD. Stud. Eng. Cujbescu D.
INMA Bucharest
Tel: 0731583104; E-mail: gabrielvalentinghe@yahoo.com

Keywords: *structural analysis, calculation, optimization*

ABSTRACT
The article presents the structural analysis by FINITE ELEMENT METHOD (FEM) using two calculation programs: Solidworks and Catia v5. The structural analysis will be performed on the active part of the equipment, namely the ploughshare forming the channel for introducing the edges that will fix the mulch film into the soil.

On one pass, the unit executes the following steps: forming the furrow at a depth of 10 cm, applying the mulch film that is fixed in soil by using the wheel and by means of disks the edges of mulch film are covered. We considered the force applied to this part as similar to the force applied to the motocultivator plow.

REZUMAT
Articolul prezintă analiza structurală cu METODA ELEMENTELOR FINITE utilizând două programe de calcul: Solidworks şi Catia v5. Analiza structurală se va efectua pe organul activ al echipamentului, şi anume brăzdarul de formare a canalui pentru introducerea marginilor foliei care va fixa folia de mulcit în sol.

La o singură trecere, agregatul execută următoarele etape: formeaza brazda la adâncimea de 10 cm, aplică folia de mulcit care este fixată în sol de către roată şi cu ajutorul discurilor se acoperă marginile foliei de mulcit. Forţa aplicată pe acestă piesă am codiderat a fi asemănătoare cu forţa aplicată la plugul pentru motocultor.

INTRODUCTION
In order to have a higher efficiency, in FEA (finite element analysis) we used a concept of more general and simpler structure than usual. Usually in the FEA, structure (strength) means a group of bars, plates, shells and volumes (solids). To shift from its real structure to the model of computing algorithms, there is no general method to ensure the development of a unique model that approximates with an error default, known as structure to be approximated. It is generally possible for a structure to develop more models, all correct but with different performance. The model for calculating the strength of a structure shall be based on intuition, imagination and previous experience of those who do those models. There is need to effectively synthesize all available information on the structure.

Meshing: The model of a structure that will be subjected to finite element analysis, in general, consists in lines which are the axes of the bars structure of flat surfaces and curves, which are surfaces median boards' components of the structure and volumes, which are massive bodies of the structure. At this stage of development, it is a continuous model with an infinite number of points, as the structure. Meshing is required by FEA and fundamental approach is to switch from continuous structure (with an infinite number of points) to a discrete model with a finite number of points (nodes). This operation is done by "covering" the model with a mesh network and justified by the fact that from a practical standpoint, sufficient information on the structure, in a certain number of points of the pattern, there are different values of displacements and stresses.

The model is developed for a certain structure in order to achieve a finite element analysis (FEA), to ensure accurate and reliable results obtained on one hand and on the other, the model must be effective. The main conditions that must be met to have an effective model are:
- development of the model to make a reasonable workload;
- the model will capitalize all available information on the structure to be analysed;
- the amount of information obtained from FEA should be large enough and with a level of confidence acceptable given the purpose, destination information and how it is exploited.

MATERIAL AND METHOD

A major task is determining the mechanical behaviour of a structure or structural elements under the effect of external actions.

Currently, most part of engineering calculations required for synthesis, design and analysis of a product can be made using the finite element method (FEM). In terms of computer-aided design (CAD) and computer-aided manufacturing (CAM), finite element analysis (FEA) is a component of a unit – integrated process. It must be noted that in the succession CAD - FEA - CAM there is an iterative process design - computing - execution. In this process, we make successive operations, summary and analysis of the prototype and the model for finite element calculation. At each repetition of the prototype process, improvements are made for the model calculation until it reaches the desired performance.

Current programs of FEM have implemented special procedures for determining optimization by automatically calculating the optimal values for design parameters so as to satisfy a set of conditions imposed on an objective function defined by user.

Before starting a simulation the element (part) that will undergo simulation must be exemplified using both Solidworks and Catia programs. The chosen part is the most active part of the equipment applying mulching films (Fig.1). That part will be executed after performing finite element analysis.

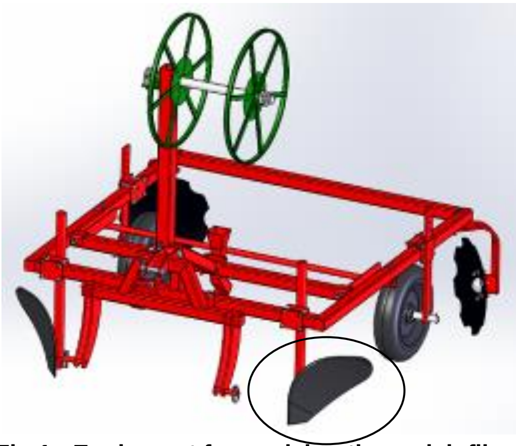


Fig.1 - Equipment for applying the mulch films

RESULTS

The first step of finite element analysis is choosing the part material.

For the study Solidworks program was used. I also used S275JR material with characteristics presented in Table 1, while for Catia program I used steel, with characteristics presented in Figure 2.

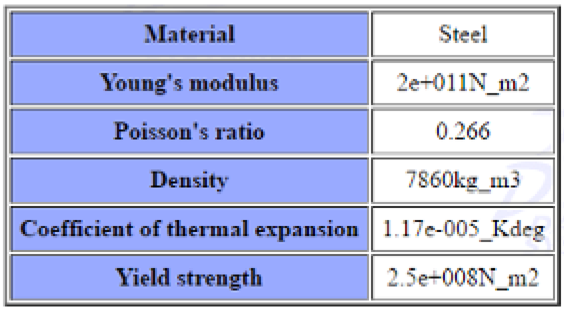
In the SolidWorks Simulation Manager tree, right-click on the EAF-2.1 folder and click Apply Material. The Material dialog box appears. Do the following: a) Expand the SolidWorks DIN Materials library folder. b) Expand the DIN Steel (Structural) category. c) Select S275JR.

Table 1

Material properties chosen (S275JR) in SolidWorks

Model Reference	Properties		Components
	**Name:**	1.0044 (S275JR)	SolidBody 1(Split Line1)(EAF-2.1)
	Model type:	Linear Elastic Isotropic	
	Default failure criterion:	Max von Mises Stress	
	Yield strength:	2.75e+008 N/m^2	
	Tensile strength:	4.1e+008 N/m^2	
	Elastic modulus:	2.1e+011 N/m^2	
	Poisson's ratio:	0.28	
	Mass density:	7800 kg/m^3	
	Shear modulus:	7.9e+010 N/m^2	
	Thermal expansion coefficient:	1.1e-005 /Kelvin	

We perform material selection, selection Part, Material Apply, then OK. By double clicking on a material we can visualize and change the material by applying mechanical and thermal parameters: Young's modulus, Poisson's ratio, density, thermal expansion coefficient, yield strength (Figure 2). In Figure 2, we can see the final report provided by the program, the material chosen for the study of its characteristics.



Material	Steel
Young's modulus	2e+011N_m2
Poisson's ratio	0.266
Density	7860kg_m3
Coefficient of thermal expansion	1.17e-005_Kdeg
Yield strength	2.5e+008N_m2

Fig.2 - Material properties chosen in Catia

Step 2: Applying Fixtures

You apply fixtures to prevent the out of plane rotations and free body motions. Press spacebar and select *Trimetric in the Orientation menu. In the Simulation study tree, right-click the Fixtures folder and click Advanced Fixtures. The Fixture PropertyManager appears. Make sure that Type is set to Use Reference Geometry. In the graphics area, select the edges that you want to fix that appear in the Faces, Edges, Vertices for Fixture box.

Constraints in Catia program are done using the command (Clamp) »constraint type recessed translational movements that cancel all of the entities to which it is applied; associated points, edges, faces or elements. Arrows simplify the cancelling of translational movements (Figure 3), the same as in SolidWorks.

Applying resistant forces of the soil on the part is step 3 of the study.

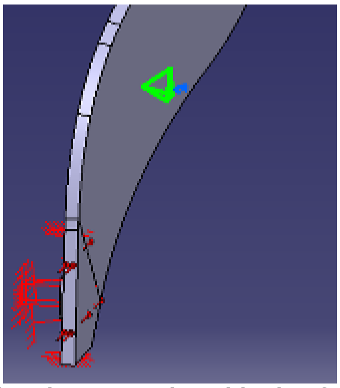
In the SolidWorks Simulation Manager tree, right-click the External Loads folder and click Force then PropertyManager appears. Under Type, select Normal to selected face and then select the surface where the part is in contact with soil. In the graphics area, select the face where you want to apply the force and the direction of the force is opposed to forward direction. Make sure that Units is set to N/mm^2 (Mpa). Forces introduced in SolidWorks are illustrated in Table 2.

Table 2

Components	X	Y	Z	Resultant
Reaction force(N)	-784.574	0.0011391	0.0886816	784.574
Reaction Moment(N·m)	0.00801731	-0.00818622	0.000352901	0.0114637

In Catia program using Distributed Force command, type resultant force. After the three axes component values are entered in the dialog box, apply points, surfaces or virtual items. Forces introduced in Catia:

Fx	=	840e+002	N
Fy	=	960e-008	N
Fz	=	421e-007	N
Mx	=	050e-009	Nxm
My	=	240e+000	Nxm
Mz	=	750e+001	Nxm



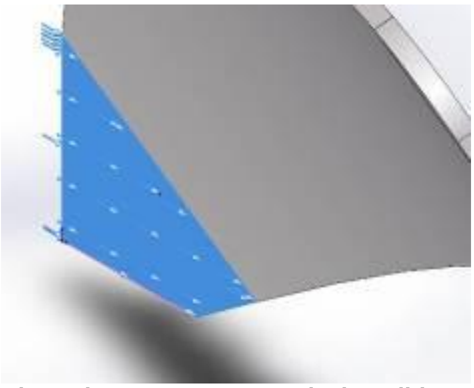


Fig. 3 - Fixing the part and positioning forces in Catia program, respectively SolidWorks

Meshing the Model and Running the Study Meshing divides your model into smaller pieces called elements. Based on the geometrical dimensions of the model, SolidWorks Simulation suggests a default element size which can be changed as needed.

In the SolidWorks Simulation Manager tree, right-click the Mesh icon and select Create Mesh. The Mesh PropertyManager appears. Expand Mesh Parameters by selecting the check box. Make sure that Curvature based mesh is selected. Type the size and accept the default values for the rest of the parameters (Minimum element size, Min. number of elements in a circle and Element size growth ratio). The results of meshing the part in Solidworks are presented in tables 3 and 4.

Table 3

Mesh Information

Mesh type	Shell Mesh Using Mid-surfaces
Mesher Used:	Standard mesh
Automatic Transition:	Off
Include Mesh Auto Loops:	Off
Jacobian points	4 Points
Element Size	5.45302 mm
Tolerance	0.272651 mm
Mesh Quality	High

Table 4

Mesh Information - Details

Total Nodes	9641
Total Elements	4722
Time to complete mesh(hh;mm;ss):	00:00:01
Computer name:	INMA-G

Meshing in Catia is achieved by one of the commands listed below, depending on the type of geometric domain (one-dimensional, two-dimensional or three-dimensional); Size refers to the size of finite element (maximum edge length) and Sag the MPE for geometric modelling.

(Octree Triangle Mesher) » finite element meshing type triangle-type surface areas; Finite Element edges can be straight lines or parabolas. Discretization results in Catia are the following: Nodes: 343 and Elements: 859 and are represented in Figure 4.

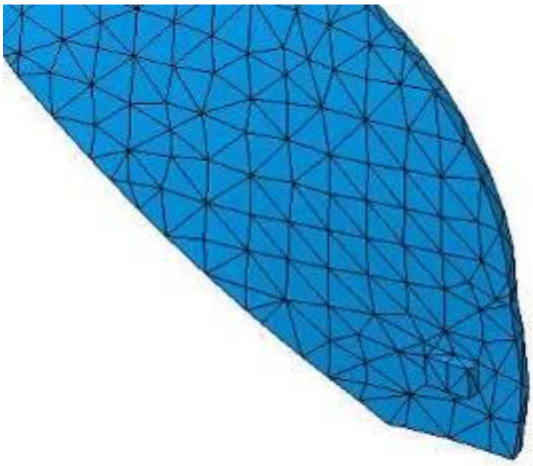


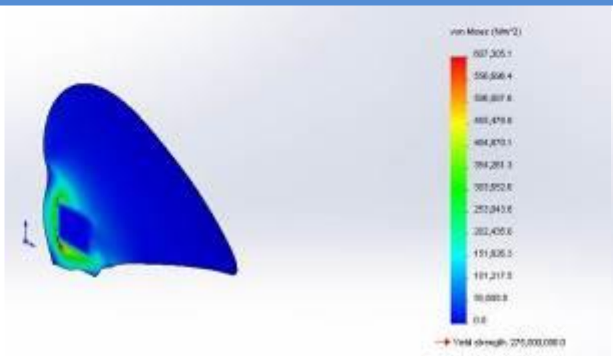
Fig.4 - Meshing in Catia program

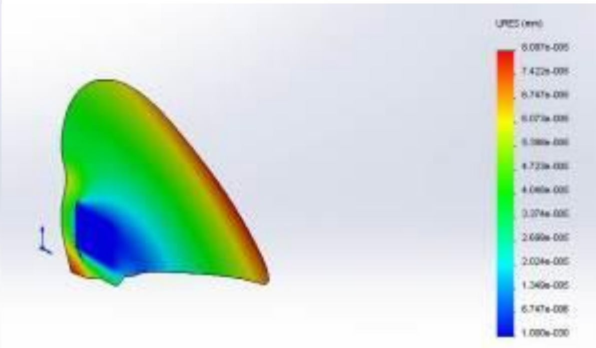
The commands shown until now are part of the pre-processing stage. Solving the model is done automatically by the software, by command (Compute) for Catia and Run for SolidWorks »solving the model finite element simulation. The finite element resulted in SolidWorks is shown in the first two pictures in table 5 and in Catia the last two pictures in the same table:

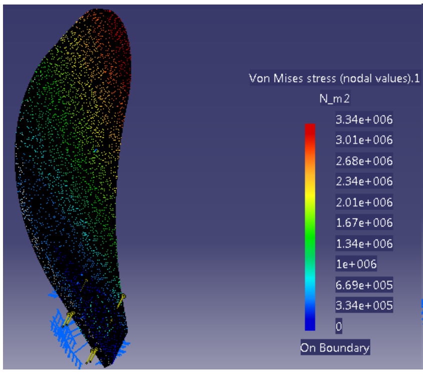
Table 5

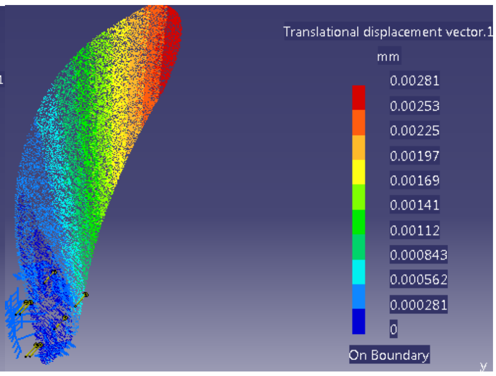
Finite element results with SolidWorks and Catia

Name	Type	Min	Max
Stress1	VON: von Mises Stress	0 N/m^2 Node: 5	607305 N/m^2 Node: 27
Displacement1	URES: Resultant Displacement	0 mm Node: 1	8.0967e-005 mm Node: 2496









CONCLUSIONS

The analysis through the finite element method is a modern method for the study of different parts for determining important parameters. Von Mises method for stresses determination allows an analysis of tension thereby allowing the possibility of identifying damages that appear.

In this work we analysed, by finite element modelling, the behaviour of the working tool in contact with the ground. Finite element modelling of this piece allowed optimizing the solution, reducing respective loading gauge sheet and reducing the production cost.

ACKNOWLEDGEMENT

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CONSIDERATIONS ON EQUIPMENT USED AT WORLD LEVEL FOR MISCANTHUS RHIZOMES HARVESTING
/
CONSIDERAŢII PRIVIND ECHIPAMENTELE UTILIZATE PE PLAN MONDIAL PENTRU RECOLTAREA RIZOMILOR DE MISCANTHUS

PhD. Stud. Eng. Sorică E, PhD. Eng. Sorică C., Eng. Grigore I., PhD. Stud. Eng. Rosu (Nitu) M., PhD. Stud. Eng. Zaica A., Ph.D. Stud. Eng. Birsan M., PhD. Stud. Eng. Zaica Al.
INMA Bucharest
Tel: +40722.487.889; E-mail: postelnicu.elena@yahoo.com

Keywords: *Miscanthus, equipment, rhizomes, harvesting*

ABSTRACT

The paper presents valuable information regarding the Miscanthus energy plant crop, benefits of planting this culture and the technical equipment used at world level for harvesting the Miscanthus rhizomes. At the same time, the main technical characteristics of most representative technical equipment are described. This equipment use enables to reduce the level of mechanical damage of rhizomes, thus ensuring their increased viability.

REZUMAT

În lucrare sunt prezentate informaţii cu privire la cultura plantei energetice Miscanthus, beneficiile cultivării acestei plante şi echipamentele tehnice utilizate pe plan mondial pentru recoltarea rizomilor de Miscanthus. De asemenea, sunt prezentate caracteristicile tehnice principale ale echipamentelor tehnice specializate reprezentative. Utilizarea acestor echipamente reduce gradul de vătămare mecanică a rizomilor asigurand in acest fel o viabilitate sporita a acestora.

INTRODUCTION

Within the context of diminishing the fossil fuel resources and taking into account that by 2030, the European countries have to obtain 20% renewable energy out of the total production of energy, respectively 27 %, the cultivation of energy plants could represent a viable solution for achieving this goal. [1]

From biomass, the dedicated cultures have the best prospects for bioenergy production. On the other part, Miscanthus plant is one of the most advantageous cultures for thermal energy and bioethanol production.

According to specialists from Illinois University (where the most important research institute from USA focussed on this plant, is located), the main advantages of Miscanthus cultivation, in order to obtain bioethanol are:

- Miscanthus is a perennial, non-invasive plant;
- Fields in which it is cultivated can be rapidly recovered to be used for food crops (corn, soybeans, beans);
- It enables to obtain biomass with small or even without any inputs;
- It is excellent in fixing carbon and recovering the soil [6].

According to the same experts, Miscanthus can annually generate a certain biomass quantity from which one can produce up to twice and a half more bioethanol than the quantity obtained from the corn biomass annually harvested on a surface of an acre (approximately 0.405 ha) [4].

A study achieved during 1997 – 1999 on 15 genotypes of Miscanthus sp. (*M. x giganteus, M. sinensis, M. sacchariflorus),* cultivated in different locations from England, Portugal, Denmark, Sweden and Germany have emphasized its extraordinary ecological plasticity. Thus, the studies have shown that the viability of plantations of *Miscanthus giganteus* and *Miscanthus sacchariflorus* is minimum when the soil temperature decreases under the limit of – 3°C at a depth of 3 cm. In Great Britain and Germany, the best performances were given by *Miscanthus giganteus*. In Portugal, although very good results were obtained also for *Miscanthus giganteus,* a hybrid of *Miscanthus sinensis was the most efficient.* Always, a series of hybrids of *Miscanthus sinensis* has obtained the best results in Sweden and Denmark climate. The study' authors concluded that *Miscanthus sinensis* presents an extremely good capacity of growing in various climate conditions, while for the Central Europe, *Miscanthus giganteus*, represents the most performant genotype [10].

Studies made in Great Britain have shown that the key factors for obtaining competitive Miscanthus productions are: number of sunny days, temperature and soil water stock. Annual variations of these factors, influence similar variations in harvest yield. Temperature necessary to Miscanthus culture are importantly smaller than those required by corn, the only significant limit being related to low temperature manifested in late spring. This low temperature may significantly diminish the harvest. Miscanthus has a very good capacity of using water, in terms of water quantity required per biomass unit obtained, its roots being able to penetrate the soil and extract water from 2m depth. The Britain experts' studies have shown that for each millimetre of water deficit in soil, the harvest diminishes by 90 kg/ha [5]. In table 1 are presented the benefits brought by different energy plants.

Table 1 [8]

Plant	Inputs	Outputs	Growth
	Quantity of energy per year (MJ / ha)	Quantity of energy per year (MJ / ha)	(no of times)
Miscanthus	9224	300000	32,53
Willow	6003	180000	29,99
Hemp	13298	112500	8,46
Wheat	21465	189338	8,82
Rape	19390	72000	3,76

Following the data from the table 1, we may notice that Miscanthus is one of the most efficient cultures in terms of quantity of inputs necessary to obtain the harvest comparing to power obtained. Miscanthus has a net calorific value reported on a dry biomass, of 17 MJ/kg. The quantity of energy resulted from 20 tons of dry biomass is equivalent to 8 tons of coal [5]. This thing demonstrates that at least, energetically speaking, the costs necessary to obtain a Miscanthus harvest can be covered by approximately 3 % from the production obtained.

Cultivation of Miscanthus has a positive impact on soil erosion processes. Intensive tillage is one of the factors determining the increasing of soil erosion. Great number of mechanized operations, necessary to most conventional agricultural crops (designed to food industry), destroys soil texture and structure thus intensifying the erosion processes due to environment factors (water, wind). Therefore, by establishing Miscanthus culture these phenomena could be significantly reduced (perennial plant, reduced number of soil works, high density per hectare, etc.).

A series of studies achieved in USA have shown that Miscanthus culture impact on soil erosion processes is minimum (Fig. 1).

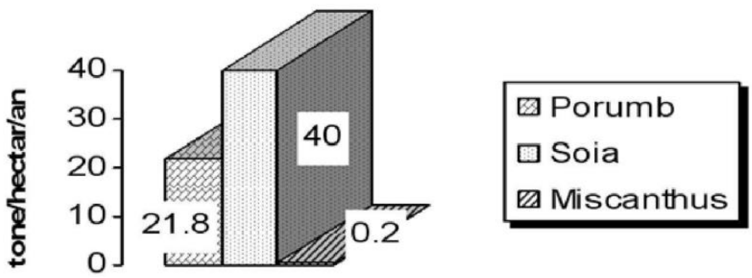

Fig. 1 - Soil losses (in tons/year/hectare) associated to cultivation of different types of agricultural cultures and Miscanthus [8]

MATERIAL AND METHOD

The first step for obtaining a Miscanthus harvest is to establish the culture in the field. Miscanthus crop, although it has proven to be a reduced input crop, due to its efficient systems of using water, nutrients and light, requires a great investment when establishing the culture. Generally, the plant propagation can be assured by: seeds, micro-propagation and rhizomes division.

In Europe, Miscanthus cannot be planted by seeds, but only by rhizomes. Rhizomes (fig. 2) of brown colour have irregular shapes, with protuberances and are even well-branched, their thickness ranging between 7 and 12 mm. At surface, one may observe that the rhizomes knots are shaped as transverse scale rings which number varies depending on rhizome length and on those rings the vegetative buds form.

For planting in the field, young rhizomes (at most three-year old ones), healthy, without mechanical damages, of 10-15 cm length and 40-60 g weight, are used, having at least 3-4 viable buds. [2, 3]

Planting may be performed in spring or autumn, manually or with a semi-automated machine.

Fig. 2 – Miscanthus rhizomes [3]

RESULTS

In most cases, in order to harvest the seed material, there are used machines harvesting other crops, such as harvesting machines for potatoes or onion, by adapting different constructive solutions, but with less satisfying results in terms of quality of seedlings obtained and energy consumption related to harvest operation. [1, 2]

Due to specific characteristics of Miscanthus culture (extension of crop between the plant rows, rhizomes irregular shape and various size) as well as, quality specific conditions imposed to seedlings required to successfully establish a new crop (without mechanical damages, having at least 3…4 viable buds), the necessity to develop new specialized equipment which ensure the fulfilment of crop qualitative working indexes, appeared.

Nowadays, in United States of America and Europe very few of such machines specialized in Miscanthus rhizomes harvesting necessary to establish a new crop, are existing.

An important research institute of Miscanthus from Illinois University has adapted a constructive solution on a potatoes harvesting machine in order to harvest rhizomes of Miscanthus. After harvesting, they are cleaned of soil in special tubs and afterwards stored in refrigerating chambers (at a temperature of <4°C) for almost a year or for shorter periods, as heaps covered by humid soil (fig. 3). [2]

Fig. 3 - Miscanthus rhizomes harvesting at University Illinois

Though, there are machinery specialized in dislodging seedlings or other plants that can be successfully used for Miscanthus rhizomes. At world level, the company Egedal (Denmark) producing plant dislodging equipment of range RR and SR-2, adapted to Miscanthus, Bermuda King (US) enterprise manufacturing the rhizomes harvesting equipment from the Road Ready Harvester and Rear Load Harvester range, as well as Sprigger's Choice, Inc.Company from Dawson, Georgia, are well-known.

The dislodging equipment Egedal model RR (fig. 4) is conceived for dislodging seedlings/saplings, transplants or other plants. As construction, the machine is simple and strong, being designed to work in any conditions of field. Dislodging equipment is endowed with a fixed frontal share, an adjustable vibrating system and a mechanism fitting the working depth. [9]

Fig. 4 - Dislodging equipment Egedal model RR (http://www.egedal.dk/) [9]

When dislodging the seedlings, the value of vibrations should be small so that the soil detaches only partially from the roots. In case of bigger plants or seedlings, the vibrations should be maximal so that to ensure the plant complete cleaning of soil. The tractor's PTO ensures the driving of vibrations.

In table 2 are shown the main technical characteristics of dislodging equipment Egedal model RR:

Table 2

Main technical characteristics [9]

Working width	Trace width	Clearance	Weight	Required power
1200 mm	1470 mm	630 mm	419 kg	40 HP
1350 mm	1620 mm	630 mm	425 kg	40 HP
1500 mm	1770 mm	630 mm	460 kg	40 HP

Dislodging equipment Egedal model SR-2 (fig. 5) is also designed to dislodge seedlings / saplings, transplants or other plants. Machine is endowed with a fixed frontal share, an adjustable vibrating system driven by a mechanism with eccentric and a mechanism fitting the working depth. [9]

Fig. 5 - Egedal dislodging equipment, model SR-2 [9]

Root pruning machine type BRS (fig. 6) mounted with hydraulic depth adjustment.

Fig. 6 - Root pruning machine type BRS [9]

Egedal root pruning machine type BRS is for root pruning of plants in beds. The share of the machine is 110° inclined to obtain an optimal cutting effect. By the inclined share it is possible to root prune ever quite small plants growing in light types of soil without drawing up soil and perhaps remnants of old plants. The share is made of special steel, which together with the share profile, makes a self-sharpening effect, so that the share edge will always be sharp even after many days use.

Egedal root pruning machine type BRS is mounted with wide supporting wheels, which can easily be altered to obtain the required cutting depth by means of screw adjusters. The machine is constructed in a rugged and strong frame on which the shares and supporting wheels are mounted by means of frame fittings. This system makes it possible to adjust the machine exactly to the actual width of the bed and width of the track.

The main technical characteristics of the machinery type BRS are presented in Table 3:

Table 3

Working width	Track width	Weight
1100 mm	1220-1420 mm	190 kg
1200 mm	1320-1520 mm	200 kg
1300 mm	1420-1620 mm	210 kg
1400 mm	1520-1720 mm	220 kg
1500 mm	1620-1820 mm	230 kg

Rhizomes harvesting machine known as **Road Ready Harvester Machine (**fig. 7) allows lateral load of rhizomes and is destined to tractors in gauge of 40 – 90 CP. Hydraulically operated elevator can adjust their position quickly and easily without being detached from machine harvested. [7]

Fig. 7 - Rhizomes harvesting machine known under the name of Road Ready Harvester Machine [7]

Rhizomes harvesting machine known as **Rear Load Harvester** (Fig. 8) is used in aggregate with a transport track where the harvested rhizomes are taken over. It is also destined for tractors in 40 – 90 CP gauge [7].

Fig. 8 - Rhizomes harvesting machine named Rear Load Harvester [7]

Sprigger's Choice company, Inc. from Dawson (Georgia) has the following Miscanthus rhizomes harvesting technical equipment:

Fig. 9 - 60" Spring Root Harvester [11]

Fig. 10 - 40" Spring Root Harvester [11]

Fig. 11 - 40" Rhizome Spring Root Harvester [11]

Technical characteristics of rhizomes harvesting equipment are presented in table 4:

Table 4

60" Spring Root Harvester	40" Spring Root Harvester	40" Rhizome Spring Root Harvester
- Fold up conveyer - Hydraulic driven conveyer - 100 HP gear box - Dual set of hydraulic required - PTO driven digger head - 60+ HP tractor	- Fold up conveyer - Hydraulic driven conveyer - 100 HP gear box - Dual set of hydraulic required - PTO driven digger head - 60+ HP tractor	- Rear Load - Hydraulic driven conveyer - 100 HP gear box - One set of hydraulic required - PTO driven digger head - 60+ HP tractor

In Romania, INMA Bucharest designed a Miscanthus rhizomes harvesting equipment-ERM.

ERM Miscanthus rhizomes harvesting equipment (Fig. 12), carrier type, works in aggregate with tractors of 70...80 CP having wheels equipped with suspended mechanisms in three points, of second category. Technical equipment the following main subassemblies:

- Frame;
- Eccentric separator;
- Dislocating plough;
- Left and right wheel;
- Hydraulic motor.

Fig. 12 - *ERM* Miscanthus rhizomes harvesting equipment [3]

Main technical characteristics of the equipment are presented in table 5:

Table 5

Technical characteristics of *ERM* Miscanthus rhizomes harvesting equipment

Crt. No.	Characteristic	UM	Value
1.	Equipment type	-	carried
2.	Action way of separation transporter	-	hydraulic
3.	Tractor in aggregate power	CP	70...80
4.	Working width	m	1.2
5.	Working depth	cm	max. 25
6.	Ground characteristics	mm	350
7.	Overall dimensions: ✓ length ✓ width ✓ high	mm	 1590 2090 1395
8.	Mass	kg	365

Equipment executes Miscanthus rhizomes dislocation from soil mass and their separation of clay. Dislocation process consists in deep soil loosening without returning, destroying the binding between soil and rhizomes and pushing up to oscillating grills, which by sifting, separate rhizomes of impurities and clay and leave them on soil in the furrow, to be loaded into vehicles. Driving of Eccentric separator is made by using a hydraulic motor coupled to the tractor hydraulics [3].

CONCLUSIONS

Using quality material is essential in establishing a good culture. The rhizomes should be purchased from Miscanthus fields, especially dedicated to obtaining biological material and be harvested from young plants category, not from aged culture.

Due to specific characteristics of Miscanthus crop (extension of culture between the planting lines, irregular shape and various dimensions of rhizomes) and specific conditions of imposed quality of planting material for the establishment successful new cultures (without mechanical damage and having at least 3 ... 4 viable buds), appeared need to develop new specialized equipment to ensure the qualitative characteristics of this culture harvesting operation.

On international plan a number of companies that produce and sell equipment for harvesting Miscanthus rhizomes are known, such as: Egedal (Denmark), Bermuda King (USA) Sprigger's Choice (USA).

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INFLUENCE OF SOME PARAMETERS ON EFFICIENCY OF SIFTING PROCESS OF MEDICINAL PLANTS
/
INFLUENTA UNOR PARAMETRI ASUPRA EFICIENTEI PROCESULUI DE SEPARARE LA PLANTELE MEDICINALE

Ph.D. Stud. Biol. Pruteanu A.*[1)], Ph.D. Eng. Sorică C.[1)], Ph.D. Stud. Eng. Muscalu A.[1)], Ph.D. Eng. Brăcăcescu C.[1)], Ph.D. Eng. Danciu A.[1)], Ph.D. Stud. Eng. Birsan M.[1)], Ph.D. Eng. Ciobanu V.[1)], Ph.D. Eng. Rădulescu D.L.[2)]
[1)] INMA Bucharest / Romania; [2)]University of Agricultural Sciences and Veterinary Medicine Bucharest / Romania
Tel: 0740690268; E-mail: pruteanu_augustina@yahoo.com

Keywords: *kinematic regime, quantity of material, medicinal plants, particle size, sieve, sifting process*

ABSTRACT

The mechanical sifting process is a complex technological process, being influenced by a series of factors that have to be correlated in order to establish the process optimum technological parameters, so that a high quality sifting is achieved. The paper presents the results of experimental studies on the separation of a non-homogeneous mixture of medicinal plants (nettle, respectively thyme) dried and minced by varying certain parameters (feeding flow and sieve oscillation frequency) of a dimensional sifting equipment of medicinal plants. Experimental data obtained for fragments distribution according to vegetal fragments size have been studied by regression analysis with the distribution law of Rosin-Rammler, determining the values of equations coefficients and correlation coefficients R^2.

REZUMAT

Procesul de separare mecanică este un proces tehnologic complex, influenţat de o serie de factori, ce trebuie corelaţi pentru a stabili parametrii tehnologici optimi ai procesului,, astfel încât să realizeze o separare de calitate. În lucrare sunt prezentate rezultatele unor cercetări experimentale privind separarea unui amestec neomogen de plante medicinale (urzica respectiv cimbrisor) uscate si tocate variind anumiti parametri (debitul de alimentare si frecventa oscilatiilor sitelor) ai unui sortator dimensional de plante medicinale. Datele experimentale obtinute pentru distributia dupa dimensiuni a fragmentelor vegetale au fost testate prin analiza de regresie cu legea de distributie Rosin-Rammler, determinandu-se valorile coeficientilor ecuatiilor si coeficientii de corelatie R^2.

INTRODUCTION

Medicinal plants contain biologically active substances with therapeutic value; they are vegetal species which accumulates in certain parts of the plant different active substances useful in different affections treatment. . Medicinal plants cultivation and capitalization by different processing operations are important for assuring an enhanced quantity of raw material and preserving or increasing their valuable constituents. In addition, obtaining available high quality phyto-therapeutic products is possible only by using technical equipment adapted and continuously improved to each plant requirements.

Mechanical separation by sifting of medicinal plants is performed by means of plane or circular sieves. This separation is made according to size features, because the particles dimension is compared to the size of sieve mesh; particles which are smaller than the sieve holes may pass, resulting in sifted material, and the others remain representing the refuse.

According to many specialty studies (*Allen T., 2003, Casandroiu T. and David L., 1994, Constantin G.A. et al, 2014, KeShun Liu, 2009; Oztekin S. and Martinov M., 2007; Sullivan J. F., 2012, Tenu I., 1999*), the vegetal products sieving is influenced by several factors among which the most important are: particles' size and shape, type of particles relative movement on sieve surface, constructive characteristics and sieves disposal manner, intensity of working regime, material quantity arrived on the sieve.

Great number of factors above (without précising the less important ones) makes extremely difficult a perfect sifting – e.g., when the particles with the same or smaller size than sieve mesh, would pass as sifted material). Practically, a perfect sifting is impossible (*Ene Gh. et Sima T., 2013*).

Among all the phases of sifting, the holes' blocking is considered as the most important, being also a control factor. The holes are closed off when particles are blocked in sieve surface. This reduces the surface of effective transfer, diminishing the sifting performance. Recently, the first paper describing the material blocking on the sieve, has appeared (*Lawinska K., et al., 2016*).

In certain studies, there was researched the particles separation efficiency by varying the vibrations' parameters (amplitude, frequency, direction) using the finite element method (DEM 3D) (*Chen Y. and Tong X., 2010*) or 3ds Max with AGEIA PhysX and MAXScript method (*Li Ai-min, et al, 2008*).

The most important characteristic of solid materials is without any doubt, the particle size. There are two mathematical models widely used for studying the solid particles' distribution, namely the Rosin Rammler model and the Gaudin-Schuhmann model that have given excellent results and a correct sifting.

In certain specialty works, the dimensional distribution of particles was studied by comparing the experimental results to mathematical modelling using the law Rosin-Rammler, of mango ginger (Murthy K. and Manohar B., 2013), of switchgrass (*Bitra V. et al, 2009*), of sawdust and wood shavings mixtures (Vítěz T. and Trávníček P., 2010), of cork (Macias-Garcia A. and al, 2004).

Law Rosin-Rammler describes the cumulative distribution of size of particles obtained by milling and sifting the solid materials (*Deb D. and Sen A.K., 2013*). This paper (*Brezáni I. and Zelenák F., 2010*) describes the importance of using MATLAB software in determining the parameters of equation Rosin-Rammler.

Sifting quality shows the extent in which the separation in real conditions is closed to the theoretical one and can be evaluated by: sifting curve, sifting efficiency, quality of sifted product obtained.

MATERIAL AND METHOD

During the experimental tests, samples from each medicinal plant, were used, respectively nettle and thyme, plants being identified and harvested from spontaneous flora according to their morphological characteristics given by specialty guides (*Ardelean A. and Mohan Gh., 2008; Bojor O., 2003*).

Common nettle *(Urtica dioica)* is an herbaceous perennial species of 20-50 (70) cm height, with aerial erect or ascendant stems of Lamium type, Lamiaceae class; it is spread in hilly areas up to the mountain level. The harvest is performed before or during blossoming from April till September (Ardelean A. and Mohan Gh., 2008). Herb of nettle contains the following active substances: rosmarinic acid, tannins (12-14%), essential oil, flavonoids, mucilage (*Bojor O., 2003*).

Thyme *(Thymus vulgaris)* is a species of herbaceous perennial with semi-wooden base, of Thymus type, Lamiaceae class; it is spread in hills, meadows and pastures. Harvest is performed in July – August (Ardelean A. and Mohan Gh., 2008). Thymol is the main active substance contained by thyme, being a natural antiseptic, very helpful against viruses (*Bojor O., 2003*).

Medicinal plants were harvested from spontaneous flora, dried in open air and minced with the mincing machine of TIMATIC type, adjusted at 6 mm size for nettle and 3 mm for thyme. Mixture of vegetal fragments out of each plant that resulted after mincing was used for supplying the sifting equipment.

Sifting equipment of cut plants (fig.1) is a mechanical equipment used for separating the vegetal products by refuse method, being driven by 2 electric vibration engines, by which means the frequency and amplitude of sieve oscillations and three pitching angles (ranging between$12-15^0$ depending on plant), can be set. Equipment is endowed with 9 frames with sieves, used as sets of three with different size meshes, made of square-shaped wire. Dimensions of sieve holes range between 1.15 – 13.2 mm and directly influence the vegetal material sieving process. *(*** Technical Book*).

Fig.1 – Aspects during experimental researches

For sorting the nettle fragments, sieves of 8.00 mm, 6.15 mm and 3.15 mm were used and for sifting the thyme fragments, the sieves of 5.0 mm, 3.15 mm and 2.15 mm holes were used. The sieves have been chosen after the dimensional analysis of vegetal fragments minced (Allen, 2003) with classifier with sieves.

Were chosen 3 feeding flows and set for the sifting, namely 50 kg/h, 40 kg/h, 30 kg/h and 3 oscillation frequencies different from the sieves ones, namely 1000 osc/min, 950 osc/min, 900 osc/min. Running time of an experiment took 30 seconds.

The interpretation of results obtained has been achieved for the four fractions by means of with the distribution law of Rosin-Rammler, using the percentages calculated from masses obtained.

RESULTS

During experimental researches, the quantity of vegetal fragments that were collected into the four boxes, as refuse of each sieve for each plant, were monitored.

Experimental data, characterizing the sorting process with dimensional sorter of 4 varieties, are shown in table 1 for nettle and table 2 for thyme.

Table 1

Influence of oscillation frequency and quantity of nettle vegetal material minced on sifting efficiency

Feeding flow, Q [kg/h]	Frequency of oscillations [osc/min]	Size category					
		Fragments separated	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Experimental flow [kg/s]
50	1000	*kg*	0.057	0.207	0.079	0.054	0.0132
		%	13.65	49.60	18.88	13.05	
	950	*kg*	0.056	0.229	0.075	0.048	0.0136
		%	13.45	54.82	17.87	11.45	
	900	*kg*	0.052	0.177	0.064	0.034	0.0109
		%	12.45	42.37	15.46	8.23	
40	1000	*kg*	0.042	0.162	0.059	0.046	0.0103
		%	12.53	48.53	17.60	13.87	
	950	*kg*	0.052	0.173	0.043	0.031	0.0099
		%	15.47	52.00	12.80	9.33	
	900	*kg*	0.051	0.153	0.040	0.033	0.0092
		%	15.20	45.87	12.00	3.29	
30	1000	*kg*	0.043	0.144	0.044	0.019	0.0083
		%	17.21	57.62	16.61	7.60	
	950	*kg*	0.040	0.131	0.035	0.022	0.0076
		%	16.01	52.42	14.01	8.80	
	9000	*kg*	0.048	0.117	0.023	0.017	0.0068
		%	19.21	46.82	9.20	1.70	

Table 2

Influence of oscillation frequency and quantity of thyme vegetal material minced on sifting efficiency

Feeding flow, Q [kg/h]	Frequency of oscillations [osc./min]	Size category					
		Fragments separated	Fraction 1	Fraction 2	Fraction 3	Fraction 4	Experimental flow [kg/s]
50	1000	*kg*	0.281	0.083	0.044	0.008	0.0139
		%	67.54	19.84	10.62	2.00	
	950	*kg*	0.283	0.082	0.039	0.006	0.0137
		%	69.04	19.96	9.57	1.43	
	900	*kg*	0.257	0.085	0.038	0.004	0.0128
		%	66.96	22.17	9.78	1.09	
40	1000	*kg*	0.213	0.071	0.023	0.003	0.0103
		%	68.55	22.85	7.53	1.08	
	950	*kg*	0.192	0.074	0.022	0.003	0.0097
		%	66.67	24.64	7.54	1.16	
	900	*kg*	0.172	0.073	0.022	0.003	0.0090
		%	63.98	27.02	8.07	0.93	
30	1000	*kg*	0.138	0.050	0.017	0.003	0.0069
		%	66.27	24.10	8.03	1.61	
	950	*kg*	0.139	0.048	0.016	0.003	0.0069
		%	67.61	23.08	7.69	1.62	
	9000	*kg*	0.124	0.053	0.014	0.003	0.0065
		%	63.95	27.47	7.30	1.29	

At the same time, the fractions distributions (sorts) can be observed in fig. 2 for nettle and fig. 3 for thyme.

Fig. 2 – Distribution of fractions (dimensional sorts) for nettle

Fig. 3 – Distribution of fractions (dimensional sorts) for thyme

Signification and size of fractions' masses shown in tables 1 and 2 are the following:

- Mass of fraction 1 represents the sifted products of sorter's lower sieve with dimensions ranged between 0.1...3.15 mm for nettle and respectively 0.1...2. for thyme;
- Mass of sort 2 is made of sifted product from the middle sieve centre and lower sieve refuse and comprises vegetal fragments ranged between 3.16...6.15 mm for nettle and respectively 2.16...3.15 mm for thyme;
- Mass of sort 3 is made of sifted product coming from the big sieve and middle sieve refuse, and comprises vegetal fragments ranged between 6.16...8.00 mm for nettle, respectively 3.16...5 mm for thyme
- Mass of sort 4 represents the refused product of the big sieve, the vegetal fragments being bigger than 8 mm, respectively 5 mm.

Sifting efficiency is presented by the level of sorting of vegetal fragments, expressed in percentages(%) and is defined as the ration between the quantity of fragments from each collecting box (fraction 1, fraction 2, fraction 3, fraction 4) and the amount of fragments from the four boxes.

The experimental data related to percentages of vegetal material separated on sieves having different mesh size have been correlated to the distribution law of Rosin-Rammler type (Rosin, P. and Rammler, E., 1933), represented by relation (1):

$$R = e^{-\left(\frac{D}{D_n}\right)^n} \quad (1)$$

where:

R is the cumulative retained at a size D (%);

D is the particle size (mm);

D_n and n are fitting parameters.

Values of coefficients D_n and n for experimental data correlated to Rosin-Rammler law (eq. 1), and values of correlation coefficient R2 are shown in tables 3 and 4. It can be noticed that the distribution law (1) has been sufficiently well correlated to experimental data values, being obtained by the correlation coefficient $R^2 \geq 0.915$ for nettle and $R^2 \geq 0.898$ for thyme.

Table 3

Coefficient values for experimental data correlated with Rosin-Rammler law type (ec. 1), D_n and n, and the coefficient of correlation R^2 for nettle

Experimental parameters	f = 1000 osc/min			f = 950 osc/min			f = 900 osc/min		
	D_n	n	R^2	D_n	n	R^2	D_n	n	R^2
Q_{alim} = 50 kg/h	3.872	-2.366	0.983	3.757	-2.658	0.982	4.246	-1.819	0.959
Q_{alim} = 40 kg/h	3.991	-2.209	0.972	3.738	-2.193	0.946	3.944	-1.839	0.936
Q_{alim} = 30 kg/h	3.517	-3.044	0.990	3.689	-2.304	0.959	3.646	-1.804	0.915

Table 4

Coefficient values for experimental data correlated with Rosin-Rammler law type (ec. 1), D_n and n, and the coefficient of correlation R^2 for thyme

Experimental parameters	f = 1000 osc/min			f = 950 osc/min			f = 900 osc/min		
	D_n	n	R^2	D_n	n	R^2	D_n	n	R^2
Q_{alim} = 50 kg/h	1.684	-3.447	0.991	1.575	-2.971	0.999	1.441	-1.945	0.989
Q_{alim} = 40 kg/h	1.370	-1.999	0.969	1.369	-1.560	0.938	1.439	-1.277	0.922
Q_{alim} = 30 kg/h	1.338	-1.283	0.939	1.289	-1.211	0.934	1.428	-1.114	0.898

In the case of the two plants analysed for the three feeding flows of 50 kg/h (0.01388 kg/s), 40 kg/h (0.01111 kg/s) and 30 kg/h (0.00833 kg/s), the maximum efficiency has been got by the frequency of 1000 osc/min, although (see table 1 and fig. 2), the results being good also for the two other frequencies. At 1000 osc/min small fragments were almost all sifted, therefore in experimental conditions sub-dimensional fragments were separated from refuse part and rapidly passed through the sieve holes.

For all the three feeding flows of both medicinal plants studied at 900 osc/min frequency, separation is much more incomplete, being required either a higher frequency or a smaller feeding flow rate, or a greater sifting period for avoiding the material stratification.

Results obtained following the experimental studies of each plant were shown as graphic in figure 4 by representing the cumulative percentage of fractions which passed through the sieve depending on the sieve mesh size.

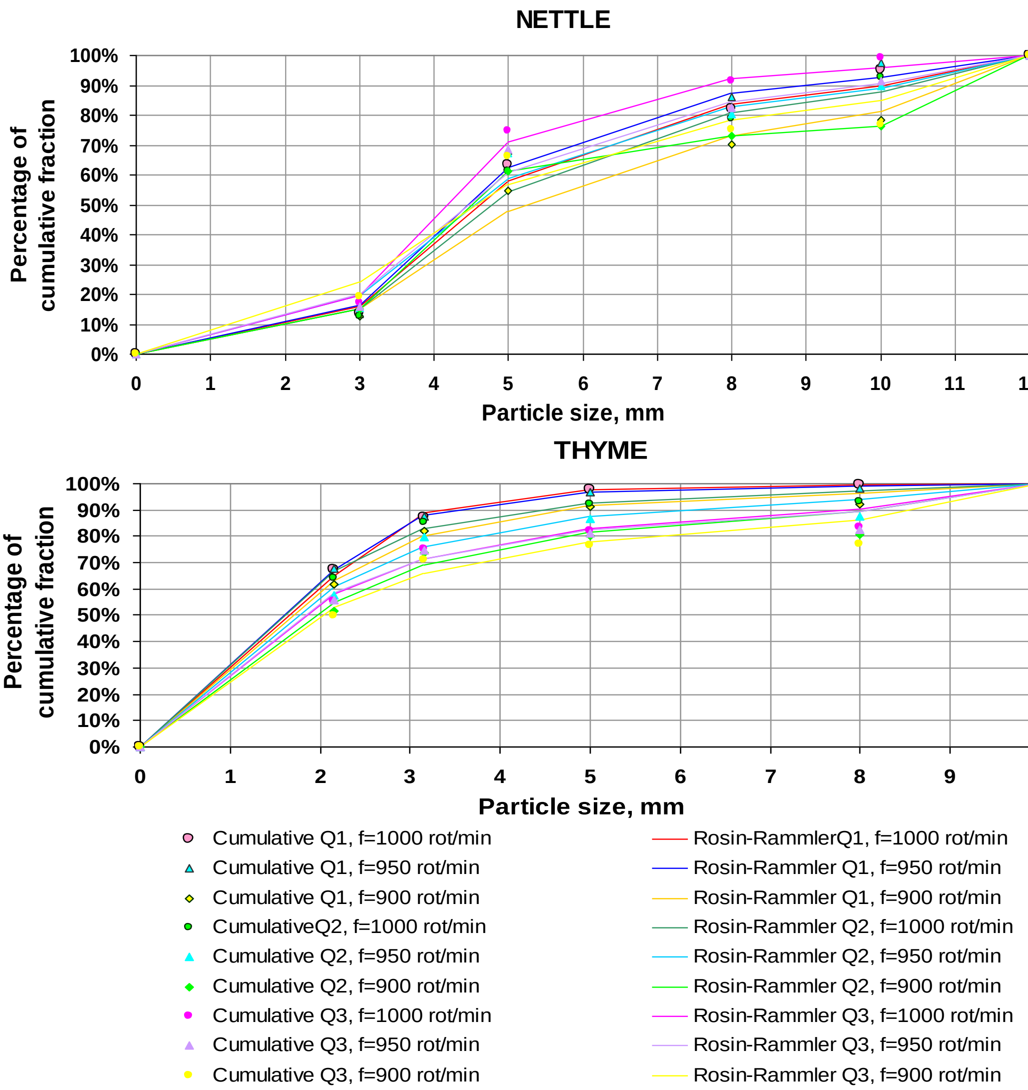

Fig. 4 - Size distribution curves given by equations Rosin-Rammler in correlation with experimental data for nettle and thyme vegetal material fractions

CONCLUSIONS

In this paper, it was presented the manner in which the distribution law of vegetal fragments size is used for finding out the over-dimensioned and sub-dimensioned fragments depending on the size of holes of plane sieves driven by two vibration engines.

Analysing both experimental and theoretical data, we may conclude that for the three quantities of material on sieve have been necessary middle to high values of frequency (950 – 1000 osc/min for avoiding the material stratification and achieve a complete sifting.

In case of large quantities (very high vegetal material on sieve surface), in order to reach a good efficiency, high frequencies are required. Refuse fragments, having the tendency to clog the sieve holes, bigger inertia forces are necessary for extracting the refuse fragments from holes and ensure a good separation. At the same time, when frequencies are higher the fragments to be sifted reach more rapidly the sieve's surface, even though the stratification is increased and they may be easily separated through the holes, if the passing time is sufficient.

Data presented can be important for all the specialists and persons involved in the field of medicinal plants processing.

ACKNOLEDGEMENT

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DETERMINATION OF NOISE AND FUNCTIONAL PARAMETERS OF A TRANSVERSAL BEATING DEVICE BY ACOUSTIC MEASUREMENTS
/
DETERMINAREA PARAMETRILOR DE FUNCTIONARE SI A ZGOMOTORULUI UNUI BATATOR TRANSVERSAL PRIN MASURĂRI ACUSTICE

Assoc. Prof. Ph.D. Eng. Orăşanu N.*1), Prof. Ph.D. Eng. Craifaleanu A.1)
1) University “Politehnica” of Bucharest, Department of Mechanics;
Tel: (004)021.402.92.50; E-mail: norasanu62@yahoo.com

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ABSTRACT

The paper presents a simple, exact method for the determination of the kinematic parameters of a transversal beating device, using acoustical measurements. The analysed stand, in possession of the Faculty of Biotechnical Systems Engineering in University "Politehnica" of Bucharest, consists of a transversal beating device with an electrically driven fan. The axle of the fan, directly driven by the engine, by means of a belt transmission, has a constant rotational speed, while the axle of the beating device receives the motion from the axle of the fan, by means of a variator with V-belts, so that its rotational speed can be modified. Acoustical measurements may represent a simple study method of the variator functioning, since the values of the rotational speed of the fan and of the beating device, respectively, can be determined, as principal noise sources. Also, the measurements determine the noise level produced by this stand, which allows it to perform researches regarding the noise reduction of the device.

REZUMAT

Lucrarea prezintă o metodă simplă de determinare cu exactitate a parametrilor cinematici ai unui bătător, utilizând măsurări acustice. Standul analizat, aflat în dotarea Facultăţii de Ingineria Sistemelor Biotehnice din cadrul Universitatea „Politehnica din Bucureşti”, este format dintr-un bătător transversal cu ventilator, acţionate electric. Axul ventilatorului, acţionat direct de motor, printr-o transmisie cu curele, are o turaţie constantă, iar axul bătătorului primeşte mişcarea de la axul ventilatorului prin intermediul unui variator cu curele trapezoidale, turaţia sa putând fi modificată. Măsurările acustice efectuate pot reprezenta o metodă simplă de studiu a modului în care variatorul de turaţie funcţionează, deoarec se pot stabili valorile turaţilor ventilatorului şi bătătorului, ca principale surse de zgomot. De asemenea, măsurătorile permit determinarea nivelului de zgomot produs de acest stand, ceea ce permite efectuarea unor cercetări privind reducea nivelului de zgomot al utilajului.

INTRODUCTION

Determination by acoustical or vibration measurements of kinematic parameters, unbalances or damages of machines or devices is a widespread engineering practice. Spectral analysis of signals allows it to determine the eigenfrequencies (*Craifaleanu and Dragomirescu, 2015; Orăşanu and Dragomirescu, 2015*), the vibration transmission means (*Ahmadian, et al., 2016*), the structural damping (*Carp-Ciocârdia and Magheţi, 2016*), as well as the damages of various parts of machines (*Haloui et al., 2007; Konstantin-Hansen and Herlufsen, 2010; Scanlon and Bergin, 2007; Zhenhuan, et al., 2015*).

Rotors in motion, especially those endowed with discs, blades, propellers, arms etc., as the case of those studied in the present paper, produce during functioning, at idle or under load, turbulences and high pressure variations in the work environment. These pressure variations produce noise, whose acoustic level is often high and exceeds admitted limits.

Similar to the case of vibrations, that can be a direct indicator in rotor monitoring; the acoustic signal spectrum is in correlation with the frequencies of the noise sources. The identification of the high amplitude spectral components allows it to determine the influence of each movable ensemble of the device, as well as to determine the work frequency of the principal kinematic parameters.

MATERIAL AND METHOD

Subsystems with periodic motions of a device produce vibrations that can be expresses as Fourier series,

$$x(t) = a_0 + \sum_{n=1}^{N} c_n \cos(n\omega t + \varphi_n), \tag{1}$$

where $\omega = 2\pi / T$, while T is the period of the motion.

The vibrations of the whole system consisting of K subsystems with periodic motions (rotations with constant but non-equal rotational speeds), with non-equal periods, are described by functions of the form

$$X(t) = A_0 + \sum_{k=1}^{K} \sum_{n=1}^{N} C_{nk} \cos(n\omega_k t + \varphi_{nk}). \tag{2}$$

It is known that vibrations of any nature, as well as the motions of objects in the air, can be acoustic sources.

In the case of rotors with blades, the vibrations, as well as the periodic motions of the blades, can be sources of acoustic emissions.

If the time variation of the acoustic pressure due to the device functioning is defined, coefficients in expression (2) can represent a part of the Fourier coefficients of the pressure function. For a rotor with N blades, the frequency of the periodic perturbations that produce pressure variation in the environment will be, according to (*Singh*),

$$f = Nf_{rot}, \tag{3}$$

where f_{rot} is the rotation frequency of the axle.

The analysed device has two rotor with blades, very close as positions and with close rotational speeds, which may lead to an “elastic coupling” between the air masses perturbed by them and to beat phenomena, i.e. to acoustic emissions of higher frequencies, similar to gear frequencies.

The time variation of the acoustic pressure, i.e. the acoustic signal, was measured using a measuring chain that consists of an acquisition card NI 9332 and a laptop computer. The acquired data were processed with specialized software.

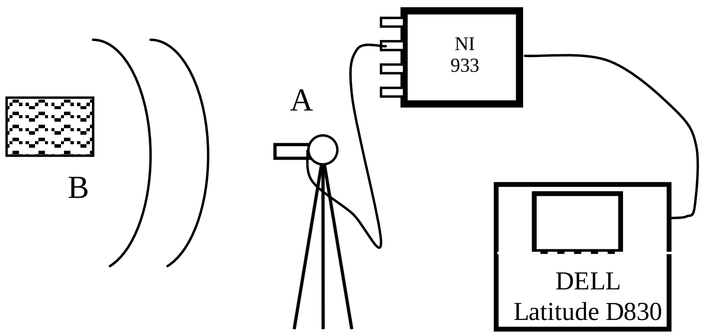


Fig. 1 - Measuring chain

The noise was measured in several points of the laboratory, situated at various distances and various directions with respect to the acoustic source.

The measurements were made for several functioning regimes of the device, in a number of points, with the microphone situated at a height of 1.3 m, which is the medium height of the ear position of the sitting audience.

The identification of the kinematic functioning parameters of the two rotors consists in finding two frequency sequences in the spectra, of the form

$$f_v, 2f_{v,} 3f_v, ..., nf_v, \quad f_b, 2f_{b,} 3f_b, ..., mf_b \tag{4}$$

where f_v is the fundamental frequency of the noise produced by the fan, while f_b is the fundamental frequency of the sound produced by the drum of the beating device.

The exact determination of the rotation frequencies of the two rotors allows it to calculate the transmission ratio of the variator, in a certain functioning regime,

$$i = \frac{n_1}{n_2} = \frac{60\,f_1}{60\,f_2} = \frac{Mf_v}{Nf_b} \qquad (5)$$

where N is the number of blades of the fan, while M is the number of blades on the beating device drum.

After determining the transmission ratio, the position of the V-belt mean fibre can be calculated and the functioning of the device in the prescribed parameters can be verified.

The calculation of the mean fibre position can be made using the maximum diameters of the pulleys, D_1 and D_2, the belt height, h, and measuring the superior position of the belt, with respect to the exterior circles of the pulleys, a and b, for each analysed working regime (Fig. 2).

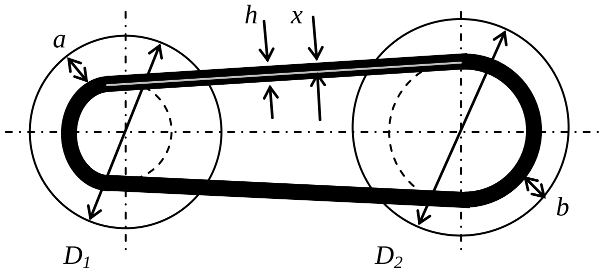


Fig. 2 - Belt transmission system

From the condition of equal velocities of the points of the belt mean fibre, it follows:

$$\omega_1(D_1 - 2a - 2x) = \omega_2(D_2 - 2b - 2x). \qquad (6)$$

Since the angular velocities of the pulleys, ω_1 and ω_2, are proportional with the frequencies, the distance x to the mean fibre can be calculated from relations (6) and (7):

$$x = \frac{D_2 - iD_1}{2(1-i)} + \frac{ia - b}{1-i}. \qquad (7)$$

RESULTS

The measurements were made in a laboratory with the dimensions 13.6 x 9.1 x 3.55 m (Fig. 3), whose walls have low absorption coefficients, which means multiple reflexions were present.

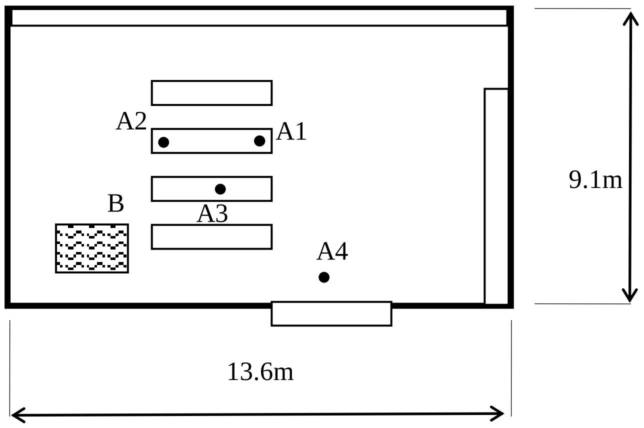
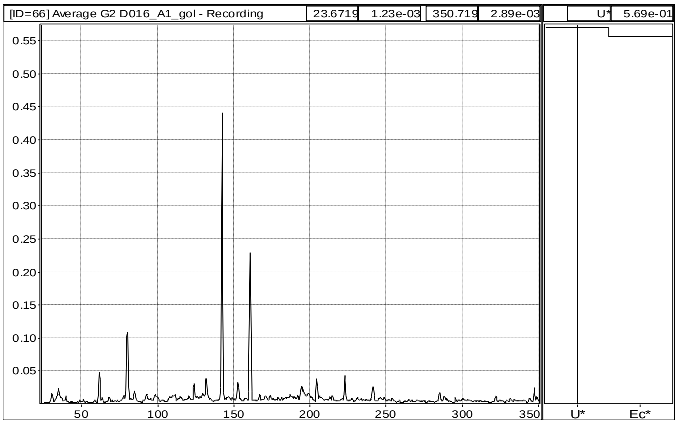
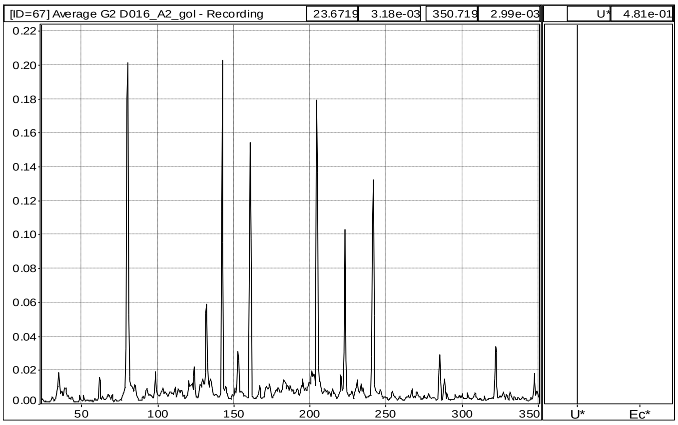


Fig. 3 - Source and measuring positions

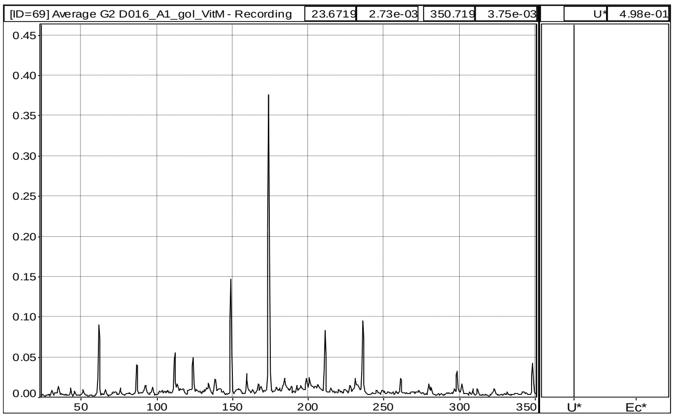
The acoustic field in the room is not very homogeneous, since measurements performed for the same rotational speed regime, in different points, showed different spectral compositions. Spectra determined in points A1 and A2 for a low rotational speed and for a higher one, respectively, are presented in Figure 4.



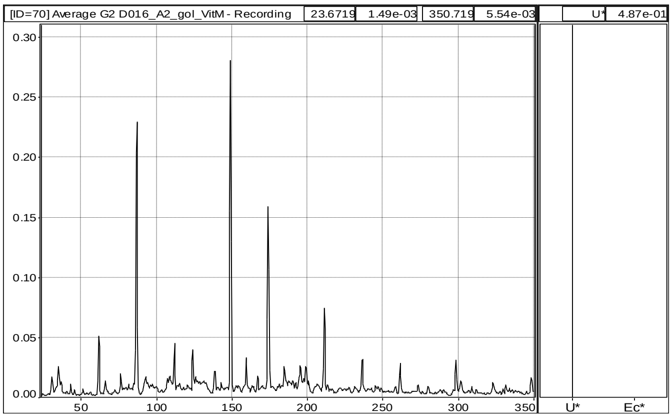
a) A1 spectrum, low rotational speed



b) A2 spectrum, low rotational speed



c) A1 spectrum, higher rotational speed



d) A2 spectrum, higher rotational speed

Fig. 5 - Measured spectra

The analysis of the measured signals spectra identified the first 12 frequencies for large amplitude noise (Table 11).

Table 1

First 12 frequencies for large amplitude noise

	A1		A2		A3		A1-Vm		A2-Vm		A3-Vm		A4-Vm	
L	89.08[dB]		87.62[dB]		90.26[dB]		87.92[dB]		87.73[dB]		87.10[dB]		89.40[dB]	
	f [Hz]	*P* [mPa]	*f* [Hz]	*p* [mPa]	*f* [Hz]	*p* [mPa]	*f* [Hz]	*P* [mPa]	*f* [Hz]	*p* [mPa]	*f* [Hz]	*p* [mPa]	*f* [Hz]	*p* [mPa]
1	142.8	448	142.9	203	142.9	505	174.4	377	149.5	281	174.6	260	95.0	459
2	161.3	203	80.7	225	161.3	301	149.4	150	87.3	256	87.3	255	190.0	172
3	80.6	125	205.1	189	241.9	90	236.7	100	174.6	163	149.5	71	285.1	91
4	62.2	50	161.3	157	205.1	89	62.2	97	211.7	79	261.9	51	146.9	89
5	223.5	46	241.9	142	80.7	89	211.7	84	62.2	55	236.8	43	219.4	89
6	132.5	44	223.5	120	62.2	89	112.2	61	112.3	46	386.3	41	157.2	73
7	205.1	39	132.5	66	124.5	49	386.1	53	124.5	42	201.5	36	62.2	63
8	153.2	35	322.7	38	153.3	44	124.4	53	463.3	38	199.6	36	127.8	63
9	366.4	33	153.3	33	223.5	30	348.8	46	159.9	37	185.0	32	252.2	57
10	124.4	29	285.8	30	547.4	24	87.2	46	236.8	37	299.0	31	124.4	51
11	547.2	29	124.5	25	366.5	24	298.9	36	299.0	31	124.5	31	380.1	48
12	241.9	29	366.5	25	194.7	21	159.8	31	261.9	30	448.5	29	94.7	46

As can be seen from the table, a sequence of harmonic frequencies is found in all measured regimes: 62.2 Hz, 124.4 Hz,...

This sequence represents the acoustic emissions frequencies of the fan, which has constant rotational speed. Therefore, its acoustic emission will be identical for all functioning regimes of the device.

The table contains also other sequences of harmonic frequencies, corresponding to the noise produced by the beating device drum. For the three studied regimes, these sequences are, respectively:

80.6 Hz, 161.3 Hz, 241.9 Hz,…;

87.3 Hz, 174.6 Hz, 261.9 Hz,…;

95.0 Hz, 190.0 Hz, 285.1 Hz,...

The analysed equipment has $N = 6$ blades on the fan and $M = 8$ blades on the drum, which means that:

$$i = \frac{Mf_v}{Nf_b} = \frac{8 \cdot 62.2}{6 \cdot 87.2} = 0.9511 \tag{8}$$

From the geometrical data of the machine, $D_1 = 360$ mm , $D_2 = 390$ mm , $a = 34$ mm , $b = 55.5$ mm, it follows:

$$x = \frac{390 - 0,9511 \cdot 360}{0.0978} + \frac{0,9511 \cdot 34 - 55,5}{0.0489} = 13\text{mm} \tag{9}$$

The rotational speeds of the two rotors care determined from formula (3):

– the fan rotational speed,

$$n_{rot\_v} = 60\, f_v / 6 = 622 \text{rot/min} \tag{10}$$

– the drum rotational speed,

$$n_{rot\_b} = 60\, f_b / 8 = 654 \text{rot/min} \quad \textbf{rot/min} \tag{11}$$

CONCLUSIONS

Determination of the kinematic parameters of a moving part can be a convenient method for obtaining exact work frequencies if the physical phenomena producing acoustic emissions are correctly understood.

There are important resemblances between the acoustic and the vibration signals, from the point of view of the spectra, but also differences, resulting from the interaction between the blades and the air.

Accurate values of the sound frequencies can be determined by spectral analysis. In the studied case, a maximum error of 0.1 Hz was achieved. By increasing the measuring time, even higher precisions can be obtained.

However, the precision of the determination of parameter x is not as good, since it depends on the values of parameters a and b, which must be accurately determined.

The noise levels are very high for a laboratory device, its value exceeding with over 10 dB the admissible level (*Orăşanu, 2016*). This results in the necessity either to take measures to reduce the noise level, or to reduce as much as possible the duration of the experiment.

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CONSIDERATIONS ON OBTAINING BIOMASS PELLETS
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CONSIDERAŢII ASUPRA OBŢINERII PELETELOR DIN BIOMASĂ

PhD. Stud. Eng. Găgeanu I.*[1,2], Prof. PhD. Eng. Voicu Gh.[2], PhD. Eng. Vlăduţ V.[1], PhD. Eng. Voicea I. [1], Eng. Dumitru I.[3], Eng. Caba I.L.[4]
[1]INMA Bucharest/ Romania; [2]University Politehnica of Bucharest/ Romania; [3]Power Group International S.R.L. / Romania; [4]S.C. Munax S.R.L. / Romania
Tel: +40762676642; E-mail: iulia.gageanu@gmail.com

Keywords: *biomass, pellets, compression, force, renewable energy*

ABSTRACT
The field of producing solid fuels from biomass has registered a considerable increase, due to the existence of important quantities of biomass that represent an important source of renewable energy. Pellets are one of the most common solid biofuels, being used for both household use and for producing energy. The article presents considerations on the production of pellets from various types of biomass using specially designed equipment and a series of considerations for the best parameters to be used for producing these types of pellets.

REZUMAT
Domeniul producerii de combustibili solizi din biomasă a înregistrat o creştere considerabilă, datorită existenţei unor cantităţi importante de biomasă care reprezintă o sursă important de energie regenerabilă. Peletele reprezintă unul dintre cei mai utilizaţi biocombustibili, fiind folosiţi atât pentru uz gospodăresc, cât şi pentru producerea de energie. Articolul prezintă consideraţii asupra producerii de pelete din mai multe tipuri de biomasă, utilizând echipamente proiectate special pentru această operaţiune, dar şi o serie de consideraţii asupra celor mai buni parametrii ce trebuiesc utilizaţi pentru producerea acestor tipuri de pelete.

INTRODUCTION
The production of pellets, also called granules, from grinded biomass is spread in the field of renewable sources of energy as innovative techniques for environmental protection, especially in Europe. Due to global warming, a phenomenon affecting the entire worldwide population, industries were forced to accelerate and cheapen the large production of pellets used as solid biofuel, by identifying new innovative technical solutions in the field of pelleting machinery (*Tumuluru et al., 2010; Voicea et al., 2014*).

Pellets represent the biofuel produced from wood or agricultural waste. They are cylindrical granules of standard sizes between Ø-5...8mm (sometimes even up 30 mm) with variable length of approximately 20-50 mm. They have increased mechanical resistance and good combustion characteristics. The pelleting process offers a real possibility of valorising wood waste. Pellets are produced from waste resulted from wood processing, agricultural residues or from energetic plants. Pellets are a non-polluting fuel, because from their combustion, there are no harmful emissions. The mass of one m^3 of pellets weighs approximately 650-700 kg and produces around 3250 kWh of energy. The process of producing pellets is not a complicated one, but it is still complex (*Stelte et al., 2012,*).

It is important that the biofuels are framed by regulation in order to facilitate commercial exchanges of energetic biomass. They refer to terminology, classification, sampling, determining the combustion power, determining particle size distribution and content of chlorine and sulphur. Currently, there are various testing methods for certifying the quality of solid biofuels as well as various practices for characterizing the parameters of these products. The biggest challenge in the case of biomass based fuels refers to the fact that they are not homogenous. Biomass properties differ depending on the raw material.

The main advantages of densifying wood biomass are:

• Increasing the density of compressed material (from 80-150 kg / m^3 for straws or 200 kg / m^3 for sawdust to up to 600-700 kg / m3 for final products);
• A higher calorific value and a homogeneous structure of densified products;
• A low moisture content (lower than 10%);
• Improved storage characteristics;
• Extending the usage period of biomass materials.

MATERIAL AND METHOD

Pellets are produced from industrial dry and untreated wood based waste such as: wood chips, wood dust, saw dust, wood shavings, etc. Wood material can be used from resinous and deciduous trees, from both xylem and bark, and due to the fact that deciduous trees have lower lignin content, they might require additives. Pellets are compact, uniform, easy to store and handle, can be used in automated heating systems, stoves or boilers (*Mediavilla et al., 2012*; *Mani et el., 2006; Kazuei et al.,*).

Fig. 1 – Example of pellets obtained through the densification process

Pellets are produced by grinding sawdust, wood chips, branches, tree bark or parts of agricultural biomass and pressing the material obtained through a die at high pressures. The heat resulted due to friction is enough to soften the lignin in the biomass. When is cooled, lignin becomes rigid and binds the material. The compressed material has the shape on noodles, their section being identical in shape to the one of the pressing channels (*Samuelsson et al., 2012; Kaliyan et al., 2010*).

The actual densification practically has two stages:

- Compacting the woody material under pressure, in order to reduce its volume and to aggregate the particles of material;

- In the second stage, the lignin is activated by the high pressure and the increased temperature and “glues” the wood particles, thus creating the final product.

The material is pressed in a special die. Due to the high pressure (800-900 bars) and the high temperature that appears during compaction, lignin, the natural binder in wood is melted and helps forming the pellets at the same exact size and shape as the channels in the die. Good quality pellets are produced at adequate pressure and temperature, so it is important to monitor those parameters very carefully.

The two main types of pelleting equipment are: **with flat die** or **with ring die**. In the first case, we have a perforated disk on which two or more rollers rotate, compressing the raw material. In the second case, we have a perforated ring (fig. 2 - left), and the pressing rollers are situated in the interior of the ring (fig. 2 – right).

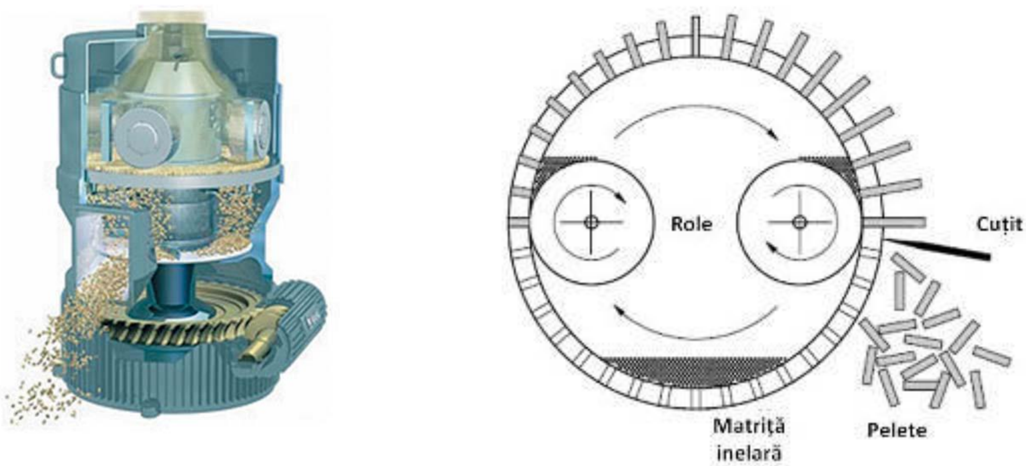

Fig. 2 – Operating principle of pellet mills (left – flat die; right – ring die) [2]

Working principle of the flat die ring pelleting machine

The flat die ring pelleting machine was the first pellet press designed at the beginning of the 20th century, based on flat dies. Generally, there are two types of flat dies machines on the market, the one with rotating die and the one with rotating rollers. The first type has a stationary roller and the second type has a stationary die. Adopting the vertical principle, the raw material falls due to its own weight in the pelleting room where it is compressed between the rollers and the matrix, forming pellets when passing through the die channels.

Working principle of the ring die ring pelleting machine

Pelleting machines with ring die are based on a simple operation where the material is distributed on the interior surface of a perforated ring die, in front of each pressing roller, which compresses the material and forces it to pass through the die channels, thus forming pellets.

The actual forming of pellets takes places in “the contact line” between the rollers and the die. All other activities connected to this operation, such as conditioning, cooling, etc. support and enhance the action in that moment in the system. In order to understand the process and to improve transition, quality and aspect, one should have a profound understanding on what happens in the locking point.

The pressing chamber has the shape of channels, the length of a channel being equal to the length of the wall of the die, which is set by its mechanical resistance. As a result of the action of the pressing body, the powdery material, which was previously homogenised and wetted, is forced to pass through the calibrated orifices of the die (is extruded). Characteristic for this densification method is the fact that in the tight space between the working bodies, the material reaches the flowing limit and slides through the die orifices (channels).

Fig. 3 – Examples of dies and pressing rolls (left – flat die, right – cylindrical die) [2, 15]

The **pressing rollers**, as the dies, are cylindrical parts that are normally built of tungsten carbide particles or are built as a grooved roller.

Rollers can have cylindrical or cone shape. Roller surfaces can be riffled or can have various shaped imprints. During movement, rollers press the material in the matrix orifices, each channel being active only when it is positioned next to a pressing roller.

The main purpose of rollers is to help the material pass through the die orifices, therefore the shape and the construction of rollers is designed to prevent material from sliding and to offer a roughened surface for a better traction. A pelleting press usually has two or three pressing rollers in its construction.

For obtaining biomass pellets, various types of raw material can be used, such as energy willow, miscanthus, sawdust, etc. These materials are suitable for compaction, because they have a high content of lignin, which is very important for the resistance of pellets in time, lignin acting as a binder when the material is subjected to compression forces within the pressing channels at increased temperatures.

Material properties necessary for densification:

• Capacity of flowing and cohesion;

• Particle size (if the particles are too fine, it translates in high cohesion, but in reduced flowing; if the particles are too large, the cohesion decreases, but the capacity to flow increases);

• Superficial adhesion forces (important for agglomeration and resistance);

• Adhesiveness (capacity to adhere);

RESULTS

The process of forming pellets consists in subjecting biomass to high pressures, period when particles are forced to agglomerate. The compression process is usually obtained in three distinct stages. In the first stage, particles rearrange under the action of a low pressure, forming agglomerations. Particles maintain most of their original properties, although the energy is dissipated due to the friction between particles and the machine wall.

During the second stage takes place the plastic and elastic deformation of particles allowing them to flow in smaller spaces, thus increasing the contact surface between particles and, as a result, appear the van der Waals binding forces. Fragile particles can break under pressures leading to mechanical interlocking.

In the final stage, under the high pressures applied in stage two, compression continues until the density of particles is reached. In this stage, particles can reach their melting point and form solid bridges when cooling down. Figure 4 shows the mechanical deformations of biomass during compression.

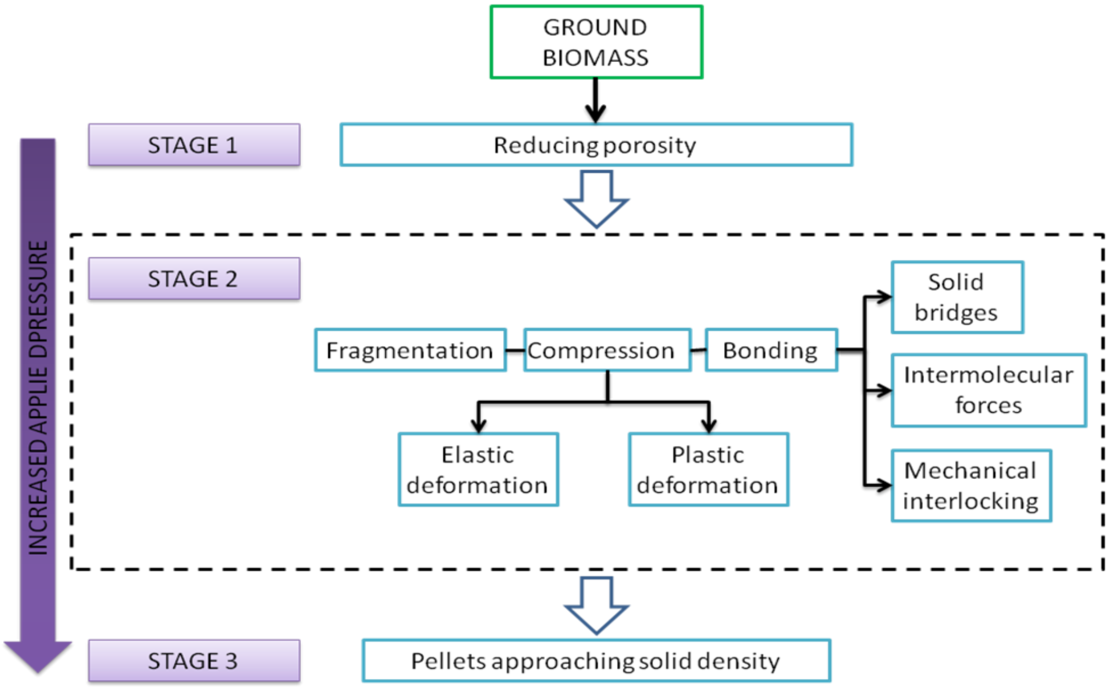

Fig. 4 - Deformation mechanisms of powder particles under compression [12]

Understanding some of the major chemical changes that take place during processing of biomass can be useful in understanding their compaction behaviour. As the densification of biomass is coupled with process variables like temperature, pressure, die geometry and mechanisms of densification, changes in these variables will bring about significant changes in the chemical composition of the biomass by the mechanisms known as interaction reactions.

In table 1 are shown the recommended values of some of the most important parameters of the densification process.

Table 1

Recommended values for the parameters of the densification process

Parameter	Biomass type	Recommended value
Die Temperature	woody	80-90º
	agricultural	80-90º
Moisture	woody	6-12%
	agricultural	10-20%
Granulation	woody	0.5-5 mm
	agricultural	0.5-6 mm
Percentage of fines	woody	10-20
	agricultural	10-12

The quality of densified biomass is given partly by the type of raw material and partly by the process variables. Process variables refer to those parameters inherent to the pelleting machine, respectively: temperature, pressure, die size, die speed, the distance between the die and pressing roller, etc.

Temperature – quality attributes such as durability and bulk density are significantly influenced by die temperature. A higher die temperature can reduce the pressure needed to compress the material and will also increase the durability of pellets.

Pressure – pressure play a very important part in the quality of pellets. It is necessary to find an optimal pressure depending on the type of material used for compression. A pressure higher than the optimal one can cause breaks in the final product due to a sudden expansion immediately after the pellets exit the die. Also, after a certain value, an increase of pressure will not offer any significant gain in the cohesion (binding) of pellets and it would only increase the production costs.

Applying high enough temperatures and pressures during densification can develop solid bridges through the diffusion of molecule from one particle to another in the contact points, thus increasing density and resistance.

Die geometry and speed – die geometry refers to its sizes and shape. These attributes can affect both the quantity of material that can pelleted, but also the energy necessary for compression and influences the properties of the final product, such as moisture, bulk density and durability.

Pelleting machines are built of a die characterized by the length / diameter ratio (L/D). Length refers to depth of the die (the length of channels in the die) and the diameter refers to the diameter of the perforations (orifices, channels) in the die. Usually, durability increases along with increasing the L/D ration, due to the increase of friction forces caused by the increased friction between the material and die. However, a ration that is to big will block the die and will strangle the pelleting machine.

Distance between pressing rollers and the die – the distances between the pressing rollers and the die refers to the space between the die and the roller that forces the material to pass through the die. Usually, the distance should be between 1.5 and 2.5 mm. increasing the distance would lead to a significantly reduced resistance and durability of pellets.

A very important structural parameter is represented by the conicalness of the pressing channels. The conicalness has a significant impact on the final quality of the product obtained by pressing, but also on the construction of pressing machines.

Geometry of the pressing chamber - each geometry has its specific shape that affects the distribution of pressures in the pressing chamber and also the final quality of pellets. Each shape of the pressing chamber is suited for certain types of materials. Therefore, it is necessary to research the influence of the construction parameters of pressing chambers on the biomass densification process and on the quality of products resulted. The research and optimizing of the pressing chamber for biomass compaction will allow designing a compaction process that is energetically efficient, leading to obtaining high quality products (*Križan et al., 2012*).

Additives - besides the variables of the process, the use of an additive for the particles of biomass could have a positive effect on the resistance of pellets. Starch, proteins, fibres, fat / oil, lignosulfonate, bentonite and modified cellulose have proven to positively influence the durability of densified products (*Byoung et al., 2014*).

CONCLUSIONS

The densification of biomass offers a real alternative to the use of fossil fuels. Also, it represents a method of using all the biomass materials that otherwise would go to waste. Densification is a relatively new method of processing biomass and still requires research and improvement.

Biomass densification can be achieved by using two types of equipment:

- Flat fie pelleting machine;
- Ring die pelleting machine.

Both types have their advantages. The flat die pelleting machine is recommended for smaller producers as it has smaller capacities, smaller size and weight, is very compact and has low energy consumption. The ring die machine is recommended for large scale producers because they have higher capacities, experience low wear and are very effective in term of energy use.

The field of producing biomass pellets still offers a multitude of possibilities for improvement and optimizing, both regarding the construction of equipment, but also for the composition of biomass mixes prepared for pelleting.

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RESEARCHES REGARDING THE INFLUENCE OF THE NOZZLE WORKING PRESSURE ON SPRAYING MACHINES DISTRIBUTION UNIFORMITY / CERCETARI PRIVIND INFLUENTA PRESIUNII DE LUCRU DE LA DUZE ASUPRA UNIFORMITATII DE DISTRIBUTIE A MASINILOR DE STROPIT

PhD. Stud. Eng. Roşu (Niţu) M. *1), Emeritus. Prof. PhD. Eng. Căsăndroiu T. 2), PhD. Eng. Matache M. 1), PhD. Stud. Eng. Cujbescu D. 1), PhD. Eng. Vlăduţ V1), PhD. Stud. Eng. Sorică E. 1), PhD. Eng. Rădulescu D.L.3)
1)INMA Bucharest / Romania, 2) University Politehnica of Bucharest / Romania; 3)University of Agricultural Sciences and Veterinary Medicine Bucharest / Romania
E-mail: rosumihaelan@yahoo.com

Keywords: *spraying machines, distribution uniformity, pressure, protection*

ABSTRACT

Quality of the agricultural products is closely linked to soil and plants health they provide. In this respect, by applying phytosanitary treatments, it is aimed to reduce the substance quantity simultaneous with increasing the treatment. These closely depend by the covering degree of the treated area.

Within this paper are presented the results of experimental researches regarding to the influence of the nozzle working pressure on distribution uniformity of the phytosanitary substance in field crops. Experiments carried on laboratory, using a stand wick simulates passing of the spraying machine in the field, using the same type of nozzles for more work pressures, assessing the coverage degree with phytosanitary substance.

REZUMAT

Calitatea produselor agricole este strâns legată de starea de sănătate a soluluişi a plantelor care le furnizează. În acest sens, prin aplicarea tratamentelor fitosanitare, se urmăreşte reducerea cantităţii de substanţă concomitent cu creşterea eficacităţii tratamentului fitosanitar, acesta depinzând în mare măsură, de gradul de acoperire al suprafeţei tratate.

În cadrul lucrării se prezintă rezultatele cercetărilor experimentale privind influenţa presiunii de lucru de la duze asupra uniformitatii de distributie a substaţei fitosanitare în culturile de câmp. Experimentările s-au efectuat în laborator utilizând un stand care simulează trecerea maşinii de stropit în câmp, folosind acelaşi tip de duze, pentru mai multe presiuni de lucru, evaluându-se gradul de acoperire cu substanţă fitosanitară.

INTRODUCTION

Agricultural productivity is influenced by the applied work technologies level; phytosanitary protection occupies an important place in these technologies.

The using of pesticides is still one of the main ways to increase agricultural production and ensure economic efficiency in agriculture.

In general, the main objective of phytosanitary treatments is to perform a quality treatment in conditions of maximum security and reducing environmental pollution.

Natural environment protection concerns have been felt since the late nineteenth century, however, we cannot talk about farming without reference to its consequences on the environment [10].

Pollution by phytosanitary treatments coming from diseases and pests in field crops, can lead to reducing the quality of food, water, and soil. Reducing soil pollution is intended to maintain optimal relationship between quantity, quality and structure of food [8].

During the working process of spraying machines, a part of the substance is lost due to existing goals in plantation, of its drain on leafs surface and due to drift of dispersed liquid droplets.

In these conditions a part of used substance remains in atmosphere, in waters, on soil and on neighbourhood plantations [2], [3].

The purpose of a spraying work is to uniformly store a maximum quantity of phytosanitary product at combating plant place, respectively on the spraying surface.

Spraying represents the decomposition process of a liquid jet in drops. By spraying the liquid is dispersed in small-diameter drops of various sizes, the average diameter of the resulting droplets ranging from several microns (μm) to 2 ÷ 3 mm. [5], [7].

The liquid spray jet, has been studied by many researchers [1], [4], [6], the obtaining results allow to conclude that surface of the jet flow exiting that get off a nozzle orifice is subject to small disturbances.

The spraying process of the liquid jet, has been studied by many researchers [1], [4], [6], the obtained results allow to conclude that jet surface which get off the nozzle orifice nozzle is subject to small disturbances.

These small disturbances are due to fluid flow regime, frictional forces, working pressure, nozzle orifice diameter variation and imperfections of its shape, orifice edge geometry, the presence of gas bubbles in a stream, of mechanical impurities, etc.

The paper aim at establishing a specific nozzle type, how influence working pressure, covering degree of the spraying surface and respective working machine process, performing a phytosanitary process with appropriate covering degree.

In the paper was defined coverage degree by density or number of phytosanitary solution drops per 1 $cm^2$of the treated surface.

MATERIAL AND METHOD

According to [10] drops size a jet produced by sprayer is not uniform. The jet (Figure 1) contains liquid particles of different, of different sizes, the size spectrum being dependent on the spraying process, type of dispersion or nozzle and working pressure of the spray (or nozzle).

To characterise the drops spectrum within a nozzle jet were established more reference sizes, of practical importance being minimum acceptable diameter. [10].

For the fan or conical nozzles used for phytosanitary treatments in field crops is considered as minimum acceptable diameter = 100 μm, respectively the value under which the drops carried on by air stream of air (danger of drift).

Applying phytosanitary treatments by small orifice drops spraying which cover sprayed surface with a fine film of phytosanitary product conducted to significant decreasing of the water necessary for solutions preparing and loss of active by draining the treated vegetable material [9].

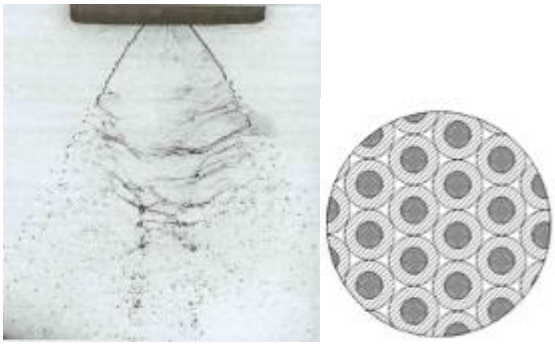


Fig. 1 - Liquid spraying and ideal covering [8]

At nozzles hydraulic sprayers there is a correlation between working pressure of the nozzle and drops spectrum. A higher working pressure induces the forming of the small diameters drops, thus, coverage an e efficient covering.

Considering that the drops shape is spherical (figure 2) and that drops form hemispheres on leafs surface or spheroid whose contact surface on foliar system is equal the with equatorial section surface of the sphere surface, in a volume V, X drops of d diameter can be obtained, according to:

$$X = \frac{6V}{\pi d^3} \tag{1}$$

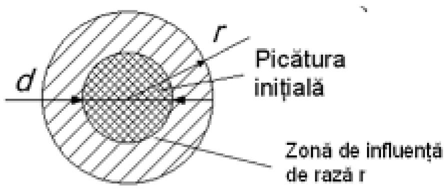


Fig.2 - Influence zone of a drop [10]

Considering that every drop is surrounded by an influence zone of influence of "r" compass, the area covered by the X drops will be:

$$S_{acoperire} = X * S_{infl.} = \frac{3Vr^2}{d^3} \quad (2)$$

Aiming at establishing the coverage degree of spraying works in the field, was used a mix solution of water and colouring agent (methylene blue), which does change physical properties of water.

Within experiments was used a stand composed of a sprayer machine and a trolley (figure 3) which it's moving on two rails and driving by an electric engine having chain transmission. This passed under the ramp spraying machine with constant speed (6 m/sec), simulating passing of the spraying machine in crop field, performing three repetitions for each working pressure, respective 2, 3, 4 and 5 bar.

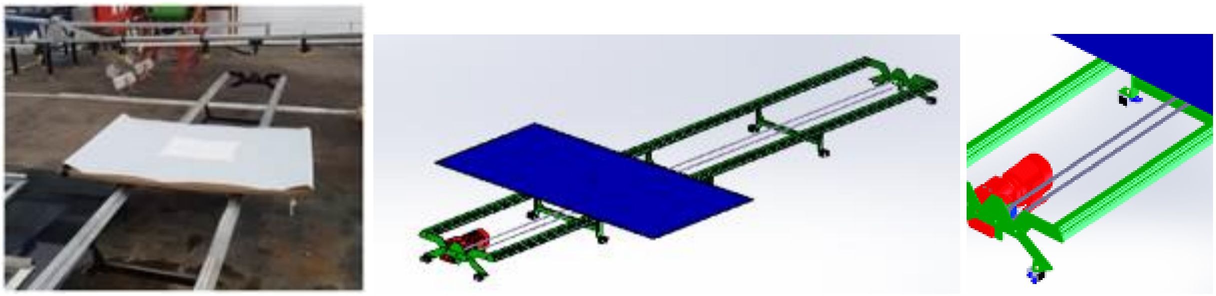


Fig. 3 - Simulation stand for passing the spraying machine in field crop

Within experimental methodology were passed the following stages:
- loading the spraying machine tank with used substance;
- Installing the same type of nozzles (nozzle = 0.2 mm) spraying machine;
- manufacturing the capture surface by plasticizing paper;
- mounting the capture surface of the drops on trolley support;
- setting the working pressure at 2 bar (respective 3, 4 and 5 bar for other samples);
- starting the sprayer machine and trolley, simulating machine passing in field;

Resulted drops have kept and stored shape capture material used thanks to surface tension. Were performed high resolution images (4962x7019pixeli) by EPSON L220 scan, of drops track on capture material. These pictures were previous processed by a specialized soft (NI Vision Builder), aim at quantification the coverage degree for every tested work regime. Image processing consisted first in drops setting the contrast between the drop colour (blue) and background (white) pixel subsequent, extraction of blue pixels and converting images in grayscale.

Next was set a threshold of pixel intensity and corresponding to form were counted the pixels with intensity above that threshold.

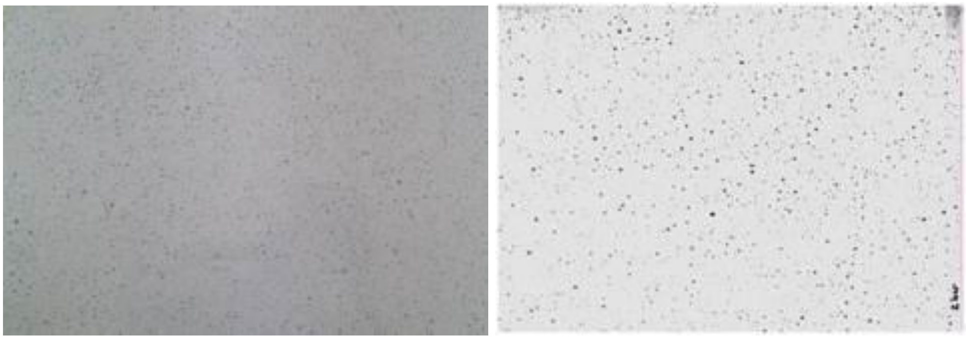
Thus was quantitated the coverage percentage of the measurement surface measurement. Still there were quantified drops with main diameter larger than one pixel (1 pixel = 42 μ) with observation that two stuck drops were considered as only one of drops smaller than a pixel smaller were ignored. Researched surface is of 135 square mm.

For example, it is presented figure 4(a – initial colour image, b - imagine grayscale imagine after processing, c –outline the coverage degree by numbering the pixels by intensity above threshold, d – significant values regarding to coverage degree) and figure 5, where are identified coverage degree and number of drops corresponding working pressure of 2 bars.

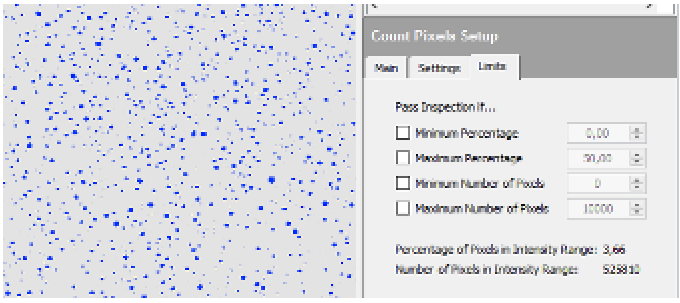
RESULTS

Following the experimental researches and samples processing obtained with specialized software were reveal a series of images for each operating pressure (2, 3, 4 and 5 bars), which outline coverage of the spraying surface, represented in figures 4, 5 and 6.

It is presented below in figures 4 and 5; 6 and 7; 8 and 9; 10:11 images on coverage and their number of drops found appropriate operating pressure, respectively 2, 3, 4 and 5 bars.



a) b)



c) d)

Fig. 4 - Images for determining coverage degree for working pressure of2 bars

a) Initial colour image, b) grayscale image after processing, c) coverage degree by numbering pixels of intensity above threshold; d) significant values

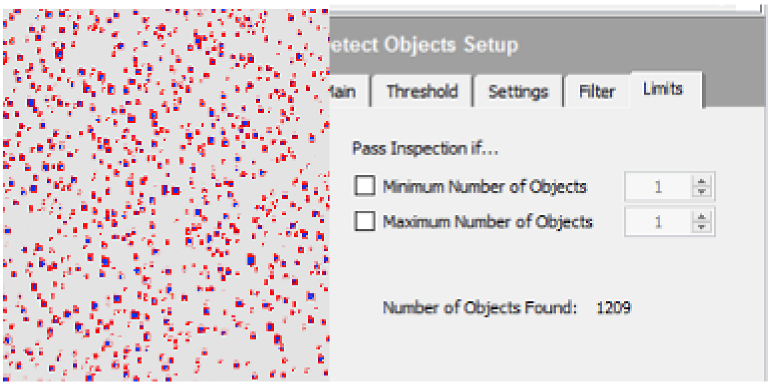
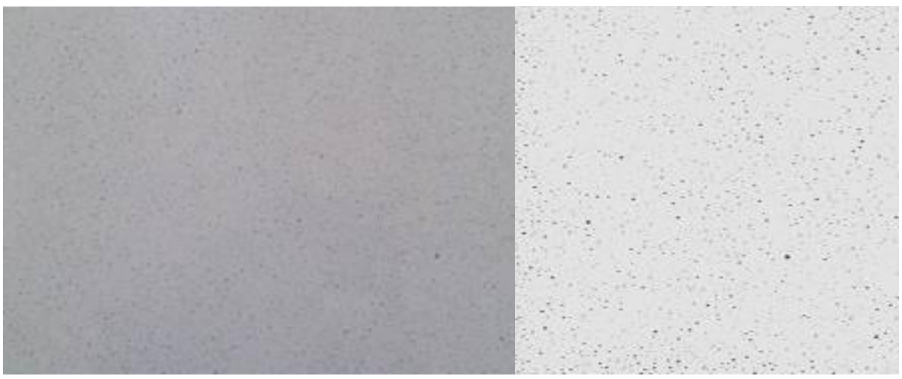
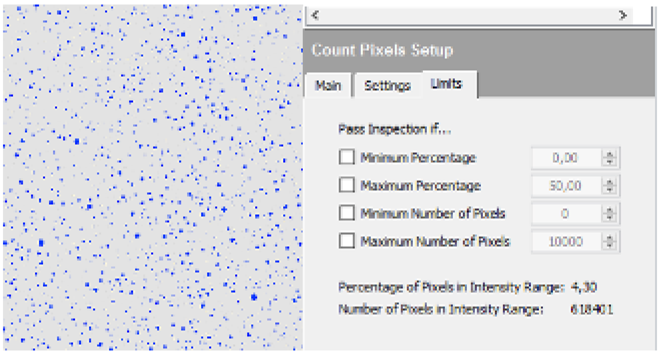


Fig. 5 – Images for determining number of drops at pressure of 2 bars



a) b)



c) d)

Fig. 6 - Images for determining coverage degree for working pressure of 3 bars

a) Initial colour image, b) grayscale image after processing, c) outlining coverage degree by numbering pixels of intensity above threshold; d) significant values

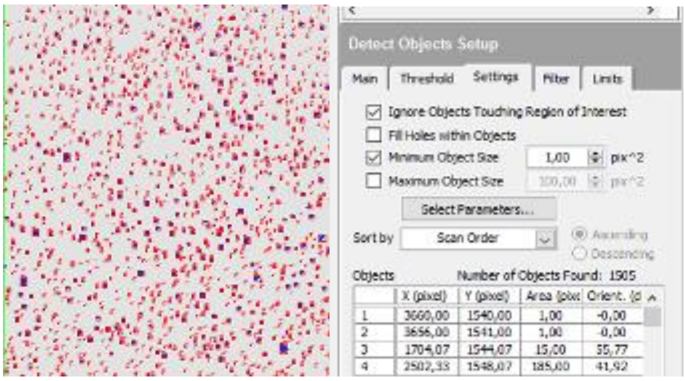
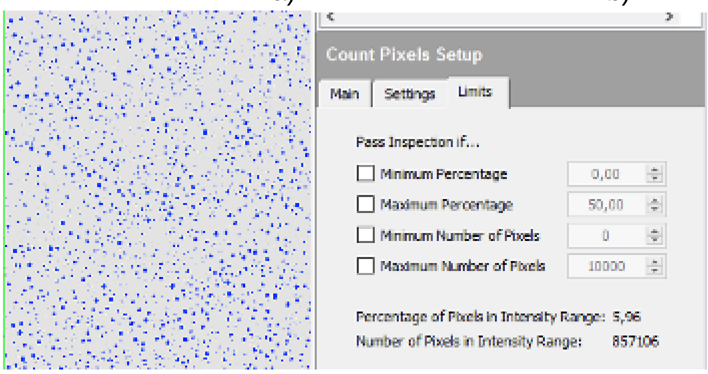


Fig. 7 - Images for establishing number of drops at pressure of 3 bars

a) b)



c) d)

Fig. 8 - Images for determining coverage degree for working pressure of4 bars

a) Initial colour image, b) grayscale image after processing, c) outlining coverage degree by numbering pixels of intensity above threshold; d) significant values

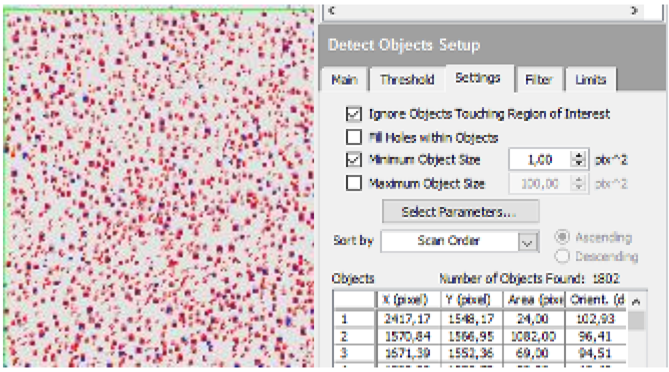
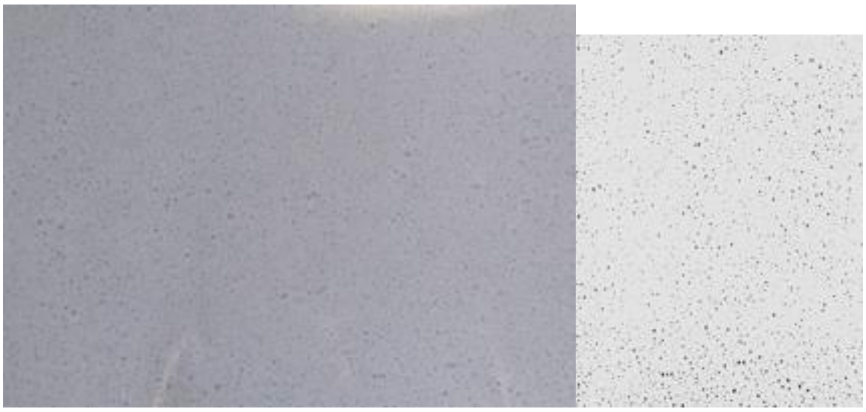
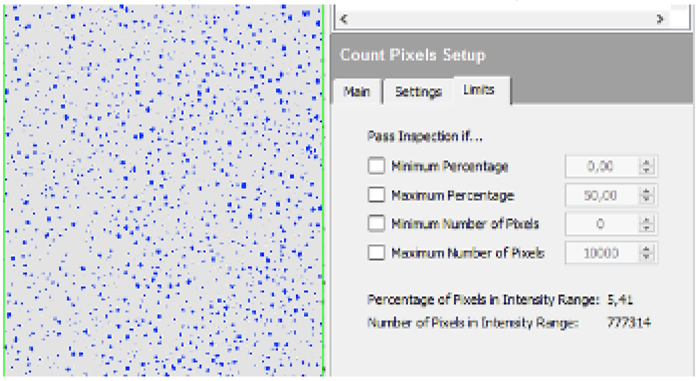


Fig. 9 - Images for establishing number of drops at pressure of4 bars



a) b)



c) d)

Fig. 10 - Images for determining coverage degree for working pressure of 5 bars

a) Initial colour image, b) grayscale image after processing, c) outlining coverage degree by numbering pixels of intensity above threshold; d) significant values

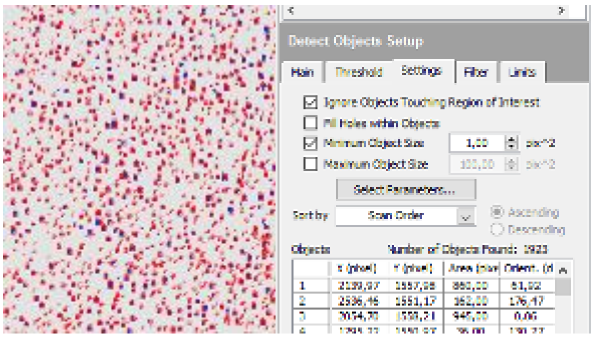


Fig. 11 - Images for determining coverage degree for working pressure of5 bars

Using the data from figures above, was compiled Table 1 having results on coverage (%) and their number of drops bigger than 1 pixel for working pressures of 2, 3, 4 and 5 bars.

Table 1

Coverage degree and number of drops for 4 working pressures

Working pressure	Determined indices	REPETITION NO. 1	2	3	AVERAGE VALUE
2 bars	Coverage degree (%)	3,62	3,69	3,67	3,66
	Number of drops (drops/ cm^2)	1170	1209	1248	1209
3 bars	Coverage degree (%)	4,3	4,1	4,5	4,3
	Number of drops(drops/ cm^2)	1491	1505	1519	1505
4 bars	Coverage degree (%)	5,39	5,41	5,44	5,96
	Number of drops(drops/ cm^2)	1802	1776	1828	1802
5 bars	Coverage degree (%)	5,96	5,93	5,99	5,41
	Number of drops(drops/ cm^2)	1907	1923	1929	1923

Analysing the experimental results , quantified (centralised) in table 1, it is noticed that evolution of coverage degree in function of working pressure is direct proportionally, increasing to 3,66% for pressure of 2 bars, to 5,41% for pressure of 5 bars

Also, average number of drops/ cm^2 increases with working pressure with about 1209 drops/cm^{2}at the pressure of 2 bars, at 1923 drops/cm^{2}for pressure of 5 bars.

In figures 12 and 13 were represented variation between coverage degree and average number of drops, for the 4thsearched working pressures (from 2 to 5 bars) according to data within table 1.

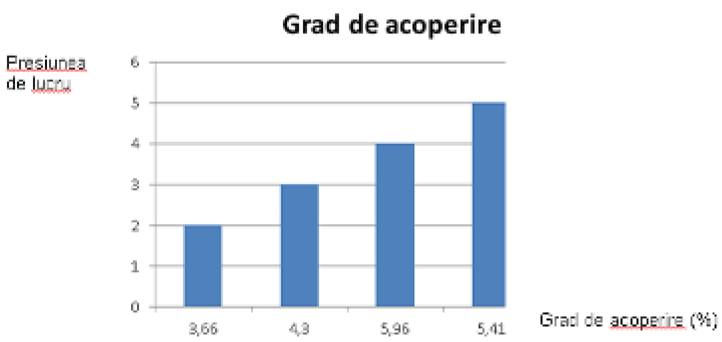


Fig. 12 - Coverage degree for average degree at the 4th working pressures

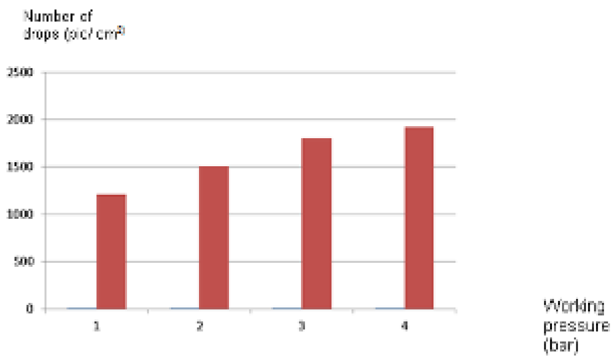


Fig. 13 - Number of drops for average values of the 4th working pressure

CONCLUSIONS

Obtained results of the experimental researches allow value establishing by which was study the quality of the applied phytosanitary treatments in field crops.

Analysing the data in tables and graphs resulting from experimental researches, some recommendations can be done, namely:

- for the researched nozzles type (d_{nozzle} = 2 mm), coverage degree increase with increasing the working pressure from la 2 to 5 bars, thus achieved works at maximum working pressure have an adequate coverage degree;
- coverage degree of the treated surfaces depend of the size and number of drops, by pressure increasing resulting a bigger number and thinner of drops with a better coverage degree.

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PELLETIZING TRANSFORMATION OF POULTRY MANURE INTO ENVIRONMENTALLY SAFE FERTILISERS
/
TRANSFORMAREA PRIN PELETIZARE A GUNOIULUI DE PASARE, ÎN ÎNGRĂŞĂMINTE SIGURE PENTRU MEDIU

Eng. Grigore I.*[1)], PhD. Stud. Eng. Sorică E.[1)], PhD. Eng. Danciu A.[1)], PhD. Eng. Sorică C.[1)], PhD. Stud. Eng. Muscalu A.[1)], Eng. Dumitru I.[2)], Eng. Caba I.L.[3)]
[1)]INMA Bucharest / Romania; [2)]Power Group International S.R.L. / Romania; [3)]S.C. Munax S.R.L. / Romania
Tel: 0721.505.338; Fax: 021/269.32.73; E-mail: ionica_grigore2001@yahoo.com

Keywords: *poultry manure, pelletizing, fertiliser, environment, cultures*

ABSTRACT

The present paper presents information on the use of poultry manure, its chemical composition as well as its transformation into bio fertiliser. In order to use poultry manure coming from farms, as natural fertiliser, an alternative would be to make a series of mixtures from this manure and solid agricultural biomass, in different proportions, to produce pellets. We also present some companies producing and merchandising fertilisers as pellets having poultry manure in their composition. Within INMA a pressing machine was made to obtain receipts for producing pellets from biomass mixed with poultry manure.

REZUMAT

În lucrare sunt prezentate informaţii cu privire la utilizarea gunoiului de pasăre, compozitia chimica a acestuia precum şi transformarea acestuia într-un îngrăşământ bio. In vederea utilizarii gunoiului de pasare rezultate de la fermele agricole, ca ingrasamant natural, o alternativa ar fi aceea de a realiza o serie de amestecuri ale acestuia cu biomasa agricola solida, in diferite proportii, in vederea producerii de pelete. De asemenea sunt prezentate unele firme care produc si comercializează îngrăşăminte sub formă de pelete având în compoziţie gunoi de pasăre. In cadrul INMA a fost proiectata si realizata o presa pentru obtinerea de retete in vederea fabricarii de pelete din biomasa in amestec cu gunoi de pasare.

INTRODUCTION

Poultry manure is an excellent bio fertiliser with rapid action and with an almost double content of nitrogen (N), phosphorus (P) and potassium (K), compared to manure [7].

Poultry manure (fig. 1) can be used either dry, or liquid, namely mixed with water. If applied dry, this type of bio fertiliser imposes a series of restrictions, because it raises soil acidity. The chemical balance of bio fertilisers obtained from poultry manure depends on the food given to them. As excrements can have high nitrogen content, it is recommended to let manure ferment long enough, for at least a year, before being incorporated in the soil where vegetables will be planted. Nevertheless, as nitrogen, in recommended amounts, is an excellent fertiliser, it is good to use a bed of sand, peat, dry ground or chaff, in order to reduce losses.

Fig. 1 – Poultry manure [13]

1,000…1,500 kilograms of bio fertiliser obtained from poultry manure is used per one vegetable hectare. The same amount is recommended in the case of fruit trees and shrubs. For vegetables, as marrow, kohlrabi or tomato, during the vegetation period, treatments with poultry manure under the form of suspension with water can be applied. More exactly, one kilogram of manure is dissolved in 4…6 litres of water to obtain a bio fertiliser.

Beyond the advantages, poultry manure used as bio fertiliser is a source of weeds. The poultry eat seeds that germinate after manure is put under furrow. Also, one should be careful also regarding the manure source that will be used as bio fertiliser. Poultry excrements coming from industrial complexes may contain drugs or heavy metals. Also, if the poultry were under treatment, the substances from these drugs will be transferred to the plants fertilised with bio fertiliser coming from the treated poultry, so it will no longer be bio at all [8].

Poultry manure storage

Poultry manure can considerably reduce its mineral value if not stored properly. The possibility of storing poultry manure reduces or eliminates entirely the need for collecting, removing and spreading it on a daily basis. Poultry manure would rather be applied in spring because it's just before the start of the cultivated plant vegetation period. Poultry manure should not be applied during periods of frost or if the soil is water-saturated, therefore periods of cold season (autumn, winter) will be avoided.

Poultry manure storage for a year has proved to be beneficial in situations in which soil humidity conditions are not appropriate for the application of poultry manure, this operation being carried out in spring before sowing. Transport and storage of solid poultry manure has certain advantages: smaller volume (solid material content is higher), fewer odours (activity of bacteria that produce odour is less intense in manure smaller water content), surface runoff has low intensity, nutrient retention capacity is higher.

The *advantages* of storing semi-liquid poultry manure are: smaller volume, the possibility to store it in tanks or special places under or on the ground with the possibility to reduce odours by covering, higher nutrient holding capacity, the collection possibility and hydraulic transport. The *major disadvantages* of these infrastructures are: odour spreading in case of using ground structures and possible leakage of polluting elements.

Solid poultry manure contains nutrients in amounts greater than the semi-liquid one. Bacteria proliferate in liquid manure, influencing processes of stabilization and treatment, but registering significant losses of nitrogen through volatilization than in the case of solid manure. If nutrients conservation is one of the priorities (large agricultural land area, high value crops), the type of structure that has the highest capacity for nutrient retention is chosen. If the farmland where poultry manure is applied is cultivated with cereals or technical plants, it is not recommended to spread poultry manure during the vegetation period [9].

In the Netherlands, the majority (89%) of poultry halls have storage facilities for a week, 10% for 1 year and 1% for up to 3 years (deep pit systems). Some egg production systems allow manure removal more frequently, almost every day. In the case of free systems, the poultry have access to outer space and excrements (manure) can be collected on this land [12].

MATERIAL AND METHOD

Poultry manure composition varies in time also due to the poultry farm type. On average one ton of fresh poultry manure contains approx. 499 litres of water, 9 kg of nitrogen, 7.25 kg of phosphoric acid and 3.63 kg of potassium. In this fertilizer the nitrogen is, usually, in the form of ammonium, which has in its composition fast-acting ferments. Therefore, poultry manure fertilization is easily carried out and without proper care. However, much of the nitrogen contained is lost as ammonia nitrogen. That is why poultry manure should not be mixed with wood waste, ash or usual lime because of the easily released ammonia, when coming into contact with an alkaline compound.

Poultry manure becomes an excellent fertiliser when mixed with compost or with an enriched soil, in proportion of 10 kg of poultry manure to 100 kg of soil. Applied after fermentation, it is capable of providing a fertilizer with high ecological value. [10]

Average chemical composition of manure of various origins is presented in table 1 [11]

Table 1 [11]

Manure	Chemical composition (%)					
	Water	N	P	K	Ca	Mg
Hen manure	56	0,7-2,5	1,5-2	0,8-1	2,4	0,7
Duck manure	53	0,8	1,5	0,4	1,7	0,3
Goose manure	83	0,6	0,5	1,1	0,6	3,3

The annual quantity that can accumulate is 6 kg per hen, 8 kg per duck and 14 kg per goose (average values) [8], while a broiler can produce about 4.9 kg of excrements in a typical lifetime of 48 days. [5]. Doses of 100 ... 150 g/m^2 garden, grinded, semi-dry or dry, incorporated into the soil are recommended [11].

RESULTS

In order to use the poultry manure coming from agricultural farms as natural fertilizer, a suitable alternative would be to mix it with agricultural solid biomass, in different proportions for producing pellets.

Pelleting is *a* granulating process based on dehydration, heating, crushing and eventually obtaining the pellets and cooling them. Fertilizer granular shape achieved by this paper's authors [5] was of approximately 4 mm per 3 mm and weighed about 30 mg per pellet. The cylindrical shape was of approximately 8 mm length, with a radius of 1.5 mm and weighed about 90 mg.

Although the known mobility benefit due to utilization of poultry manure, there is an adverse aspect impacting on health because of the arsenic presence in some of the pellets obtained from poultry manure in which foddering were introduced antibiotics and coccidiostats [5].

But, in [4] it is specified that drying and pelleting can importantly reduce the pathogen burden and content of antibiotics residues related to fresh manure. Fresh litter passes first through a drying tunnel at 250 °C, then is milled in a hammer mill, sieved, homogenized, after which the pellets are made in a press, obtaining granules of 5 mm diameter and 12...14 mm length. Pellets achieved by paper's authors [4] from chicken litter have a high content of N (5.2% as dry weigh, 80% as organic nitrogen), as well as of P and K (ratio of NPK being of 3.2: 1.0: 1.6), and product resulted meets all the current Spanish law regulations related to its marketing as organic fertilizer.

The paper [2] specifies the capability of active coal to absorb from the poultry manure the positive metal ions, such as copper, cadmium and zinc in a larger extent than their similar elements based on plants, such as carbon atoms made of bark of wood, coal waste or coconut shell when preserving the same processing system.

According to [3], for obtaining coal active granular, one can use the manure coming from turkey litter, except coal, peat, lignite, wood and coconut, shells, that are ones of many raw materials used up to present for activating carbon atoms.

Although the fact that coal active granular is widely used for waste water treatment, the carbon absorption is still remaining a costly process; thus, the paper [1] specifies the preliminary data related to carbon producing by chemical and physical activation during the pyrolytic conversion (rapid heating at approximately 400 °C, in an environment without oxygen) of chicken litter manure.

Pellets would represent a viable alternative to classical sources of natural fertilizer used for obtaining soil fertilization. They are natural product, obtained following a series of mechanical processes by which the solid biomass finely processed passes through compacting units and transformed in little high density cylinders of different size. Among the obvious advantages of pellets capitalization, we can observe: constant price, short distances transport, easy storing even as bulk state, without dust, having neutral olfactory characteristics, reduced volume of storage and diminished energy consumption.

Using different types of biomass, such as straw, leaves mixed with poultry manure coming from agricultural farms could be obtained pellets that subsequently will be used as natural fertilizer, especially in vegetable growing.

In paper [17] are specified pelleting equipment and systems designed to turn poultry manure into pellets, that can represent safe organic fertilizers for environment and be used by agricultural enterprises, independent farmers for fertilizing golf courses, lawns, gardens and landscape.

Poultry manure pellet technology was mainly used in order to agglomerate, agitate and transform fine powder in spherical or cylindrical granules. Following this process, the valuable nutrients and mineral substances coming from cereal fodder together with organic material and humus, are captured in order to produce a high importance organic fertilizer and obtaining major new incomes from a material considered as a waste up to now.

Pellets advantages:

- compost manure so that it ensures environment safety, being easily transported and stored on soils requiring conditioning and natural nutrients;
- reduce the need to use expensive fertilizers, being water-soluble and non-polluting the water courses and underground water sources;
- enable higher germination rates of seeds and plants growing;
- offer a complete and safe culture environment, which is welcoming for humans and animals and proper environment.

Therefore, a series of companies producing and marketing pellets made of poultry manure and agricultural biomass mixture, are existing on the market.

Authors of paper [6] emphasize how pellets are obtained (organic fertilizers) out of solid fraction of pig manure both using it alone and in combinations with sawdust, shavings and wheat straw (totally four variants), that were tested for making the difference between pellets physical and chemical features and their distribution characteristics on agricultural fields. They were compared to two organic pellet fertilizers usually available at retailers. Results have shown that in terms of physical and chemical features the biggest difference comparing to reference products used in this study, is given by granular distribution of pellets after their management, because pellets disintegration is less intense and their resistance at fragmentation is higher for the three sorts made of solid fraction of pig manure mixture (with 18% sawdust, 30% shavings and respectively 14% wheat straw content).

Pellets obtained from these mixtures were compared to two reference marketing products ("mixed manure" and "poultry manure") and the following chemical and physical characteristics were measured: - content of organic matter (OM);

- total Kjeldahl nitrogen (TKN);
- carbon: nitrogen ratio (C / N);
- moisture content (% raw material);
- bulk density (kg /m3);
- uniformity of distribution for three cumulative fractions with the following size intervals ("> 5 mm", "from 5 to 2 mm" and "<2 mm") for evaluating the spreading effect.

Any significant difference related to OM, TKN and C / N ratio between tested products and reference material has not been found.

S.C. Morami S.R.L. Company manufactures and trades homogeneous cylindrical-shaped pellets of 3-4 mm diameter and 5-7 mm average length, exclusively derived from mixing and humifying the selected manure (cattle manure and poultry dung) that was subject to a fermentation/ humifying process of 9 months.

Product has not been artificially dried (by using furnaces or warm air), because the « living matter » (microbiological flora) comprised in fertilizer can be destroyed and it does not reach anymore the soil to be fertilized.

The best results were obtained by spreading the fertilizer before the final preparation of field and incorporating it into the soil before sowing or planting; it has to be spread on the field and applied at a minimum depth of 2 cm and maximum depth of 15 cm; it may be similarly used in orchards, at 10…15 cm depth and 18…20 cm distance laterally to the fruit trees' row (fig. 2) [14].

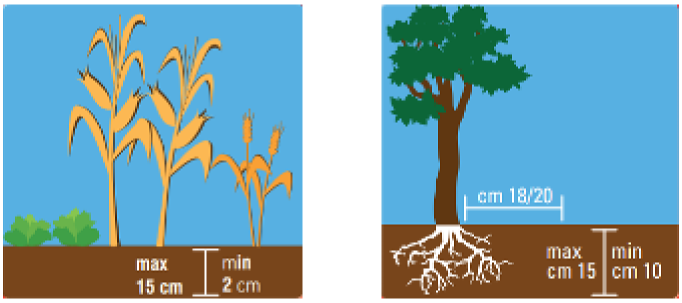

Fig. 2 - Fertilizer applying [14]

Average content of pellets' principal substances is shown in table 2:

Table 2 [14]

Characteristics	Values
Moisture	16…18%
pH (indicator)	6…7
Total organic nitrogen (N)	3…4%
Total phosphoric anhydride (P_2O_5) (from phosphates and phosphorus organic compounds)	3…4%
Total potassium oxide (K_2O) total	3…4%
Organic carbon of biological origin (C)	22…26%
Fulvic acid	9%
Humic acid	10%
C/N ratio	7/3
Micro-elements:	
Manganese (Mn)	350 mg/kg
Magnesium (MgO)	1%
Micro-organisms:	
Content of total of aerobic bacteria	2,164,000.000
Content of total anaerobic bacteria	1,715,000.000

Product is intended to all crops, being used especially in soil with high porosity (sandy) or heavy soils (clayey) presenting compacting risk.

In figure 3 is shown the fertilizer amount recommended for different cultures:

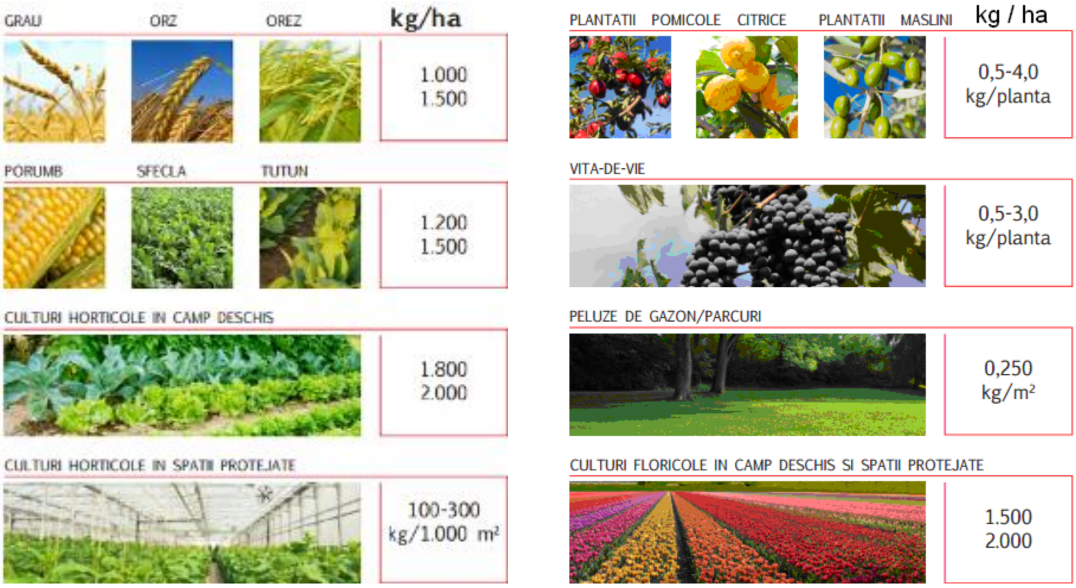

Fig. 3 - Recommended doses for different cultures [14]

Another company that merchandises organic fertilizers composed by organic mix of selected poultry manure (poultry excrements) as homogenous pellets is *SC MARCOSER SRL.*

Homogenous pellets of cylindrical shape, with diameter of 3...4 mm and length of 5...7 mm. Humus, ready to be used, exclusively from selected poultry manure mixing and humification (poultry excrements) which carried on fermenting/humification 7 days long [15].

A famous company is *Italpollina* which produces and merchandises organic fertilizers as pellets. (fig. 4)

Fig. 4 - Organic fertilisers (pellets)

Organic fertilizers include poultry manure, manure, peat, algae and humic acid. These contain all base elements which contribute to plant development (nitrogen, phosphorus, potassium, microelements), which decompose slowly and have a long lasting effect [16].

ITALPOLLINA product (4 N - 4 P_2O_5 - 4 K_2O) is the richest poultry fertilizer in: nutrients, humification organic matter (without impurities with a purity of 95%), useful microorganisms. The organic fertilizers have the following characteristics presented in Table 3:

Table 3 [16]

Characteristics	**Values**
Total nitrogen (N)	4%
Phosphorus pentoxide (P_2O_5)	4%
Potassium oxide (K_2O)	4%
Water-soluble magnesium oxide (MgO)	0,5%
Biological organic carbon (C)	41%
Other properties	
Humidity	12%
pH	7
Specific weight, kg/l	0,74
Shape	pellets

In figure 4 is presented a pressing machine for obtaining receipts in order to process biomass pellets in mix with poultry manure. For this purpose were used a plane disc-like matrix having cylindrical channel with a diameter which may be between 4 ... 8 mm (fig. 5).

The channels have a special configuration to facilitate the pressing material process. Cutting pellets out of the matrix and their discharge through the outlet, the device consists of two blades mounted on the axis of rotation.

Fig.4 - Pellet pressing machine

Fig. 5 – Pellet matrix

CONCLUSIONS

In quite broad terms regarding to the component percentage may be obtained pellets compose of poultry manure mixed with various solid biomass and (or) binders, constituting an alternative to capitalization poultry manure as fertilizer in agriculture. By pelleting it is maintain the chemical composition of poultry manure, transporting, storing and preserving easily take place.

Drying and pelletizing can significantly reduce pathogen load, and the residues of antibiotics to fresh manure, showing pellets with high contents of N, P and K (NPK ratio is 3.2 / 1 / 1.6). Pellets obtained are free of dust and have neutral olfactory characteristics, being suitable for all crops.

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INNOVATIVE METHOD OF IMPLEMENTING THE ALGORITHMS FOR PROCESSING IMAGES IN PRECISION AGRICULTURE
/
METODA INOVATIVA DE IMPLEMENTARE A ALGORITMILOR DE PRELUCRARE A IMAGINILOR IN AGRICULTURA DE PRECIZIE

PhD. Stud. Eng. Gheorghe G., PhD. Stud. Eng. Persu C., PhD. Eng. Matache M., PhD. Eng. Mateescu, M., PhD. Stud. Eng. Cujbescu D.
INMA Bucharest
Tel: 0731583104 E-mail: gabrielvalentinghe@yahoo.com

Keywords: *intelligent, hoeing, images recognizing method*

ABSTRACT

This paper presents general aspects and a comparison between two smart cameras; the first one is black-and-white and the second is a colour camera. Recognition and processing of images algorithm depends on colour, shape or position. If the first uses shape to recognize and make the difference between weed and plant, the second uses the difference of colour pixels to make that difference. The paper also includes the stages of algorithm realization and implementation for images processing and recognition.

REZUMAT

Articolul prezintă aspectele gerelae si o comparatie dintre doua camera inteligente, prima este alb si negru si a doua este color. Recunoasterea si procesarea algoritmului de imagini se face in fuctie de culoare, forma sau pozitie.Daca prima foloseste forma pentru a recunoaste si a face diferenta dintre buruiana si planta, a doua foloseste diferenta de pixeli a culorilor pentru a face diferenta. Lucrarea de asemenea include etapele realizarii si implementarii algoritmului pentru procesarea si recunoasterea imaginilor.

INTRODUCTION

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and after that it destroys the weed. It is based on two intelligent cameras; the first one is black-and-white and the second is colour, endowed with internal memory card able to store the software steps and it has integrated controller aiming to achieve images processing operations. Each camera surveys two rows of culture and digitally transmits the commands obtained after processing the images, to a logical programmable controller (PLC).The experiment was performed on lettuce (Fig.1) at INMA Bucharest.

Fig.1 - Image from experiment filed with IHE 1) black-and-white camera 2) colour camera

Among the new farming technologies, we must mention the GPS automated guide, fields mapping, aiming to obtain maps with soil features (such as, soil electro-conductivity, PH, nutrients quantity, etc.) which should be used by specialists to obtain a high-performance management of cultures, the use of intelligent algorithms for recognizing images of crops' weed percentage level, for evaluating the crops' health degree, aiming to identify possible pests attack, ensuring a sustainable management of sprinkling, etc.

In figure 2 is presented the experimental model of intelligent hoeing equipment - IHE, produced by INMA Bucharest.

The intelligent hoeing equipment, three-point mounted in front of the tractor, will be traveling in crops with weeds. Through the light sensor, intelligent camera type and the recognition methods implemented in this, the intelligent system will differentiate the weeds from the plants and will command the knives on plant rows, via electric actuators, to destroy the weeds. To guide the tractor, an agricultural GPS is used. The correlation of the working knives position with the light sensor location will be done through a speed sensor mounted on the equipment wheel.

Fig. 2 – Experimental model IHE
(1–frame, 2 – hoeing section, 3 – wheels of displacement and working depth adjusting, 4 – cameras supports, 5 – cameras, 6 – parking foot)

MATERIAL AND METHOD

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and their latter destruction. It is based on two intelligent cameras, endowed with internal memory card able to store the software steps and have integrated controller aiming to achieve images processing operations.

Each camera surveys two rows of culture and digitally transmits the commands obtained after the images processing, to a programmable logic controller (PLC). PLC achieves the synchronization of cameras with the moving speed of the tractor and with the state of the four electric linear actuators, driving the equipment knives.

PLC also commands the opening and closing of actuators in weed areas, by transmitting digital signals to controllers. Interface between technical equipment, intelligent control system and the operator is made by an operation terminal with touchscreen. By the intermediary of touchscreen, the operator can obtain the start-stop functioning commands of TE, monitor the actuators, number the crop plants and assess the weed level.

At the same time, it can guide the technical equipment by means of a GPS, so that it achieves the optimum crop maintenance, without surpassing the distance between rows and destroying the plants. Cameras are designed by National Instruments company aiming the industrial screening installations and using algorithms for images detection.

Image processing represents the process of modifying the properties of images in order to extract relevant information to the user. Evolution of computerized imaging technology allowed the implementation in a large number of fields, including agriculture.

There are several methods of image processing, such as:

Image restoration aims to eliminate distortions which affect the image distortion due to known physical phenomena, mathematically modelled or estimated.

Image segmentation realizes separation of uniform regions of interest in the image. Uniformity is a general concept; it does not reduce the consistency of grey levels (the same texture, the same properties, etc.).

In the case of computer graphics, it starts from a description of the image, aiming in the most general case a synthesis of a realistic image. Obtaining the realistic image is translated by a sequence of algorithms that "closes" the image synthesized from the real one.

Contour filling algorithms perform the complementary operation to contour extraction, while expansion is complementary to thinning operation.

2D reconstruction restores plane section of the body studied from a set of 1D projection in different directions of the section. Having available several such sections (parallel or radial) of the studied body, its 3D reconstruction can be achieved. The reverse is called 2D projection.

Shape recognition is a commonly used way to extract information from images acquired. It is a broad field that includes handwriting recognition, human face recognition, fingerprint recognition, etc. Shape recognition consists in a classification and / or a description of the image content.

RESULTS

The method for recognizing the images proposed consists in performing the following operations:

- sequences of images, in real time, taken directly from the field. This operation will be continuously performed by intelligent camera, with acquisition frequency adjusted by the user, each image being subsequently analysed by performing the operations below.

- storing images for a subsequent analysis. This operation is optional, allowing to user to estimate the crop weeds level and, after that, the necessary maintenance works.

- dividing the image in interest areas. The final purpose of this operation is to use a sole intelligent camera for monitoring two rows of crop simultaneously or to perform maintenance works of several crop types with plants of different growing stages.

- identifying the distinct objects from images (soil, stones, plants, etc.). This operation will be made by numbering the pixels suitable to each different object, depending on the grey tone intensity of each pixel, taking for reference a scale introduced by the user.

- identifying the space between crop plants.

- PLC gives the command according to the existence/non-existence of crop plants. In this stage, the digital command will be given within the range of 0-24Vcc to digital input of PLC, in order to drive the mobile knife arm of the multifunctional technical equipment designed to mechanical maintenance in row and between plants of agricultural crops.

Operations described above are performed by making the following steps (described in the software of Vision Builder AI):

Images are taken in sequences, with 640x480 pixels resolution. Images acquired are stored in the internal memory of the camera. The number of images (frames) the acquisition is made with may be adjustable, according to the exposure time, light and sensor amplifying - figure 3, and with colour camera figure 4.

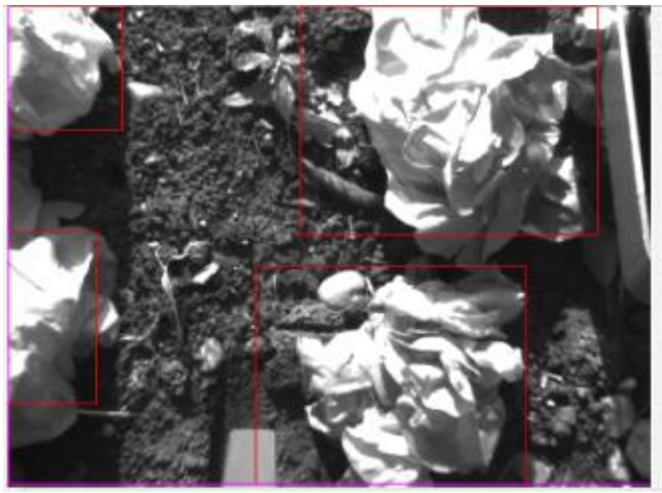

Fig. 3 - Real-time image acquisition with black-and-white camera

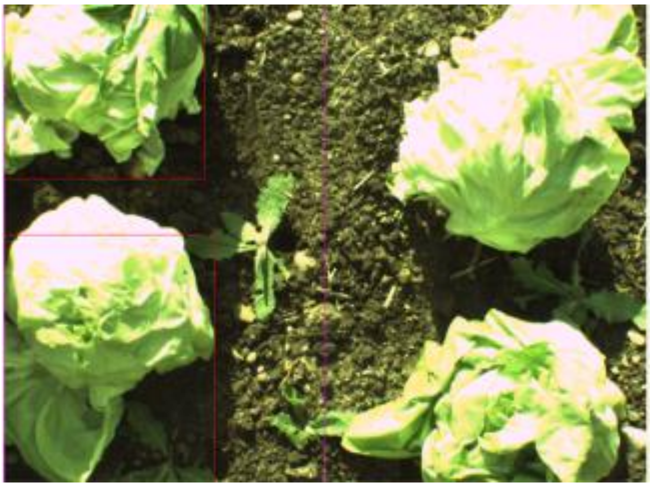

Fig. 4 - Real-time image acquisition with colour camera

There are identified the interest objects from image lower part, by numbering the pixels of a certain intensity, appropriate to the respective object (crop plant, weed, stone, etc.). In figure 5 these objects are in the left row identified with black and white camera, while in figure 6 they are in the right row.

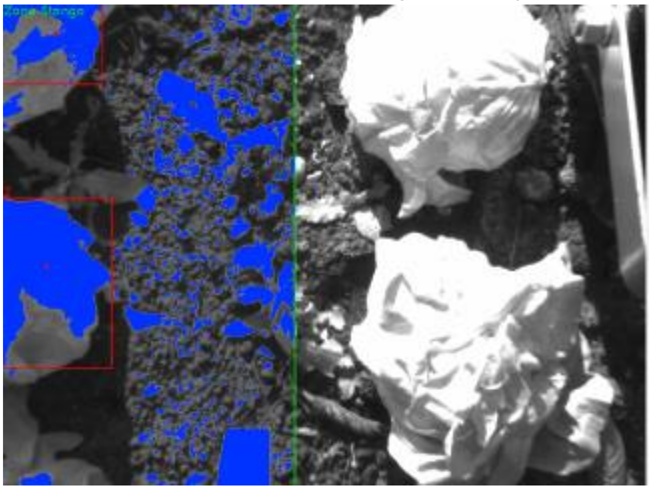

Fig.5 - The interest objects from the left row with black-and-white camera

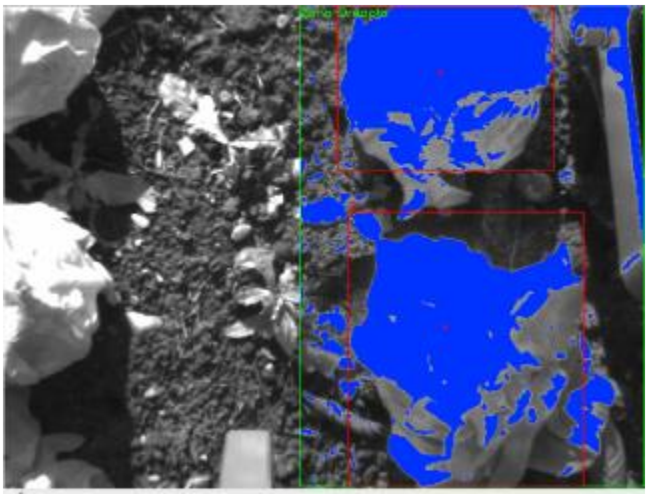

Fig.6 - The interest objects from the right row with black-and-white camera

The program identifies the row and makes the acquisition from 2 rows. In the next step, the objects area surpassing 10000 squared pixels is identified (this number can vary according to the crop plant and its average surface at the plant growing level suitable to performing crop maintenance), for image lower part.

The area of weeds location is framed in red, in figure 7, in the left row and, in figure 8, in the right row with colour camera, the gap between them representing the field that requires to be worked.

Fig.7 - The area of weeds location with colour camera in the left row

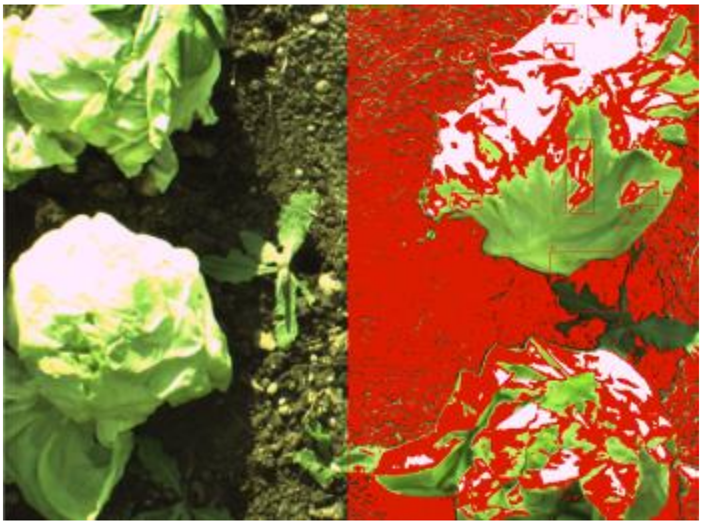

Fig. 8 - The area of weeds location with colour camera in the right row

During the final step, the output channel, by means of which the signal is sent to PLC, is set as well as the conditions of transmitting it.

CONCLUSIONS

Agricultural research played an important role in order to increase production and the most efficient exploitation of the existing resources, taking into account that the planet's population is constantly growing and exploited agricultural fund is limited and with clear trends of deterioration.

The development of precision farming is one of the main priorities for the development of crops with productivity that satisfy the market demands, in environmentally friendly conditions and with minimal resource consumption. The colour camera is better than the black-and-white one since the number of pixels gives higher accuracy.

ACKNOWLEDGEMENT

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CONSIDERATIONS ON THE USE OF OZONE WITHIN DIFFERENT DECONTAMINATION PROCESSES
/
CONSIDERAŢII PRIVIND UTILIZAREA OZONULUI IN CADRUL DIVERSELOR PROCESE DE DECONTAMINARE

PhD. Eng. Sorică C., PhD. Stud. Eng. Sorică E., PhD. Stud. biol. Pruteanu A., Eng. Grigore I., PhD. Eng. Brăcăcescu C., PhD. Stud. Eng. Muscalu A., Eng. Epure M., PhD. Stud. End. Găgeanu I.
INMA Bucharest
Tel: 0728.045.004; Fax: 021/269.32.73; E-mail: cri_sor2002@yahoo.com

Keywords: *oxidising agent, decontamination, ozone, industrial processes*

ABSTRACT

In the decontamination methods, ozone decontamination has great potential. This is a strong oxidising agent with a long history of safe use in disinfecting municipal water, process water, bottled drinking water and swimming pool water. Various processes using ozone technology has penetrated in our country in recent years, the latest applications including the treatment of wastewater, hospital water systems and equipment, aquariums and aquaculture, etc.

The paper presents some of the achievements of renowned companies in the field of ozone decontamination installations both at international and national level.

REZUMAT

In cadrul metodelor de decontaminare, un potential deosebit il are decontaminarea cu ozon. Acesta este un agent oxidant puternic, cu o lunga istorie de utilizare în condiţii de siguranţă în dezinfectarea apei municipale, apei de proces, apei potabile îmbuteliate şi piscinelor. Tehnologia utilizarii ozonului in diferite procese a patruns si in tara noastra in ultimii ani, aplicaţii mai recente incluzand tratamentul apelor uzate, sistemelor de apa si echipamente din spitale, acvarii şi acvacultura, etc.

Lucrarea prezintă câteva din realizările unor firme de prestigiu în domeniul instalaţiilor de decontaminare cu ozon atât pe plan intern cat si pe plan extern.

INTRODUCTION

Ozone is a powerful oxidising agent with a long history of safe use in disinfecting municipal water, process water, bottled drinking water and swimming pool water. Latest applications include the treatment of wastewater, hospital water systems and equipment (*Davies et. Al., 2010; Sharma and Hudson, 2008; Moat et al., 2009*), aquariums and aquaculture, water theme parks, etc.

The discovery of ozone is attributed to Schonbein, around 1840. He presented his discovery at the University of Munich and was the first person who studied the mechanism of ozone and organic materials. The first installation using ozone was produced in the Netherlands, in 1893. In 1916 there were already 49 ozone installations in Europe. After World War II, this method of disinfection was used again so that in 1985 the number of installations was over 2000.

More wide-scale use of ozone was boosted by the difficulties of eliminating organic pollutants in surface waters - these compounds appear to be oxidized by ozone faster than chlorine or its compounds. In 1982, ozone was classified as a product generally recognized as safe (Generally Recognized as Safe - GRAS) (Rice, 1999) and in 2001, the Food and Drug Administration (US FDA) approved its use as an antimicrobial agent in food products (*Federal Register, 2001*).

Unlike other antimicrobial chemical agents, ozone does not generate residues, decomposing completely in diatomic oxygen in periods between 2 and 30 minutes.

Ozone is considered the most powerful oxidant known. The supplemental oxygen radical in ozone molecule rapidly binds to each of the components coming into contact with the ozone molecule. Thus, can be oxidised organic materials, inorganic (oxidation) or microorganisms such as viruses, bacteria or fungi.

Ozone properties

Table 1 presents physico-chemical properties compared to oxygen ones:

Table 1

Properties	Ozone (O_3)	Oxygen (O_2)
Molecular weight	48	32
Colour	Blue	Colourless
Solubility in water at 0 °C	0.64	0.049
Density (g/l)	2.144	1.429

Table 2 presents the halving time of gaseous ozone and ozone dissolved in water:

Table 2

Gaseous ozone		Ozone dissolved in water	
Temperature [^{0}C]	Time	Temperature [^{0}C]	Time [minute]
-50	3 months	15	30
-35	18 days	20	20
-25	8 days	25	15
20	3 days	30	12
120	1,5 hour	35	8
250	1,5 seconds		

Table 3 presents ozone oxidation potential compared to different reagents oxidation potential.

Table 3

Oxidising reagent	Oxidation potential
Ozone	2.07
Hydrogen peroxide	1.77
Permanganate	1.67
Chlorine dioxide	1.57
hypochlorous acid	1.49
Chlorine gas	1.36
Oxygen	1.23
Bromine	1.09
Hypochlorite	0.94
Chlorite	0.76
Iodine	0.54

Ozone solubility is very high. At 25 ° C, ozone solubility is 109 mg/l and the solubility of oxygen is 8 mg/l. Ozone is 13 times more soluble than oxygen.

MATERIAL AND METHOD

Because short lifetime, ozone is always generated where it is used with an ozone generator. There are two methods for ozone production: by UV radiation and by Corona discharge.

Ozone generation by Corona discharge is currently used more and more, being more advantageous in terms of ozone generation equipment lifetime and lower costs. UV radiation can be used when small amounts of ozone are required, for example in laboratories.

Currently, the ozone is used in the following main fields: swimming pool water treatment, drinking water disinfection, water treatment in cooling towers, treatment of the water used in industrial laundries (hotels, hospitals, etc.), cleaning of industrial installations, surface hygienisation, fruit and vegetable washing and processing, fruit and vegetable storing etc.

Among the effects of ozone use in various applications, we mention:

- destroys viruses and bacteria;
- oxidises organic compounds;
- oxidises heavy metals (iron and manganese);
- eliminates water colour (as for example the yellowish colour generated by tannin);
- eliminates water smell (caused by hydrogen sulphide);
- eliminates odours in the air;
- eliminates the smell of smoke and the one of fire and burnt;
- destroys pathogens: E-coli, Listeria etc.;
- destroys mould and mould spores;
- destroys fungi.

Due to its ability to destroy microorganisms without addition of chemicals, ozone can be used both in processing as well as in storing food.

The benefits of ozone in the food industry can be summarized this way:

- improves product taste and appearance;
- decreases the number of microorganisms and ensures a longer period of validity;
- destroys pesticides and residues;
- destroys the risk of cross-contamination with pathogens;
- doesn't leave chemical residues and final products don't require final rinsing;
- is natural and it can be used in organic food production.

Usually, fruit and vegetables may have, on their exterior surfaces, a number of microorganisms that can cause various diseases during post-harvest period, reducing the term of validity and that can also cause serious health problems. Under these conditions, simple rinsing doesn't sterilize adequately against mould and bacteria.

Ozone is an extremely strong germicide, with a broad action area that leads to the eradication of microbiological activity. Ozone fumigation is an effective way to eliminate plant and animal pathogens, with exceptional results in purifying water, beverage, aquaculture, aquaristics, horticulture and food storage. This treatment showed the extension of vegetable and fruit storage period, by removing from their surface the bacteria producing spoilage.

Ozone can oxidise and decompose traces of insecticides, fertilizers, hormones, antibiotics in vegetables, fruit, fish, meat, eliminates colon bacilli, streptococci, dysentery bacilli, A and B hepatitis viruses, as well as other bacteria and viruses harmful to the human body. Penetrating power of ozone in vegetables, fruit, fish and meat up to 5-10 cm (antibacterial and disinfecting effect reaches up to 99.5%), ensuring in the same time freshness, hygiene, food safety (particularly for vegetables, fruit, mushrooms, fish, meat) so that the structure of food nutrients be preserved.

In the food industry, ozone is used in advance in the disinfection process of the air inside the storage precinct. For this purpose it is necessary to use a sufficient reagent amount for the destruction of microorganisms. It should also be taken into consideration the amount of humidity that may be present and the reaction against the wall surface in ozone gas decomposition process.

These two processes require an optimal distribution of ozonated air circulation in the storage ozone and the ozone generator must also have sufficient capacity to ensure the necessary equilibrium concentration. Also, the storage space must be tightly sealed. During the storage process, the ozone has a complex action by destroying microorganisms, removing odours, oxidation of organic substances and by involving in metabolic processes.

The purpose of using ozone does not lie in masking existing odours, but in destroying the sources generating them. Following ozone decomposition, atomic oxygen rapidly oxidizes the volatile substances as odour source. A fall in temperature also decreases the oxidation rate. To neutralize odours, it is enough to have a concentration between 0.01 and 0.04 ppm in the storage space air.

Ozone excess auto-decomposes rapidly and produces oxygen leaving no residues and it is active against all forms of microorganisms at a relatively low concentration.

Together with increasing the temperature, ozone becomes less soluble and less stable, but the speed of reaction with the substrate increases.

Related to pH, the degree of microbial inactivation remains effectively unchanged for values between 5.7 and 10.1. The efficiency of ozone decreases with alkaline pH.

Ozone concentration level is determined through physical, physico-chemical and chemical methods. Physical methods measure the direct absorption in the UV, in the visible or infrared area of the spectrum. Physico-chemical methods are related to heat and chemiluminescence effects caused by the reaction. Chemical methods measure the resulting products when ozone reacts with a chemical agent such as potassium iodide.

Ozone is an antimicrobial that has a strong action against bacteria and fungi viruses. Bacteria inactivation using ozone is a complex process because the ozone attacks many cell compounds, even proteins, unsaturated lipids and enzymes in the cells, enzymes and nucleic acid in the cytoplasm etc.

RESULTS

Ozone has been evaluated previously for controlling various illnesses occurred during post-harvest and for other uses, especially during storage (removes ethylene, purifies the air, removes odours) (*Graham*, *1997; Kowalski, 1998; Kim et al., 1999a; Kim et al., 1999b; Kim and Yousef, 2000*). Some commercial uses were recorded for some products such as apples, cherries, carrots, onions and potatoes. There is an increasing interest in assessing the ozone applied to the process water and air, in the post-harvest treatment processes.

In recent years, the technology of using ozone in different household or industrial processes emerged also in our country, mostly within companies distributing such equipment produced by internationally well-known firms. Household applications especially refer to the purification of drinking water and washing the vegetables and fruit with ozonated water. Industrial applications using the ozone technology are related to purification of water in the treatment plants, disinfection of air in social destination spaces (hospitals schools, sport halls) and precincts destined to food industry (stores of fruit and vegetables, processing rooms etc.).

At world level, a series of companies manufacturing ozone generators (WEDECO – Germany, Ozone Solution – USA, Oxyzone – Australia etc.) that have been successfully used in applications such as smell control (in hospitals, hotels, smell caused by fire and floods etc.) and microorganisms (sterilization of drinking water, process water or swimming pool water, disinfection of production plants, storing rooms and packages used in food industry etc.).

Oxyzone Pty Ltd Company, Australia, produces equipment generating ozonated water for different purposes and equipment that generates ozone gas for use in various storage facilities. *Total Ozone System* (fig. 1a) equipment delivers ozonated water directly to the work area. Among the equipment main components are:

Total Ozone System (fig. 1a) equipment delivers ozonated water direct to the work area. Among its main components are: ozone generator by Corona discharge, own storage tank, pump, injector and degasifier. Ozone generators in *Silver Harvest* (fig. 1b) range produce ozone gas using UV radiation, are ideal for cool rooms and can be operated independently or centrally controlled.

a.

b.

Fig. 1 – Equipment produced by Oxyzone Pty Ltd [13]

a - Total Ozone System; b - Silver Harvest

Ozone Solutions Company, USA, produces a large range of industrial ozone generators (fig. 2), with a capacity of 10 to 600g per hour, with an ozone dosage rate between 1.5 and 17.6 ppm.

a. b. c.

Fig. 2 - Equipment produced by Ozone Solutions [14]

a – Waterzone System; b – Waterzone SE System; c – Waterzone IS System

Wedeco Company, **Germany**, currently a brand of Xylem Company, USA, produces *Wedeco SMOevo* ozone generators, which combines maximum flexibility and reliability for small and medium capacities of ozone production. The ozone generator system and the control unit can be combined and supplemented with a large range of options allowing projects specific customization for almost all applications.

Xylem's Wedeco SMOevo ozone generators, represent a completely integrated system capable of producing 400g to 25kg of ozone per hour.

Wedeco SMOevo generators (fig. 3) are equipped with a PLC system for internal control and monitoring of the ozone generating system. The local interface panel ensures that operators can easily and quickly access system parameters and control elements that are vital to the operation of an ozone generator. The air conditioning system separates the electrical components from the ambient air and ensures protection class IP 54.

Fig. 3 - ***Wedeco SMOevo*** **Generator [17]**

Ozone Tech Systems Company, Sweden, produces ozone generators (fig. 4), in ranges ACT, FTX, ICT and DCT, made of stainless steel having capacity of production of gaseous ozone, with 0 and 5000 g/hour production capacity.

Ozone generators within the range DCT (fig. 4d) *are based on* a modular approach which make their maintenance easier, have a monitoring system PLC, three internal connections for oxygen, ozone and cooling water and two connections supplying electric energy and providing signals.

Ozone generators within ICT range (fig. 4c) are also built from stainless steel and their parameters are controlled by a microprocessor and the errors are shown by a relay that can be connected to an external interface. Production of ozone can be initiated manually or by means of an analogue signal of 4-20 mA.

a. b.

c. d

Fig. 4 Ozone generators manufactured by OzoneTech Systems company [15]

a – Range ACT; b –Range FTX; c – Range ICT; d – Range DCT

BiOzone Corporation Company, USA, is manufacturing ozone generators made of high quality materials, efficient in treating water and air. *Series BIO2000-S* with compressed air or oxygen supply (fig. 5) has the following characteristics:

- is manufactured from stainless steel and borosilicate glass;
- allows a pressure of cooling water up to 10 bar;
- allows a gas pressure up to 3 bars;
- condensing jacket with water is thermally insulated against condensing water forming;
- unit of air drying is integrated in ozone generator's unit;
- control of ozone production is automatically performed;

Fig. 5 - Generator of ozone BiOzone [11]

Primozone Company, Sweden, produces generators of ozone from *series GM* (fig. 6), built of steel and aluminium based on a state-of -the art technology allowing to produce high concentration ozone at a very big output pressure. Ozone generators of *series GM* are energetically efficient, do not require maintenance, and have a low cost.

Fields of application for these types of ozone generators are: food, medicine, swimming pools, water cooling tower, textile industry, aquaculture, etc.

Fig. 6 – Ozone generators from *GM* range [16]

a – Primozone GM18; b – Internal view GM 48; c – Primozone GM 3

In our country, the concerns in the field of research and manufacturing of equipment that use these technologies in used water treatment and decontamination of food storing spaces, have been identified at **S.C. I.C.P.E. Bistrita S.A Company.** This company is manufacturing *container stations of producing drinkable water using ozone*, comprising ozone generators through Corona effect, of different capacities (fig. 7).

Fig. 7 – Ozone generators of small and medium capacity [12]

INMA Bucharest has designed an *equipment of decontamination using ozone in aqueous solution-EDO* (fig. 8), aimed at the post-harvesting treatment technology of fresh horticultural products to be consumed and at decontaminating the products' external surface prior to post-harvesting treatment with UV-C and temporary storage.

Equipment of decontamination using ozone in aqueous solution is based on certain technical solutions that allow to homogenously applying ozone on products external surface. In order to ensure various exposure times and implicitly to apply the ozone quantities depending on the product subject to decontamination, the equipment enables to change the working regime.

Among the main elements of the equipment of watery solution ozone decontamination, the following main assemblies may be mentioned:

- Frame;
- Transport system;
- Collecting mass;
- Feeding tank;
- Ozone treatment tunnel;
- Collecting basin;
- Ozone evacuation system;
- Ozone generating system;
- System of aqueous solution ozone spreading.

Fig. 8 - Equipment of aqueous solution ozone decontamination – EDO

Equipment main technical characteristics are:

- Ozone generator: Corona discharge type;
- Capacity of producing ozone: 0.5 – 3 g O_3/h;
- Concentration of diluted ozone: 1 – 2 ppm;
- Minimum pressure of input water: 1.5 bars;

Equipment working process

Horticultural products charged in the feeding tank reach the driving rollers where they are subject both to an advance movement and a rotation movement around a perpendicular axis to the forward direction. Therefore, the products external surfaces are continuously and homogenously subject to aqueous solution ozone, applied by means of conical distribution nozzles with square print on target surface. The aqueous solution used is collected into the basin and then spilled over outside. The gaseous ozone coming from the used solution will be evacuated by means of the evacuation system made of a metallic filter for retaining the eventual water vapours driven by air current, tubes and aspiration fan. After being removed from the installation, the products arrive at the collecting table from where they are manually charged in boxes, after which they are subject to UV-C decontamination.

CONCLUSIONS

In recent years, the technology of using ozone in different household or industrial processes emerged also in our country, mostly within companies which are marketing such equipment already manufactured by internationally well-known enterprises. Household applications especially referred to the purification of drinking water and washing the vegetables and fruit with ozonated water. Industrial applications using the ozone technology are related to purification of water in the treatment plants, disinfection of air in social destination spaces (hospitals schools, sport halls) and precincts aimed to food industry (stores of fruit and vegetables, processing rooms etc.).

Ozone was previously evaluated for monitoring the different diseases appeared in post-harvesting period and also in other purposes, especially at storing (it removes ethylene, purifies the air, removes bad smells). Commercial utilization was observed for a few products, such as apples, cherries, carrots, onion and potatoes. Nowadays, there is an increasing interest for evaluating the ozone applied to process water and air, within the post-harvesting treatment processes.

In Romania, S.C. I.C.P.E. Bistrita S.A company is being concerned of studying and manufacturing equipment for treating the used water and decontaminating the storing spaces aimed to food products.

At world level, a series of companies manufacturing ozone generators (WEDECO – Germany, Ozone Solution – USA, Oxyzone – Australia etc.) successfully have used them in applications such as smell control (in hospitals, hotels, smell caused by fire and floods etc.) and micro-organisms (sterilization of drinking water process water or swimming pool water, disinfection of production plants, storing rooms and packages used in food industry etc.).

ACKNOWLEDGEMENT

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SUPERIOR CAPITALISATION OF SOYBEAN SEEDS IN ANIMAL FEED USING DRY EXTRUSION PROCESSING OF SEEDS
/
VALORIFICAREA SUPERIOARĂ A SEMINŢELOR DE SOIA ÎN HRANA ANIMALELOR UTILIZÂND PRELUCRAREA PRIN EXTRUDARE USCATĂ A SEMINŢELOR

PhD.Eng. Păun A.*, Eng. Milea D. Eng. Ionita Gh., PhD.Eng. Gageanu P., PhD.Eng. Brăcăcescu C., PhD.Eng. Nedelcu A.
INMA Bucharest / Romania
E-mail: ani_paun@yahoo.com

Keywords: *soybeans, extrusion, processing, animal feed*

ABSTRACT

Soybean seeds are an important raw material source both for animal feed and human nutrition. Soybean and grit represent the vegetable protein with the highest crude protein content and the most balanced amino acid content. This paper presents the technology for dry extrusion of soybean seeds - process that occurs due to the high oil content of seeds and its main parameters. In conclusion, the extrusion technology is one of perspective and high efficiency processes, combining hydrothermal and mechanical processing of raw material – soybean seeds, allowing new-generation products and components with predetermined properties, with a new structure, to be obtained.

REZUMAT

Seminţele de soia reprezintă o sursă importantă de materie primă atât în hrănirea animalelor, cât şi în alimentaţia omului. Soia şi şroturile reprezintă proteina de origine vegetală cu cel mai mare conţinut în proteină brută şi cel mai echilibrat conţinut în aminoacizi. În lucrare este prezentata tehnologia pentru extruderea uscată a seminţelor de soia - proces care are loc datorită conţinutului mare de ulei din seminţe precum si principalii parametrii ai acesteia. In concluzie, tehnologia de extrudare este unul dintre procesele de perspectivă şi de înaltă eficienţă, care combină prelucrarea hidrotermică şi mecanică a materiei prime- semintele de soia, permiţând obţinerea de produse şi componente de generaţie nouă cu proprietăţi prestabilite, cu o structură nou.

INTRODUCTION

The increase of livestock production is directly linked to a complete nutrition, at a low cost level and occupies an important place in the agricultural sector of our country. According to several literature works (*Jim Kaput, Raymond L. Rodriguez, 2006*), satisfactory results in livestock breeding depend largely on the use of good quality fodder (use of local feed materials, respectively cereals: corn, barley, wheat, soybean (soy grit), sunflower grit, etc.), on the functional quality of equipment and facilities for their production, processing, distribution, on the feed recipes used and the quality staff involved in the production process (*Halga P. et al., 2005* - Nutrition and animal nutrition, *Ciobanu et al., 2016*). Nowadays, animal nutrition is perceived as an area with multiple connections in biological sciences and beyond, with a share of over 60% in the cost price of livestock production, with a huge impact *on the livestock sector, the animal and human health status and the environment protection*.

The need to modernize agriculture and its related areas, namely livestock sector, finding new technologies and advanced, intelligent technical equipment solutions that would cope with beneficiaries' demands, increasing transformation efficiency; optimizing food products, reducing losses of raw materials processing in the food chain as well as quality and safety requirements imposed by the European Commission, are more and more intense preoccupations of research in livestock field.

Progresses in livestock field have shown that fodder rations containing soybean may be supplemented with vitamins eliminating the need for adding animal protein in the ration and soy grit is an important protein component in animals fodder ration, in particular pigs (. For our country, soy grit is also a key source of protein, being a basic component, along with cereals, in mixed fodder structure.

Currently, by producing top machinery, there is the possibility to obtain the two types of soy grit (of peeled and unpeeled soybeans) as well as "full fat" soybean product by processing soybeans without extracting the oil. Taking into account the importance of knowing extrusion processing of soybean seeds, this paper presents concentrated fodder processing methods, the extrusion technology to obtain feed ingredients, the main parameters and the advantages of using it.

MATERIALS AND METHODS

Fodder processing technologies are based on the livestock requirements for each type of fodder according to its destination. Among these technologies a large range of machines are used starting with the simplest ones and ending with complex equipment running several technological operations.

As presented in figure 1, (*Păun A. et al., 2006*) concentrated fodder processing methods are divided into four categories: mechanical, thermal, chemical, biological.

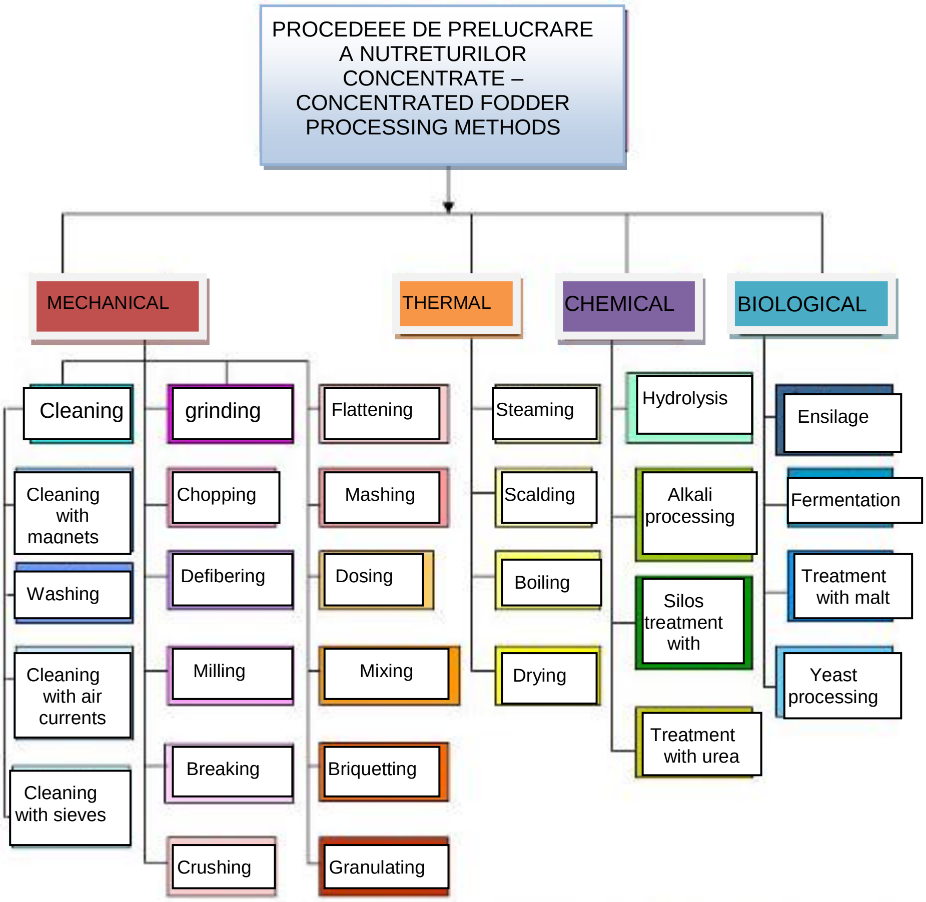

Fig. 1 - Concentrated fodder processing methods [8]

Equipment and installations used to obtain fodder must satisfy the following conditions:

- be universal, in order to be able to process as many kinds of feed and for as many animal species;
- allow easy operation and maintenance;
- have great working capacity and energy consumption as low as possible;
- machine parts that come into contact with the product do not affect its quality;
- ensure products processing according to the requirements of animal feeding process.

Extrusion technology is one of the perspective and high efficiency processes, combining hydrothermal and mechanical processing of raw materials – soybeans, allowing obtaining new-generation products and components with predetermined properties, with a new structure: instant products. In the case of extrusion processing of raw material containing starch and protein compared to traditional technologies there is a number of advantages:

- products ready for consumption or components are obtained, having high capacity of water and fat retention;
- the degree of assimilation and utilization of the raw material is higher;

• the degree of raw material microbial contamination and neutralization of thermosensitive legume anti-nutritive components is reduced.

Mixing soybean oil with dried fodder favours, in the case of fodder mixtures in farms, lower amounts of dust are generated in fodder mixing, transport and enrichment process.

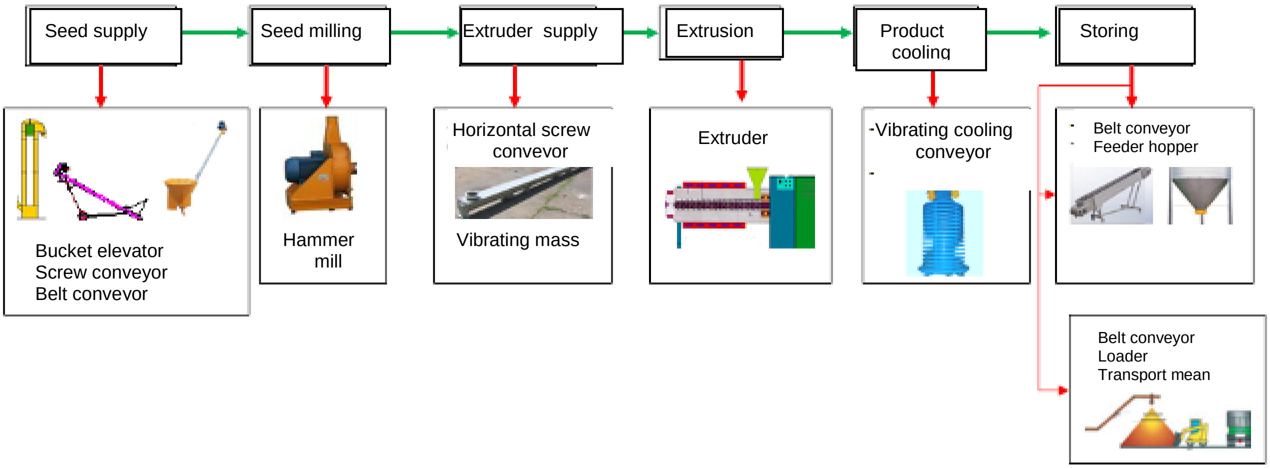

Fig. 2- Soybean seeds extrusion technology [12]

Figure 3 presents the installation for soybean seeds superior capitalisation –IVSS

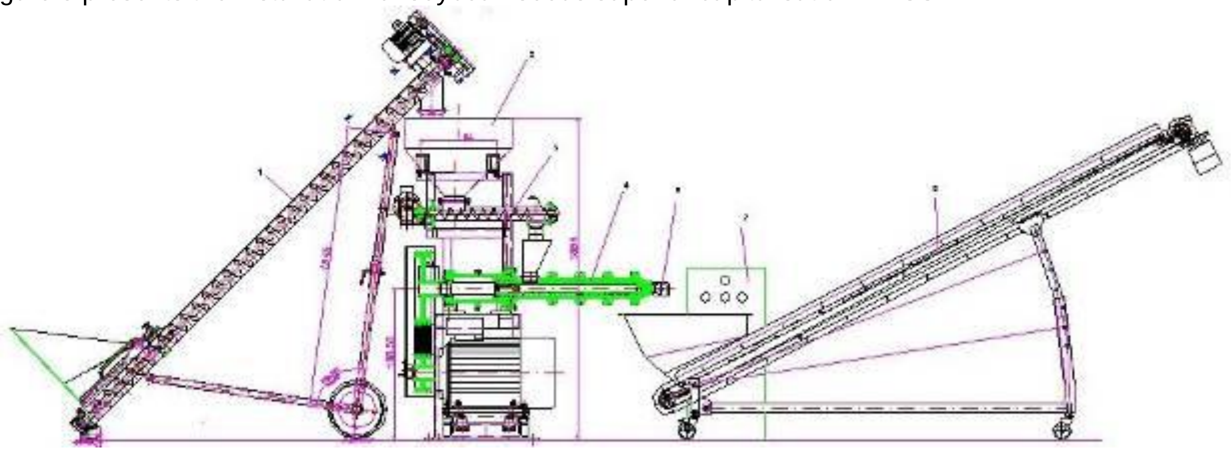

Fig. 3 - Installation for soybean seeds superior capitalisation – IVSS
1-Inclined screw conveyor; 2- Supply system; 3- Extruder; 4- Cooling system;
5- Mobile belt conveyor; 6- Command and control system [12]

The installation for soybean seeds superior capitalisation – IVSS will be a support in the interest of farmers who want to approach a strategy on: choosing fodder recipes depending on the animals in the farm, using own fodder and not only, the technical base necessary to the farm, and in the same time they will meet the requirements according to which agriculture no longer serves only to produce wheat, corn, milk and other agricultural products, but it also provides environment conservation and product consumers food safety.

Technical characteristics:

- Productive capacity kg/h	150-200
- Installed power, kW	25
- Gauge size:	
- length, mm	~6720
- width, mm	~1420
- height, mm	~2550

The installation for soybean seeds superior capitalisation

The installation for soybean seeds superior capitalisation – IVSS using soybean seeds extrusion as processing method ensures:

- *reduction of raw material processing losses on food chain*
- *realisation of complex fodder receipts;*
- *intensification of production process;*

• *increase of raw material use degree;*

• *obtaining food products ready for consumption or creating components for them, having high thickening and water and fat retention capacity;*

• *assimilability increase;*

• *reduction of products microbiological contamination;*

• *reduction of environment pollution;*

• *increasing Romanian economy competitiveness through innovation with impact on economic agents by adapting and developing domestic production of equipment in the field at the technical level and the current requirements worldwide.*

Soybean seed dry extrusion is a process that occurs due to the high oil content in seeds. During the extrusion product can reach temperatures of approx. 140-150 °C.

During the extrusion process a series of complex phenomena take place in the working area of the screw, which is the main element of soybeans processing as it performs seeds transport and processing but also the forced evacuation of flow through die holes. To better analyse phenomena occurring in the extruder, the screw length will be divided into several activity sections, Figure 4:

- feed section;
- melting section;
- pressure section;

The feed section is the screw area that takes over the seeds (feedstock) entering the screw and realizes the filling of the channel between screw coil and cylinder inner part to make possible the friction leading to the melting of the material. By filling this portion of the screw, part of the air within this area is removed, seeds are compacted and rearranged.

In general, this section represents 10-20% of screw total length.

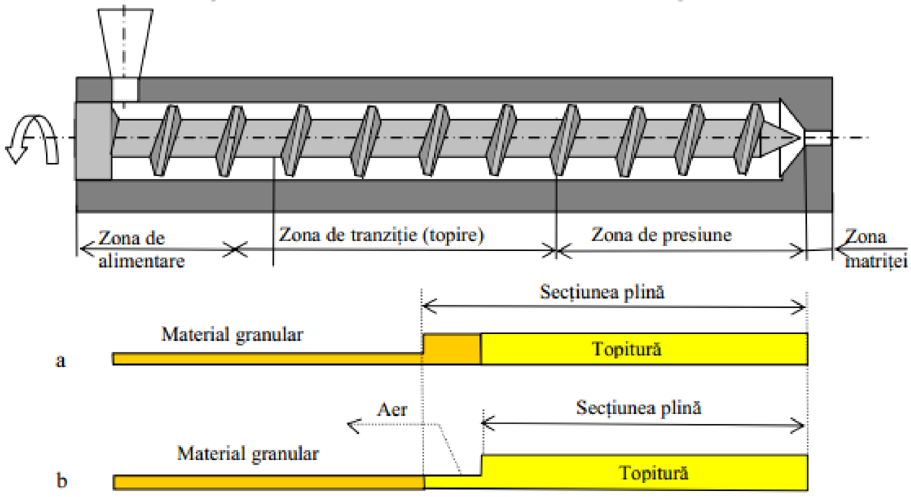

Fig. 4 - Extruder activity areas [2]

A second section is the melting (transition) one. In this section takes place the friction and temperature increase following material compression between the screw and the cylinder. This is the longest area, approx. 50% of screw total length.

The last section is the *pressure* one, where the material is mostly melted. This area, by the pressure and viscosity of the molten material causes the flow of the melt exiting the extruder die thus determining the extruder productivity. This area is also called metering zone and has a length of 30-40% of the screw length.

RESULTS

The extrusion process of soybean seeds is conducted in optimal conditions when there is interdependence between the following parameters:

1. **System parameters**:
   - raw material:
     - *composition, granulation, humidity etc.;*
     - *raw material flow;*

Raw material humidity variations lead to the unevenness in the operation of the extruder and consequently affect the quality of the final product.

- extruder characteristics
  - *screw speed;*
  - *driving power consumed;*
  - *geometry of working elements* (extrusion cylinder, screw, die);
  - *active parts wear*

2. Extrusion process parameters

- *temperature of processed material melt;*
- *time of material being within the extruder;*
- *pressure of processed material melt;*
- *shear strength*

3. Final product parameters

- *expansion degree* characterised by:
  - final product *density*;
  - *apparent specific volume*

$$V_s = \frac{4}{\pi D_e L_{se}} \tag{1}$$

where:

D_e – outer diameter of expended product;

L_{se} – specific average length (for 1g of extruded product).

- *expansion index* characterised by:
  - *transverse expansion index (IET)*

$$IET = (D_e/D_m)^2 \tag{2}$$

where:

D_e – outer diameter of extruded product;

D_m – die hole diameter

  - *longitudinal expansion index (IEL)*

$$IEL = \frac{\pi D_m^2}{4 L_{se} \rho_t} x \frac{1-u_e}{1-u_t} \tag{3}$$

where:

D_m – die hole diameter*;*

L_{se} – specific average length (for 1g of extruded product);

ρ_t – melt density when entering the die;

u_e – expanded product humidity content;

u_t – melt humidity content when entering the die.

  - *volumetric expansion index (IEV) (*total expansion index)

$$IEV = IET \ x \ IEL \tag{4}$$

Numerous studies carried out in expansion field have showed that the total expansion index (IET) is obtained by expanding pure starch (IET=5), followed by cereals (IET=4), legumes (IET=2-3) and oilseeds (IET = 1,5 – 2). The starch content for these raw materials is of 100%, 50-80%, 25 – 50%, respectively 0 – 10% [7].

- mechanical resistance uses as measure the braking force defined by the relation:

$$F = \frac{E_s}{\pi r^2} \tag{5}$$

where:

F_s – breaking force (kJ/m^2);

E_s – breaking energy;

r – expanded product range.

- extruded product form;
- extruded product solubility;

CONCLUSIONS

For the superior capitalisation of feed resources in livestock farms is necessary the development of technologies to obtain a wide range of compound feed directly in the farm, in terms of efficiency and quality as required at world level.

The extrusion technology is one of the perspective and high efficiency processes, combining hydrothermal and mechanical processing of raw material – soybean seeds, allowing obtaining a new-generation products and components with predetermined properties, with a new structure: instant products.

Extrusion technology is one of the perspective and high efficiency processes, combining hydrothermal and mechanical processing of raw materials – soybeans, allowing obtaining new-generation products and components with predetermined properties, with a new structure: instant products.

In the case of extrusion processing of raw material containing starch and protein compared to traditional technologies there is a number of advantages:

- products ready for consumption or components are obtained, having high capacity of water and fat retention;
- the degree of assimilation and utilization of the raw material is higher;
- the degree of raw material microbial contamination and neutralization of thermosensitive legume anti-nutritive components is reduced.

This project of installation for soybean seeds superior capitalisation – IVSS tries to transform typical farmer in professional livestock farmer who would make a superior capitalisation of the technologies established by research, develop the farm in close connection with the processing units and provide high quality productions by capitalising the production of cereals and technical plants of their own cultures.

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EXPERIMENTAL RESEARCHES ON FORCES AND STRESSES INSIDE COUPLING DEVICES – REVIEW

/

CERCETĂRI EXPERIMENTALE PRIVIND FORŢELE ŞI SOLICITĂRILE DIN DISPOZITIVELE DE CUPLARE - REVIEW

PhD. Stud. Mircea D.I.*[1)], Prof. PhD. Eng. David L.[1)], Prof. PhD. Eng. Biriş S.Şt.[1)], Assoc. Prof. Savin L.[2)], Assoc. Prof. PhD. Eng. Atanasov A.[3)], PhD. Eng. Ciupercă R.[4)], PhD. Stud. Eng. Găgeanu I.[4)], PhD. Eng. Vlăduţ V.[4)], PhD. Eng. Neacşu Fl.[5)], Eng. Caba I.L.[6)]

[1)]P.U. Bucharest; [2)]University of Novi Sad, Serbia; [3)]University "Anghe Kanchev" Russe, Bulgaria;
[4)]INMA Bucharest, [5)]NHR Agropartners / Romania, [6)]S.C. Munax S.R.L. / Romania
E-mail: mircea.ionut@gmail.com

Keywords: *tractor aggregate, system force, trailer, coupling*

ABSTRACT

This paper presents a synthesis of experimental researches carried out in Romania and worldwide on forces and stresses in coupling devices.

REZUMAT

Lucrarea prezintă o sinteză a cercetărilor experiemntale realizate în ţară şi pe plan mondiale privind forţele şi solicitările din dispozitivele de cuplare.

INTRODUCTION

To increase traffic safety in Romania were introduced strict regulations on the access to public roads of road vehicles of any type, based, mainly, on European Union Directives (EU/EEC) and ECE – UN regulations which refer, to the same extent, to tractors, agricultural trailers and machines (Bodea C., 2008; Iordache S., 2011).

Thus, tractors, their trailers and agricultural machines, when in traffic on public roads in Romania are considered as road vehicles, like cars, trucks, buses, trolleybuses, etc. and must satisfy the technical requirements imposed for the vehicle category they are part of.

Shape, dimensions and technical conditions imposed to coupling devices for trailers framing within categories O_3 and O_4, and also for semi-trailers with saddle are given in speciality literature.

The yoke ends mounted on the towing vehicle must have the shape shown in figure 1 and ensure the mobility of drawbar eye of the hitch under the following angles:

- In longitudinal vertical plane with a tilting angle of at least $\alpha = \pm 20°$ on both sides of horizontal plane which is perpendicular to the bolt;
- In horizontal plane, with a steering angle of at least $\beta = \pm 75°$ on both sides of median longitudinal plane;
- In perpendicular plane to longitudinal axis with a cross tilting angle of at least ±25° on both sides of median longitudinal plane.

Resistance of yoke end can be verified by dynamic tests; therefore, it is rigidly fixed on the stand in the same manner in which it is placed on the motor vehicle. A sinusoidal variable force of at most 30 Hz frequency, per 2 x 10^6 cycles is applied on median longitudinal plane, under an angle of 15° to front or rear part, towards the coupling device centre.

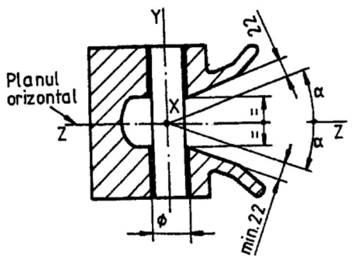


Fig. 1 - Shape and size of yoke end mounted on the tractor

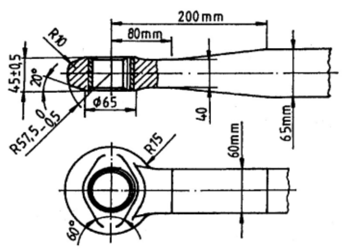


Fig. 2 - Shape and size of trailer towing eyelet

The trailer coupling eyelet must have the shape and size from figure 2. As the yoke end, the coupling eyelet must be built from steel, by forging. The eyelet mechanical resistance can be tested through dynamic trials, with variable forces per cycle, whose evolution, placement, amplitude and applying duration are similar to those presented when testing the yoke end. Any breakages, permanent deformations or other visible damages are not allowed during the tests.

For saddle couplings, the pin fixed on semi-trailer must have the shape and dimensions described in figure 3; saddle fixed on tractor has the dimensions shown in figure 4.

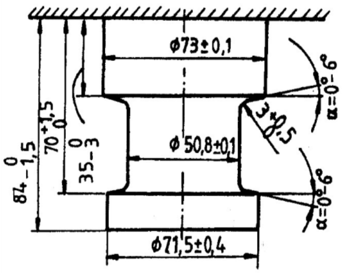


Fig. 3 - Shape and dimensions of semi-trailer pin

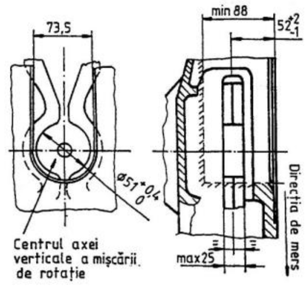


Fig. 4 - Shape and dimensions of saddle on tractor motor vehicle

Tractor with saddle should allow to trailer to steer with an angle of $\beta = \pm 90$ to the median longitudinal axis. The degrees of freedom in longitudinal plane (angles α_1 and α_2 from figure 5) and in transversal plane (angles δ), as well as other values such as height H at which the saddle must be placed, radius R_{1max} and R_{2min} limit the semi-trailer edges coming near the cabin or respectively limit the semi-trailer lower part coming next to the tractor's rear side, length S between the semi-trailer pin and the edge of the plane surface around it (fig. 6).

Values of α_1 and α_2 from the table should be ensured for semi-trailer steering angles of at most $\beta = 25°$; within the range $\beta = 25°...90°$, a decrease of α_1 and α_2 up to 3°, being allowed.

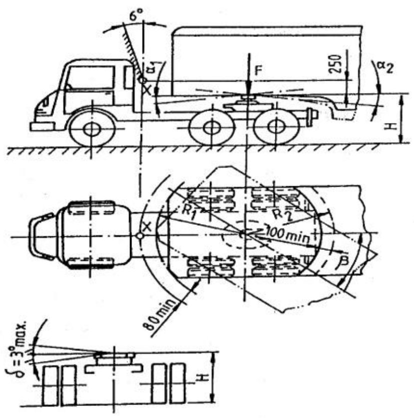


Fig. 5 - Degrees of freedom and dimensions imposed to assembly made of tractor motor vehicle with saddle and semi-trailer

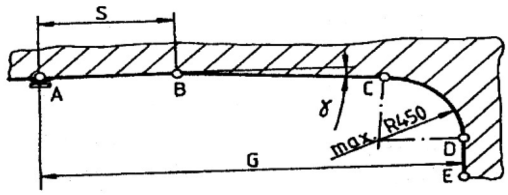


Fig. 6 - Main longitudinal section behind the coupling pin of semi-trailer

In longitudinal section, the surface behind the coupling pin of semi-trailer should have the shape shown in figure 6. Constructive elements may be endowed behind the cabin of tractor if they are situated at a distance bigger than R_{1max} + 80 mm and at 250 mm height, at most, comparing to the horizontal plan passing through the saddle top; behind the semi-trailer coupling pin, the tractor rear part should be at a distance of at most R_{2min} - 100 mm comparing to coupling centre

Vehicles equipped with short coupling devices (automated couplings)

The short coupling device (abbreviated as DAS) is built so that it allows the automated adjustment of distance between the tractor and semi-trailer avoiding their contact when the angle between their axles requires the increment of the free space between them. Such devices are used for vehicles of categories N_2, N_3, O_3 and O_4 and aim to correct the kinetics of semi-trailer movement for improving the turning stability. Technical provisions imposed by *DAS* and those required for vehicles equipped with such devices, are presented in specialty literature. Functioning of *DAS* must be automated, without any human intervention; it should allow to motor vehicle-trailer assembly to move straight in a plane road, without making forward movement corrections.

Coupling and decoupling *DAS* should be possible when tractor and trailer axles are inclined at 50° angle to right and left in horizontal plane, 10° up and down in vertical plane for trailers with many axles or 60° vertical up and down for trailers with rigid hitch; at the same time, an angle of 7° should exist around longitudinal axes, in both directions. A single person should be enough to ensure coupling. The final coupling operation (intermediate positions are also allowed to ensure an appropriate final operation) is possible when between vehicles, there is a distance of at most 500mm. Hitch level in vertical plane should be adjusted for coupling in any normal traffic position.

DAS must not affect the movement of vehicles on which it is mounted; it is subject to dynamic tests which must meet the conditions hereinafter presented.

Mechanical connections between agricultural vehicles

Shape, dimensions and technical conditions imposed to coupling devices of trailers and agricultural equipment with tractor, are given in specialty literature.

Eyelet and drawbar of trailer's hitch must be made of steel, by forging. Eyelet is built as in figure 7 (fig. 7), which continues with a bar resistant enough to traction and which dimensions may be chosen by the manufacturer.

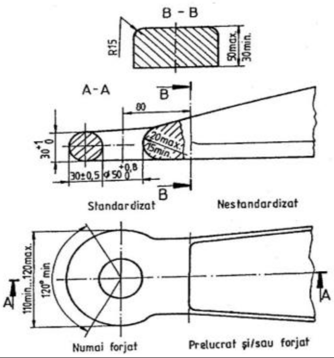


Fig. 7. Shape and dimensions of coupling eyelet of agricultural trailer

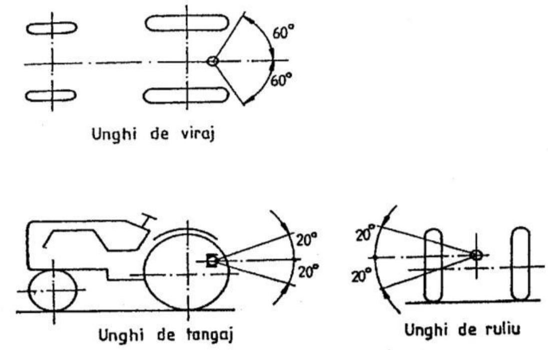


Fig. 8. Degrees of freedom of trailer hitch coupling to tractor

When coupled, with the device (bolt) mounted on tractor, the hitch should rotate freely under the steering angle, pitch angle and gyration angle whose minimum values are shown in figure 8.

MATERIALS AND METHODS

When determining the forces of stresses in coupling devices it must be taken into account the shape, size and technical conditions imposed to their aggregation devices.

Thus, for each type of coupling system the legislation (directives, regulations, standards, etc.), stipulates the conditions they must meet and comply with.

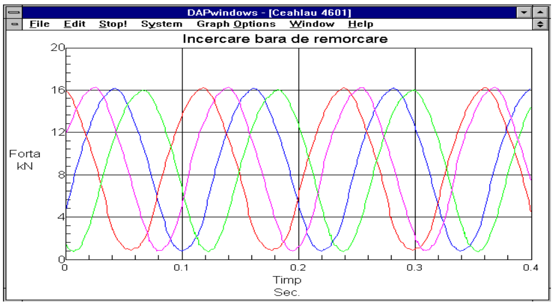
RESULTS

In the paper (Vlăduţ V. Et al., 2004), authors studied the breaking resistance of a towing bar-as component part of towing device mounted on tractor (fig. 9), taking into consideration the freedom degrees required by the regulations in force and determined the effective values of forces applied and appropriate movements measured on the hydraulic cylinder axle direction (table 1).

Table 1 [3]

Den.No	Number of cycles performed	Maximum force [kN]	Maximum forward movement [mm]
1.	5,000	16.26	5.1
2.	850,000	16.30	5.1
3.	1,400,000	16.30	5.2
4.	2,000,500	16.28	5.2

Diagram force-time is represented in figure 9:



La n = 5,000 cycles
La n = 850,000 cycles
La n = 1,400,000 cycles
La n = 2,000,500 cycles

Fig. 9 – Force-time diagram for swinging towing bar of tractor Ceahlău 4601 [3]

Tests were performed on a testing installation of Hydropulse type and after running 2,000,500 cycles no ruptures, permanent deformations or visible external damages appeared.

In the paper (Biriş S.Ş. et al, 2001), author analyses the distribution of stress and deformations in the sidebars of suspension mechanism to tractor, by using finite plane triangular elements of CST type. Study can optimize in terms of geometry and shape for the lateral sidebar, by increasing its thickness in areas where stress is too big, respectively, by diminishing its thickness in areas where stress is too small.

Nowadays, the carried agricultural machines are most spread worldwide, being placed behind tractors, the coupling being performed by suspension mechanism. The most common suspension mechanisms are the three-point suspension ones, which are equipping all the agricultural tractors. Side bars (fig. 10) are main components of suspension mechanisms, being differently subject to stress according to the type of carried machine and the operation performed. Thus, in lifting or transport position, the main stress of sidebars is that of bending and in working position, the main stress is of stretching.

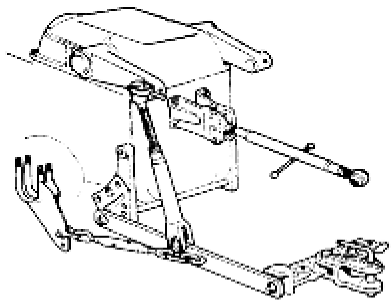


Fig. 10 - Suspension mechanism of tractor U 650 M [4]

Using the method of finite elements (Biriş S., 1999; Andrei I. et all., 2006; Cârdei P. et all., 1999; Vlăduţ V. et all., 2015), is possible to make the study of stresses and displacements in sidebars points, framing within the problems of plane plate type with constant thickness, for the least favourable case, that of lifting position, at which the external force was considered to be the maximum load provided for mechanisms of category II (15680 N). Contour of side bar with all details was generated in AutoCAD 14, and analysis based on finite element method was made by specialized program QuickField, version 4.2.

In figure 11 is shown the model of discretized sidebar for which triangular finite elements of CST (Constant Strain Triangle) type were used; it is made of steel, for which the longitudinal elasticity module is $E_X=E_Y=E_Z=2.1\cdot10^{11}$N/m^2, Poisson coefficient is $\nu_{XY}=\nu_{XZ}=\nu_{YZ}=0.3$, transversal elasticity module is $G_{XY}=8.0769^3 10^{10}$ N/m^2, and thickness of sidebar is steady, t=18 mm.

Displacement field is considered to be completely defined for plane problems by two components of vector of displacements δ in each point, so [4]:

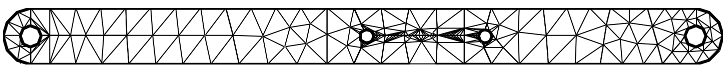


Fig. 11 - Discretization of sidebar [4]

$$\{\delta\} = \begin{Bmatrix} \delta_x \\ \delta_y \end{Bmatrix} \tag{1}$$

Only three components of tensors of deformation and stress are independent both in case of stress plane and deformation plane. Relation deformation-displacement is defined as:

$$\{\varepsilon\} = \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} = \begin{Bmatrix} \dfrac{\partial \delta_x}{\partial x} \\ \dfrac{\partial \delta_y}{\partial y} \\ \dfrac{\partial \delta_x}{\partial y} + \dfrac{\partial \delta_y}{\partial x} \end{Bmatrix} \tag{2}$$

Distribution of nodal displacements and deformed sidebar is shown in figure 12, for which the absolute value of nodal displacement is calculated by relation:

$$\delta = \sqrt{\delta_x^2 + \delta_y^2} \tag{3}$$

Components of appropriate stress are:

$$\{\sigma\} = \begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} \tag{4}$$

Balance equations for plane problems are:

$$\begin{cases} \dfrac{\partial \sigma_x}{\partial x} + \dfrac{\partial \tau_{xy}}{\partial y} = -f_x \\ \dfrac{\partial \tau_{xy}}{\partial x} + \dfrac{\partial \sigma_y}{\partial y} = -f_y \end{cases} \tag{5}$$

where f_x and f_y are the components of volume force vector.

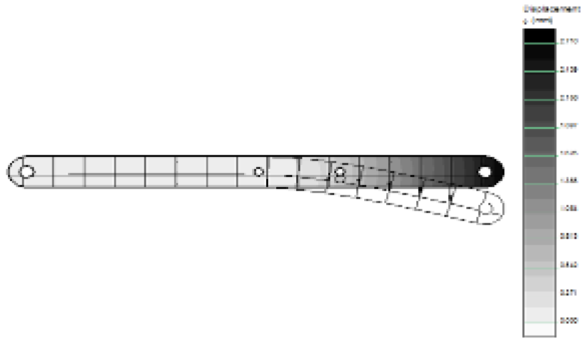


Fig. 12 - Distribution of nodal displacements [4]

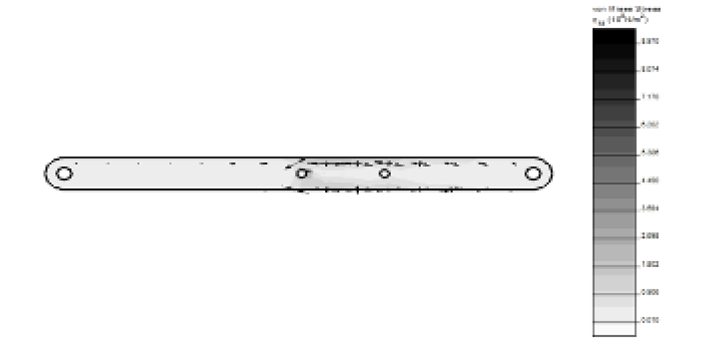


Fig. 13 - Distribution of equivalent stress according to Von Mises criterion [4]

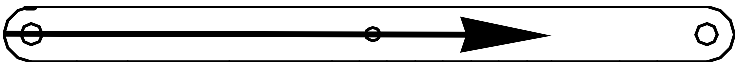


Fig. 14 Analysed contour [4]

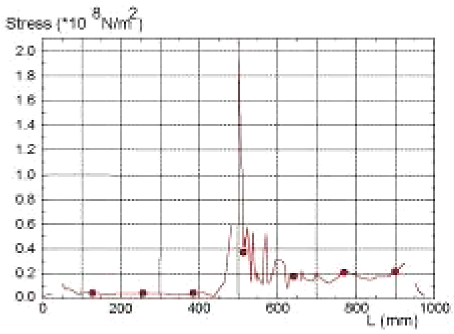


Fig. 15 - Variation of equivalent stress along the contour [14]

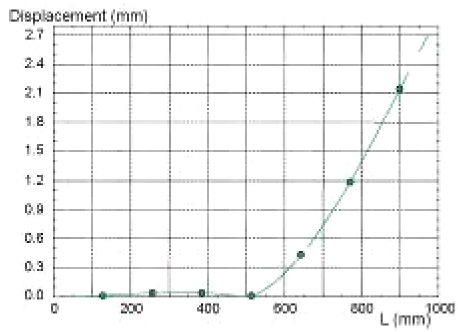


Fig. 16 - Variation of total nodal displacement along the contour [14]

In case of linear elasticity, connecting relations between stress and deformation are [4]:

$$\{\sigma\} = [D] \cdot (\{\varepsilon\} - \{\varepsilon_0\}) \quad (6)$$

where [D] is a matrix of elastic constants and $\{\varepsilon_0\}$ represents the initial deformation due to temperature. Specific shape of matrix [D] depends on the practical formulation of problem.

For stress plane state, in case of isotropic materials [D] is:

$$[D] = \frac{E}{1-\nu^2} \cdot \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \quad (7)$$

For deformation plane state, in case of isotropic materials, [D] takes the expression from relation:

$$[D] = \frac{E \cdot (1-\nu)}{(1+\nu) \cdot (1-2\nu)} \cdot \begin{bmatrix} 1 & \frac{\nu}{1-\nu} & 0 \\ \frac{\nu}{1-\nu} & 1 & 0 \\ 0 & 0 & \frac{1-2\nu}{2 \cdot (1-\nu)} \end{bmatrix} \quad (8)$$

In figure 13, is presented the distribution of equivalent stress according to Von Mises criterion whose calculation formula is shown in the following relation, where σ_1, σ_2 and σ_3 represent the main stresses in decreasing order.

$$\sigma_e = \sqrt{\frac{1}{2}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right]} \quad (9)$$

For a contour situated on symmetry axis (median) of sidebar (Fig. 14), the graphic variation of equivalent stress (Fig. 15) and the graphic variation of equivalent total nodal displacement(Fig. 16)., were studied. Thus, the areas where equivalent stresses are high and displacements on sidebar points are maximal could be emphasized.

Paper (Andrei I. et all, 2006) presents the results of dynamic experiments achieved for endurance tests of a tractor-trailer coupling system (fig. 17) on stand comparing to numerical simulation of the same tests made on mathematical models based on finite element method (Cârdei P. et al., 1999), observing that the theoretical results are finally similar to those of physical tests. We can notice that, in recent years, the number of cycles that we must take into consideration for fatigue calculus, have risen from 20,000 to 2,000,000 and is keep growing, thus ensuring an increased safety.

Fig. 17 – System of coupling tractor – trailer [6]

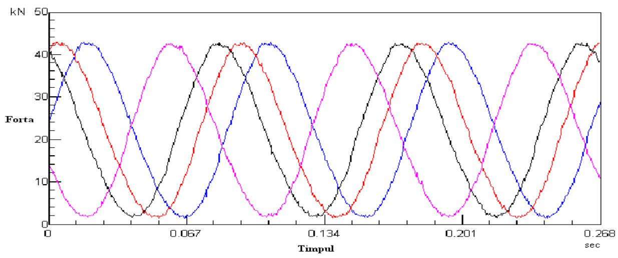


Fig. 18 – Variation of tensile force on testing bench (testing frequency – 12 Hz) [6]

Distribution map of equivalent stress in structural model of tractor-trailer coupling system can be observed in figure 19 (by components and assembly), the map of the whole structure being shown on its deformed shape, amplified by one factor to make it visible to human eye.

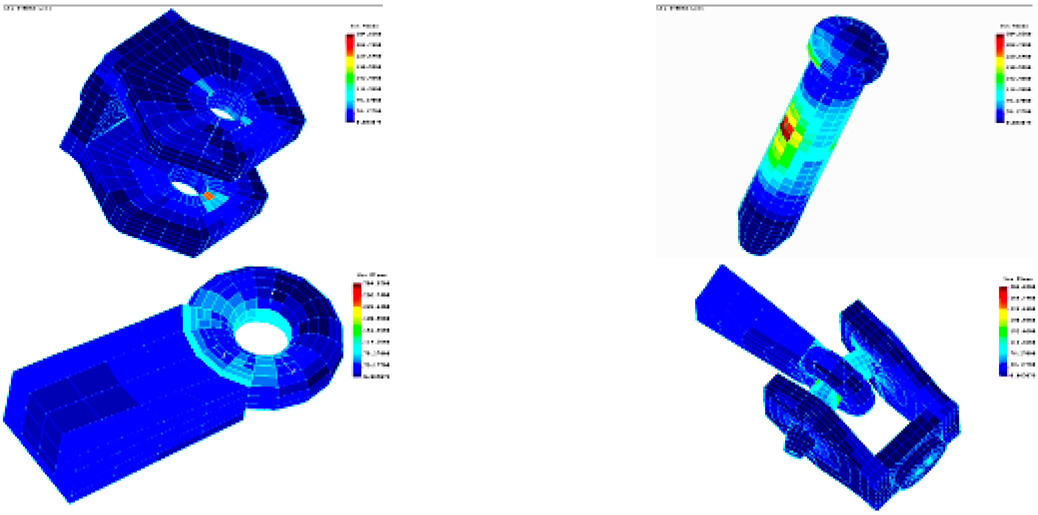


Fig. 19 – Map of relative displacement state of elements within the coupling system structural model, on components, on structure deformed shape [6]

In the paper (Vlăduţ V. Et al., 2015), it is presented a testing method of a tractor's towing bar in terms of resistance to traction during the movement of tractor-trailer aggregate. This is achieved by using a testing installation in accelerated and simulated regime through the finite element method with one of programs CATIA, COSMOS, or ANSYS. Testing the different components as integral part of research, development, design, exploitation and reparation of products has a great contribution at continuously improving them in all stages.

Using the finite element method, the testing costs in exploitation or in simulated and accelerated regime may be reduced and the precision of determining the maximum stress (critical) areas or even the lifespan of structure is rather accurate. Therefore, the researches achieved aimed to determine the fatigue behaviour of different towing devices from tractor (fig. 20, 21).

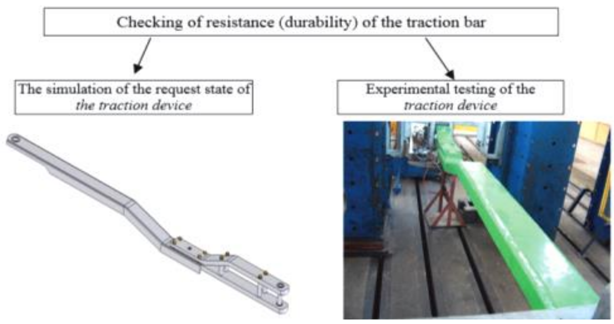


Fig. 20 Mathematical model **Fig. 21 Testing stand [8]**

For determining the breaking resistance of towing bar of a tractor of 20 HP [8], after achieving 2,000,000 cycles, in accelerated regime, a series of tests were performed for finding out if this type of bar ensures the mobility degrees required by the Directive, finally determining if any ruptures, permanent deformations or visible external damages have appeared. Main parameters of towing bar are shown in table 2.

Table 2 [8]

Den.No.	Parameter name	Values
1.	Maximum towable mass	2,500 [kg]
2.	Tractor exploitation mass	1,400 [kg]
3.	Maximum vertical load static on bar	1.5 [kN]
4.	Dynamic test load, *D*	8.8 [kN]
5.	Horizontal/vertical force, F_H / F_v	8.8 / 2.25 [kN]
6.	Maximum/average/minimum force, F_{max} / F_{med} / F_{min}	9.08 / 4.76 / 0.45 [kN]
7.	Testing angle	14°20'
8.	Testing frequency, *f*	6÷7 [Hz]
9.	No. Of cycles of alternating stress	2,000,000

Effective values of force applied and appropriate displacement measured along the hydraulic cylinder axis during test are shown in table 3.

Table 3 [8]

Den.No.	Number of cycles achieved	Maximum force [kN]	Maximum displacement [mm]
1.	3,000	9.06	3.85
2.	658,500	9.08	3.85
3.	1,360,000	9.09	4.05
4.	2,000,350	9.07	4.05

Diagrams force-time are represented in figure 22, after achieving 2,000,350 cycles at amplitude and frequency from table 2 it has found that no permanent deformations were present.

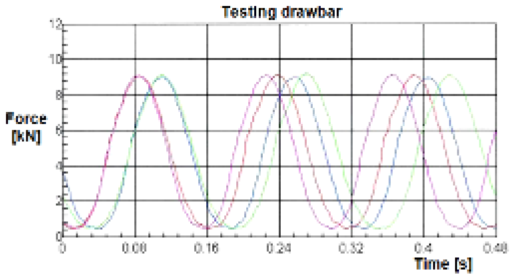


Fig. 22 – Diagram force-time for towing bar of tractor of 20 HP [8]

Paper (*Păunescu D. et al., 2005*) presents the method of testing the support of towing device used as intermediate element of hitching to tractor a yoke end type device. Both subassemblies were mounted and tested at the same time on a testing platform from Hydropulse installation (fig. 23). The testing parameters and their values are shown in table 4.

Table 4 [9]

Den.No.	Parameter name	M.U.	Values
1.	Dynamic test load, **D**	kN	40.00
2.	Horizontal force, $\mathbf{F_h}$	kN	40.00
3.	Vertical force, $\mathbf{F_v}$	kN	14.00
4.	Testing force, **F**	kN	42.40
5.	Maximum force, $\mathbf{F_{max}}$	kN	42.40
6.	Average force, $\mathbf{F_{med}}$	kN	22.26
7.	Minimum force, $\mathbf{F_{min}}$	kN	2.12
8.	Testing angle α	°	19° 20'
9.	Testing frequency, **f**	Hz	10.3 Hz
10.	No. of cycles of alternating stress	Nr.	2,000,000

Real values of force applied to assembly made of the support of towing device and displacements measured on direction of hydraulic cylinder axis during the test are shown in table 5.

Table 5 [9]

Den.No.	Number of cycles achieved	Maximum force [kN]	Maximum displacement [mm]
1.	10,000	42.5	0.88
2.	800,000	42.4	0.9
3.	1,600,000	42.4	0.9
4.	2,000,050	42.5	0.9

Force-time diagrams are presented in fig. 24. After achieving 2,000,050 cycles at amplitudes and frequencies indicated in table 5, no cracks, tears, permanent deformations or visible external damages were found.

Fig. 23 - Fitting on Hydropulse installation for testing the assembly of device support – towing yoke [9]

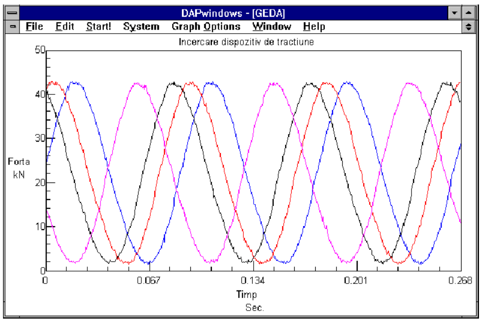


Fig. 24 – Force-time diagram obtained during the test of device support – towing yoke [9]

Paper (Păunescu D. Et al., (2001) presents the test of towing hitch that is used for trailing mono-axle trailers with maximum towable mass of 2500 kg, performed on an installation of simulated and accelerated regime (fig. 25). Testing parameters and their values are shown in table 6.

Table 6 [10]

Den.No.	Parameter name	Values
1.	Maximum towable mass	2500 kg
2.	Tractor exploitation mass	1400 kg
3.	Maximum vertical load on hitch	4 kN
4.	Dynamic testing load, **D**	8.8 kN
5.	Horizontal force, $\mathbf{F_h}$	8.8 kN
6.	Vertical force, $\mathbf{F_v}$	5.88 kN
7.	Testing force, **F**	10.58 kN
8.	Maximum force, $\mathbf{F_{max}}$	10.58 kN
9.	Average force, $\mathbf{F_{med}}$	4.66 kN
10.	Minimum force, $\mathbf{F_{min}}$	0.53 kN
11.	Testing angle	$33^\circ\ 45'$
12	Testing frequency, **f**	8÷9 Hz
13.	No. of cycles of alternating stress	2,000,000

Values of force applied and appropriate displacements measured on direction of hydraulic cylinder axis are shown in table 7.

Table 7 [10]

Den.No	Number of cycles achieved	Maximum force [kN]	Maximum displacement [mm]
1.	5000	10.58	0.89
2.	650,000	10.59	0.89
3.	1.350,000	10.55	0.90
4.	2,000,500	10.58	0.91

Force-time diagrams are represented in figure 26. After achieving 2,000,050 cycles at amplitudes and frequencies indicated in table 7, no cracks, tears, permanent deformations or visible external damages were found.

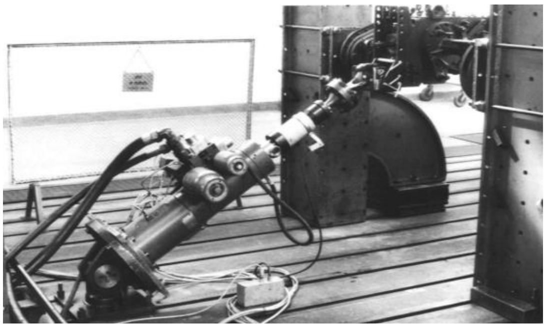


Fig. 25 - Fitting on Hydropulse installation for testing the towing hitch [10]

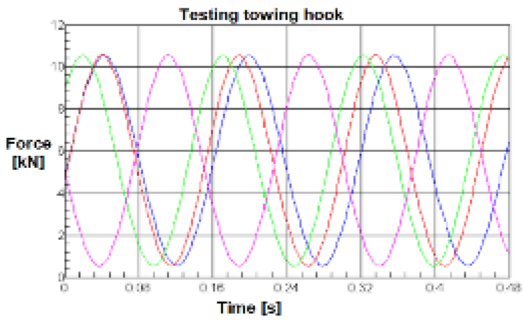


Fig. 26 - Force-time diagram for towing hitch [10]

Paper (Păunescu D. Et al., (2003) presents the test of a towing bar- as component part of towing device mounted on tractor and that is used for towing the agricultural implements (fig. 27); testing parameters and their values are shown in table 8.

Fig. 27 - Fitting performed on Hydropulse installation for testing the swinging towing bar11]

Table 8 [11]

Den.No	Parameter name	M.U.	Values
1.	Maximum towable mass	kg	12000
2.	Tractor total mass technically allowable	kg	5500
3.	Maximum vertical static load on bar	kg	1000
4.	Dynamic testing load, **D**	kN	37.00
5.	Horizontal force, $\mathbf{F_h}$	kN	37.00
6.	Vertical force, $\mathbf{F_v}$	kN	14.70
7.	Testing force, **F**	kN	39.80
8.	Maximum force, $\mathbf{F_{max}}$	kN	39.80
9.	Average force, $\mathbf{F_{med}}$	kN	20.89
10.	Minimum force, $\mathbf{F_{min}}$	kN	1,.9
11.	Testing angle	°	21° 40'
12.	Testing frequency, **f**	Hz	9 – 10 Hz
13.	No. of cycles of alternating stress	nr	2,000,000

Values of force applied and appropriate displacements measured on direction of hydraulic cylinder axis are shown in table 9.

Table 9 [11]

Den.No	Number of cycles achieved	Maximum force [kN]	Maximum displacement [mm]
1.	10,000	39.82	3.9
2.	950,000	39.85	3.9
3.	1,500,000	39.83	3.9
4.	2,001,500	39.80	3.9

Force-time diagrams are shown in figures 28 and 29. After achieving 2,000,050 cycles at amplitudes and frequencies indicated in table 9, no cracks, tears, permanent deformations or visible external damages were found.

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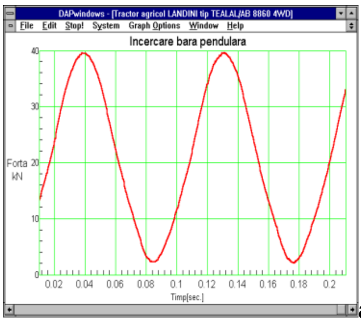
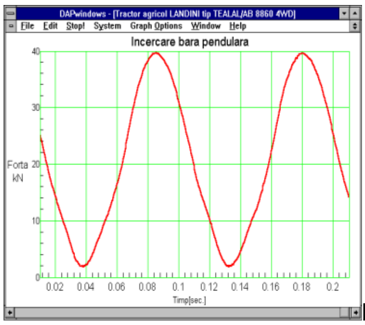


a)



b)

Fig. 28 - Force-time diagram for tractor swinging towing bar at) 10,000 cycles; b) 950,000 cycles [11]

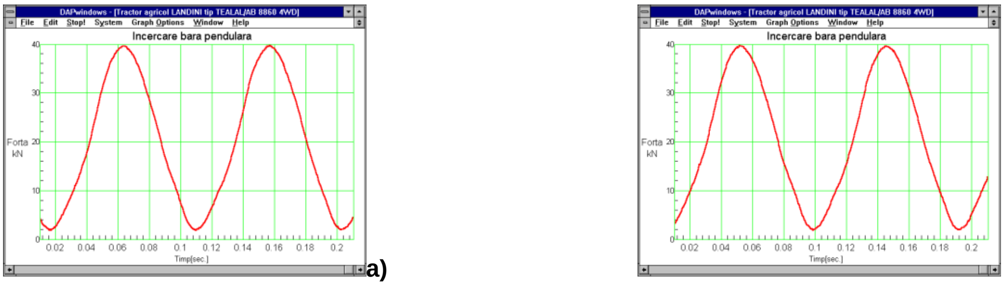


Fig. 29 - Force-time diagram for tractor swinging towing bar at: a) 1,500,000 cycles; b) 2,001,000 cycles [11]

Researches performed (Zatocilová A. Et al., 2014) present a method of measuring the deformation of a towing hitch (fig. 30), based on finite element analysis. Monitoring the loading forces that act on the towing hitch has been made by means of software Catman Easy, the static deformations being measured by industrial photogrammetry system Tritop. In order to process the 3D virtual model of towing hitch through finite element method, it was created by reverse engineering with a scanner 3D Atos III Triple Scan. This paper presents the results AEF, comparing to photogrammetry results following the measurements made on an experimental stand.

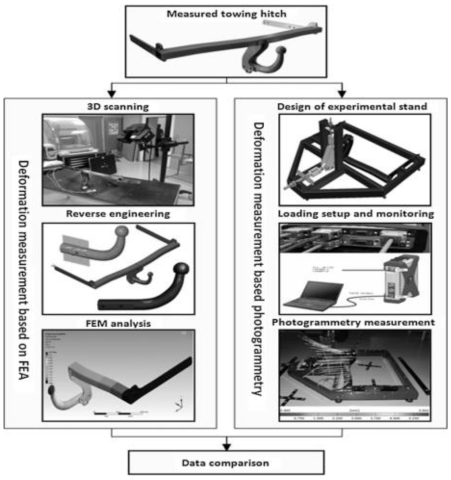


Fig. 30 Approaches of analysis of towing hitch deformation [12]

An optional testing method of an agricultural trailer for determining its functional load (fig. 31) was studied in (Constantinescu A., Voicu E., 2010), experiments being performed both statically and dynamically, the sensors being placed on towing eyelet, axle components and trailer chassis. Experimental results were explained by finite element method.

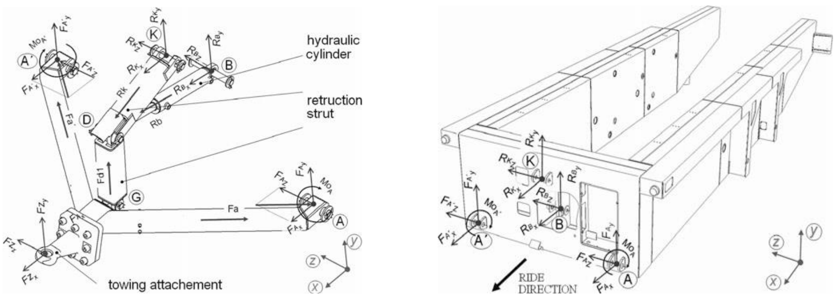


Fig. 31 - Forces acting on trailer during the towing [13]

Forces applied and appropriate displacements measured during tests are shown in figure 32.

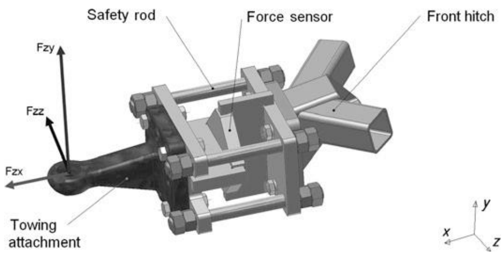


Fig. 32 - Forces applied [13]

Diagrams of force-displacement are shown in figure 33.

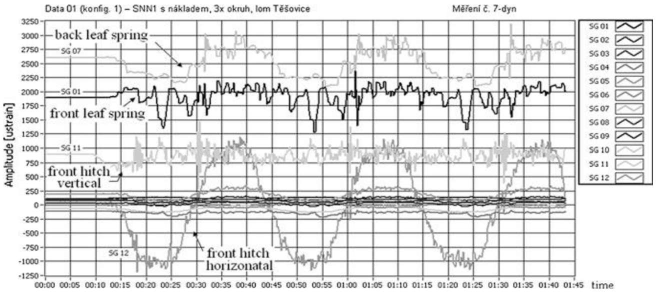


Fig. 33 - Force-displacement diagrams [13]

Experimental measurements and analysis of results obtained by finite element method have led to a great and valuable amount of information. Data described the load, forward speed, field characteristics, etc. Taking into account that many types of trailers are similar to that tested, the results can be also obtained by developing these trailers.

CONCLUSIONS

The aim of this review was to highlight the conditions and limitations of coupling systems that equip agricultural aggregates tractor-trailer/semitrailer, during use on the public roads, respectively during performing various agricultural works.

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RESEARCHES ON THE PHYSICAL CHARACTERISTICS FOR VARIOUS TYPES OF BIOMASS
/
CERCETĂRI PRIVIND CARACTERISTICILE FIZICE ALE DIFERITELOR TIPURI DE BIOMASĂ

PhD. Stud. Eng. Găgeanu I.*[1)], Eng. Găgeanu G.[1)], PhD. Eng. Vlăduţ V.[1)], PhD. Eng. Sorică C. [1)], Eng. Oprescu M.R[2)]
[1)]INMA Bucharest/ Romania; [2)]Condor Comimpex S.R.L. / Romania
Tel: +40762676642; E-mail: iulia.gageanu@gmail.com

Keywords: *biomass, renewable energy, willow, miscanthus, calorific power, moisture*

ABSTRACT

The use of biomass has registered a considerable increase, due to the existence of important quantities of available biomass that represent an important source of renewable energy. Biomass helps reduce the consumption of fossil fuels, helps decrease greenhouse gas emissions and has the advantage that it can be easily obtained. The article presents researches on the physical characteristics of various types of biomass in the view of using them as biofuels in various forms.

REZUMAT

Utilizarea biomasei a înregistrat o creştere considerabilă, datorită existenţei unor cantităţi importante de biomasă disponibilă care reprezintă o sursă importantă de energie regenerabilă. Biomasa ajută la reducerea consumului de combustibili fosili, ajută la scăderea emisiilor de gaze cu effect de seră şi are avantajul că poate fi obţinută uşor. Lucrarea prezintă cercetări supra caracteristicilor fizice ale mai multor tipuri de biomasă în vederea utilizării lor ca biocombustibili de mai multe forme.

INTRODUCTION

The manner in which we obtain energy occupies an important place within the efforts to reduce pollution and climate changes. Currently, our energy still mostly comes from fossil fuels, which release greenhouse gases when they are burned for obtaining energy. (*Benefits of renewable energy, 2011).*

Biofuels benefits compared to traditional fuels target a greater energy security, lower impact on the environment, money savings and social-economic aspects related to the rural sector. The concept of sustainable development embodies the idea of inter-connectivity and balance between economic, social and environmental preoccupations (*Demirbas A., 2009).*

Biomass is the degradable part of products, waste and residues (including plant and animal substances) from agriculture, forestry and adjacent industries, as well as the biodegradable part of industrial and urban waste. This includes the entire organic matter produced through the metabolic processes of live organisms. Biomass is the first form of energy used by humans, since the discovery of fire (*Decision no. 1844 of 2005*).

An overwhelming part of the biomass available for bioenergy comes from plant material and animal products. A first distinction can be made taking into account the origin of biomass from different sectors, such as agriculture, forestry, industry and urban areas. Another classification can be done by nature: energy crops, agricultural and forestry residues and waste (*Manual - Renewable Energy Sources*).

Lignocellulosic crops include perennial herbaceous crops and other tree crops. Herbaceous species include crops such as: Panicum virgatum, Phalaris Arundinacea and Miscanthus (Miscanthus spp.). Deciduous species include woody species such as: willow (Salix Spp.), poplar (Populus spp.) and other.

Out of these, poplar, Miscanthus and willow have received increased attention due to their high biomass production, efficient use of nutrients, their reduced potential for soil erosion, their ability to capture carbon and low inputs of fossil fuel, compared with annual crops (*Abbasi T. et al, 2010*).

MATERIALS AND METHODS

Biomass properties are the ones controlling the manner in which biomass is prepared for handling and for being converted into other forms. These properties can be divided into structural, thermal and compositional properties. Structural properties can manifest as mechanical and physical properties. Compositional properties represent the chemical constituents of biomass and thermal properties refer to the heat transfer between the material and the environment, but also to the calorific power.

Biomass properties affect greatly the quality of the raw material for densification and eventually its use for combustion applications. These properties include density, particle size, flow, moisture, calorific power, ash content, etc. and represent very important characteristics for designing systems for handling, transport, storage and equipment for biomass conversion (*Danciu et al., 2009*).

The majority of biomass resources have high moisture when harvested, making on site processing very difficult. Currently are used processes that convert biomass into high energetic density materials in order to reduce moisture and to increase bulk density. Moisture present in biomass facilitates starch gelatinization, protein denaturation and fibre solubilisation processes during extrusion, pelletizing or briquetting (*Tumuluru et al., 2010*).

Calorific power (heat of combustion) represents the number of heat units released through the complete combustion of a fuel mass unit in the conditions given in standards. The mass unit can be the mol, kilogram or normal cubic meter. [10]

The chemical reaction is typically a hydrocarbon or other organic molecule reacting with oxygen to form carbon dioxide and water and release heat.

The quantity known as lower heating value (LHV) (net calorific value (NCV) or lower calorific value (LCV)) is determined by subtracting the heat of vaporization of the water vapour from the higher heating value. This treats any H2O formed as a vapour. The energy required to vaporize the water therefore is not released as heat,

Ash is the product resulting after the combustion of a material, and it is composed of in-combustible inorganic substances, such as mineral salts. They remain as residues in the form of dust deposited in the places where the fuels were combusted (*Popa V.I.*).

Plant ash (from wood, branches, etc.) has a high content of potassium, calcium, magnesium and other minerals essential for them. This type of ash can used as fertilizer, because it does not contain heavy metals or other contaminants.

For biomass, ash content is a very important quality characteristic, because it causes several operational problems during biomass processing and combustion. For example, the silicon in biomass ash is the main contributor to the wear of the blades of grinding equipment. Potassium and calcium cause the fouling of heat exchangers and the formation of slag on the base of combustion furnaces.

The main quality indices of biomass samples were determined using the laboratory equipment shown in figure 1 and table 1.

a b c

Fig. 1 – The equipment used for tests

a – analytical scales; b – drying oven; c - calorimeter

Table 1

Equipment used for tests

Name/type	Measuring range / Precision	Series
High precision weighing apparatus /AW 220, with self-calibration	0÷200 g / 0.1 mg	D440100161
Oven with temperature control /MEMMERT-UFE 500	0÷260 ºC / 1 ºC	G 507.1422
Calorimeter /CAL 2k;	0.001 Mj/kg	04-15/11-06/063

RESULTS

Some of the important characteristics of different types of biomass are shown in table 2.

Table 2

Results from testing different types of biomass

Sample type	Moisture [%]	Lower calorific value [MJ/kg]	Unburned substance content [g/kg]
Chopped miscanthus	8.8	15.992	4.8
Miscanthus stems	7.6	16.208	13.0
Reed stems	**9.4**	15.163	58.2
Energy willow core	48.47	9.487	4.6
Energy willow bark	48.04	8.198	15.3
Forestry residues	9.23	18.451	25.8
Corn cobs	31.0	12.047	2.25
Chopped beech	18,13	16.300	0.92

The influence of moisture on the lower calorific value and on the unburned substance content can be seen in table 3 and figure 2.

Table 3

Influence of moisture on the lower calorific value

Willow mix (core + bark) sample number	Moisture [%]	Lower calorific value [MJ/kg]	Unburned substance content [g/kg]
1	48.47	10.271	30
2	33.98	11.805	9.9
3	22.45	14.007	8.2
4	11.35	16.778	7.4
5	9.81	17.446	8

All samples were collected from energy willow that was harvested in the same conditions, at the same time. Sample 1 moisture was determined immediately after harvesting and the moisture for samples 2-5 was determined after they were left to dry for different periods of time, in laboratory conditions (at a temperature of 20^{o} C in open polyethylene bags, to allow moisture to decrease).

In figure 2 is shown the comparison between the samples analysed and it can be noticed that as moisture decreases, the calorific value tends to increase. The unburned substance content also tends to be lower as the moisture in the material decreases.

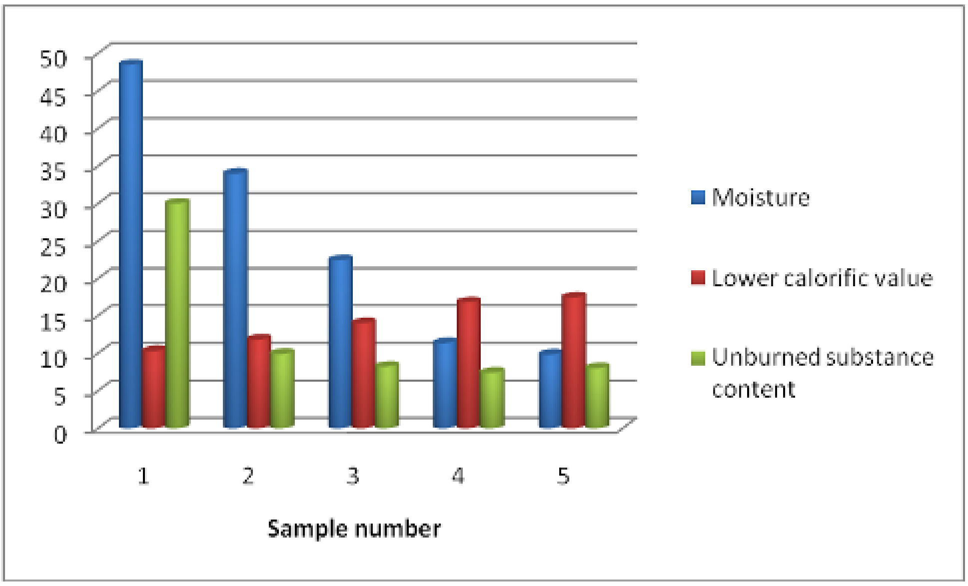

Fig. 1 – Relation between moisture and lower calorific value for willow samples

CONCLUSIONS

Moisture is one of the parameters influencing the final quality of compressed biomass products the most. A moisture content that is too low makes the material hard to create the bonds that are necessary to maintain the shape of the product during handling and storage. On the other hand, a moisture content that is too high also affects material binding and has a negative effect on the final product.

Calorific value is one of the most important quality characteristics of biomass and of solid biofuels, and determines the suitability of biomass to produce high quality fuel. Calorific value is influenced by the moisture content of materials. High material moisture results in low calorific value and low moisture content gives an increased calorific value.

The content of unburned substances is important for the combustion of pellets. A high content of unburned substances causes problems and can damage the combustion systems. This characteristic can be used to determine if a certain biomass material is suitable to be turned into solid biofuel. The highest content of unburned substance is found in herbaceous biomass, in forest residues and in tree bark.

ACKNOLEDGEMENT

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SUPERIOR CAPITALIZATION OF LAVENDER BY OBTAINING VOLATILE OILS APPLYING STEAM DISTILLATION
/
VALORIFICAREA SUPERIOARA A LAVANDEI PRIN OBTINEREA DE ULEIURI VOLATILE APLICAND METODA DISTILARII CU VAPORI DE APA

Eng. Grigore I., Ph.D. Eng. Sorica C.*1), Ph.D. Eng. Vladut V.1), Ph.D. Eng. Matache M.1), Ph.D. Stud. Eng. Cujbescu D.1), Ph.D. Stud. Eng. Sorica E.1), Eng. Dumitru I.2), Eng. Oprescu M.R.3)
1)INMA Bucharest / Romania; 2)Power Group International S.R.L. / Romania; 3)Condor Comimpex S.R.L. / Romania
Phone: +40212693250; E-mail: ionica_grigore2001@yahoo.com

Keywords: *medicinal plants, technology, volatile oil, floral water distillation*

ABSTRACT

The present paper aim to bring a wide and updated information regarding to necessity of establishing medicinal and aromatic plant cultures (lavender, mint), to outline the large variety of products to be obtained from these plants and last but not least, the method currently used at volatile oil extraction. The paper is addressed both to specialists in larger farms and family, emphasizing the most important aspects for essential oils obtaining in favourable economic conditions.

REZUMAT

Prezenta lucrare îşi propune să ofere o informaţie cât mai bogată şi actualizată asupra unor aspecte privind necesitatea infiintarii culturilor de plante medicinale si aromatice (lavanda, menta), sa evidentieze paleta larga a utilizarii produselor ce se pot obtine din aceste plante si nu in ultimul rand metoda folosita in mod curent la extractia uleiurilor volatile din aceste plante. Lucrarea se adresează atât specialiştilor, fermieri în exploataţii mai mari, cât şi asociatiilor familiale, evidenţiind aspectele cele mai importante pentru obţinerea de uleiuri esentiale în condiţii economice avantajoase.

INTRODUCTION

In our country, the most common variety of lavender is that with narrow leaves, having width of 3-4mm and a length of 30-40mm named *Lavandula angustifolia*. To achieve lavender plantation over an area of 1 hectare, about 18000-19000 seedlings which need 3 years to reach maturity and production, can reach 4000-4500 kg/ha of green flower (fresh).

If the summer harvest is done properly, it can be done a second harvest in autumn in the fall, out of which still get 1000-1500 kg more lavender flower.

Lavandula angustifolia is a perennial, considered small shrub, because the branches get woody. There are eternal leaves, even in winter, usually leaves are silvery green, but there are varieties with green or silver leafs. They reach maturity in 2-5 years and can live 30-40 years. The benefits of lavender essential oil: lavender has a calming scent, which makes it an excellent tonic for nerves. Therefore, helps in treating migraine, headaches, anxiety, depression, nervous tension and emotional stress, induces sleep and is often recommended for insomnia. It is also an excellent remedy for various types of pain, including those caused by sore muscles, tense muscles, rheumatism, sprains, backache and lumbago. Lavender oil is beneficial for urinary tract because it stimulates urine production. It helps to restore hormonal balance and reduces cystitis or bladder inflammation. Also, it is widely used for various respiratory problems including throat infections, flu, cough, asthma, sinus congestion, bronchitis, whooping cough, laryngitis and tonsillitis. This oil is used either as vapour or applied to the skin of the neck, chest and back. It is also added to vaporizers and inhalers for cold and cough. The medical benefits of lavender oil in terms of skin can be attributed to its antiseptic and antifungal properties. It is used to treat various skin conditions such as acne, wrinkles, psoriasis and other inflammations. It may treat wounds, cuts, burns, sunburn, because it helps generating scar tissues.

Regarding **mint**, in our country, there are culture varieties "Column", "Cordial" and "Cristal", At Mentha piperita, respective "Mencris" and "Record" on Mentha crispa. Peppermint is multiplied by heels or cuttings rooting stems heel start node. Propagation material must originate from organic peppermint crops which are withdrawn. Heels harvesting for establishing new culture should be done in planting rhythm. For establishing 1 hectare a quantity of 1.2-1.4 t heels is necessary. Productivity mint can be between 15t and 20t of green plant per 1ha.

Aerial parts harvested during flowering contain 0.3-0.5% volatile oil and the leaves 1-2% volatile oil with different chemical composition according to origin. The main component of the essential oil of peppermint is menthol (up to 70%) and menthone, menthofuran, α-pinene, phellandrene, limonene, cadinene, cineol, acetaldehyde and valerate, amyl alcohol and isoamyl thymol, carvacrol, sesquiterpenes alcohols, caryophyllene.

Pharmacodynamic action: is provided by volatile oil composition and the presence of other substances in the plant, mint-eupeptic having tonic action, slightly analgesic and carminative. Peppermint oil is in small quantities especially exciting action on sensory nerve endings in the skin and mucous heat. To produce excitation period began feeling cold, then a sensation of warmth emphasized. It also has antispasmodic action on smooth muscle. It is used in dyspepsia, nausea, pyloric spasms, gastrointestinal and biliary dyskinesia.

Enter in numerous medicinal teas: anti-asthmatic, anticolitis, diarrhoea, diet, gastric, hepatic no. 2, etc. The volatile oil enters in different pharmaceuticals (Carbocif, Colebil, Boldocolin, Inhalant etc.) and corrective to the taste of some medicines, massages, inhalations etc. Peppermint is used successfully in recipes juices, frozen candy etc.

MATERIAL SI METHOD

Technologies for volatile oils achieving

Industrial extraction of essential oils from various herbs is achieved by different methods depending on their specific attributes. Each method is important and has its place in production of essential oils. The main methods of obtaining essential oils are:
- Distilled by water vapours;
- Extraction of volatile oils by organic solvents;
- Extraction by animal fat: enfleurage and maceration;
- Extraction by liquefied gas (supercritical CO2);
- Extraction by pressure;
- Adsorption on an adsorbent material.

Water vapour distillation is the method used currently for volatile oil extraction in most herbs; it is frequently used for industrial-scale extraction, but also has widespread use in the laboratory.

By this method, water vapour enters in vegetative mass, subjected to distillation, destroy the cover oil glands, volatilize oil and then mix with it. The mixture of water vapour and oil vapour passes into the condenser (condensing vessel), where it turns into a liquid that is nothing but the mixture of water and essential oil. This mixture reaches the Florentine vessel (separation vessel) where the separation takes place, namely, volatile oil being lighter will be deposited in layer above the water.

Advantages of water vapour distillation:
- Convenient for almost all herbs, with exception of jasmine;
- Time save: distillation begins immediately after loading;
- Controlled distillation duration, because is not expected to warm water as the hydro-distillation;
- Allow distillation from different herbs;
- Allow distillation of herbs which need high temperature;
- Good conditions of vapour diffusion;
- Steam pressure is adjusted depending on boiler;
- Distillation high speed;
- Well used properly yield;
- Good quality oil.

Obtaining plant for distilled volatile oils - EUV 500, used for experimentation, is composed of the following main elements: boiler source steam that sits raw materials, refrigerant vessel and vessel for separating Florentine vessel for separation of volatile oil and flower water.

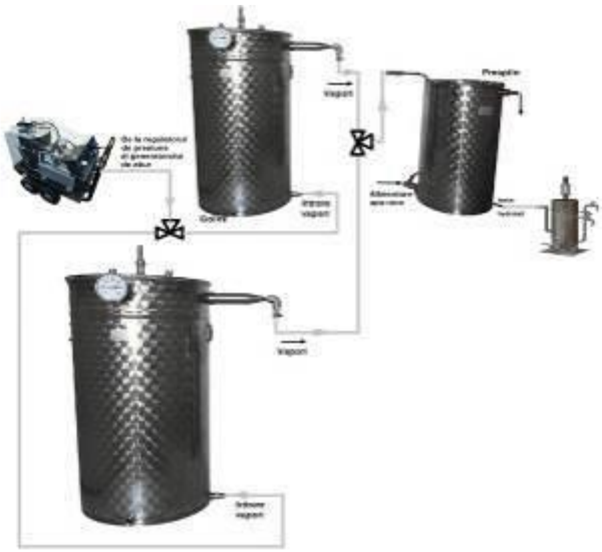

Fig. 1 - EUV 500 equipment for volatile oils obtaining by distillation equipped with alternative power (EAA-1000)

To eliminate unproductive time, consumed with downloading the charge of used plants from the vessel after its cooling, cleaning and loading a new plant charge was implemented a solution that makes possible to extract oil from plants without breaks. For this purpose, the EUV-500 equipment was equipped with a second distillation vessel, with a capacity of 1000 litres, afferent taps and connecting hoses that allow an alternative switching and steam supply of the two distillation vessels (alternative power equipment - EAA-1000).

All elements that come into contact with products subject to or obtained during processing are made of material compatible with food.

Steam source is an electric generator to produce steam under pressure.

Distillation boilers (tanks) with capacities of 500 litres, respectively 1,000 litres, are provided at the top with inside temperature indicator display and safety valves that open if there is overpressure. Cooling vessel and coil are designed to reduce the temperature of volatile elements obtained from distillation, in order to condense. Essences separator (Florentine vessel) serves to separate the essential oils from flower water obtained previously. The connections between installation components are made only through stainless steel fittings and tubes, and special hoses, resistant to high temperatures and pressures.

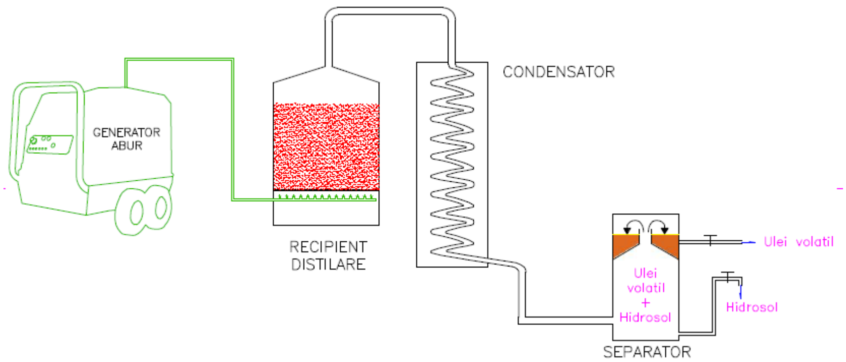

Fig. 2 - Technological scheme of equipment for obtaining essential oils EUV 500

Main technical characteristics of the installation for obtaining essential oils through distillation are:

- Working capacity of vessel 1: approx. 350 l (35kg - 40kg);
- Working capacity of vessel 2: approx. 700 l (70kg - 80kg);
- Working pressure: 0.18 – 0.2 bar;
- Working temperature: 103 - 105°C.

RESULTS

In order to conduct experimental research, two varieties of medicinal plants (lavender and mint) were used, both fresh harvested and dry. Parameters registered during experiments, are presented in the table below.

Table 1

Parameters determined for lavender, distillation vessel 500l, respectively 1000l

Parameters	Freshly harvested lavender		Dry lavender	
	500 l vessel	1000 l vessel	500 l vessel	1000 l vessel
Charge weight, [kg]	37.67	73	34	67.67
Temperature, [°C]				
- air	30.33	30.33	29.33	29.33
- cooling water	20.33	20.33	20	20
- steam pipe at generator output	130.33	130.33	130.33	130.33
- steam pipe at distillation vessel input	107.5	107.5	107.33	107.33
- steam in distillation vessel	105	105	105	105
- steam pipe at cooling water input	91.33	91.33	91	91
Test time, [min]	65	121.67	61.67	115
Resulted products volume, [l]				
- oil	0.273	0.41	0.197	0.33
- flower water	22.33	39	22.67	35.67

Table 2

Parameters determined for mint, distillation vessel 500l, respectively 1000l

Parameters	Freshly harvested mint		Dry mint	
	500 l vessel	1000 l vessel	500 l vessel	1000 l vessel
Charge weight, [kg]	40.66667	73.33	42	75.33
Temperature, [°C]				
- air	30.33	30.33	31	31
- cooling water	20.33	20.33	20.33	20.33
- steam pipe at generator output	130.33	130.33	130.33	130.33
- steam pipe at distillation vessel input	107.5	107.5	107.5	107.5
- steam in distillation vessel	105	105	105	105
- steam pipe at cooling water input	91.33	91.33	91.33	91.33
Test time, [min]	66	113.33	61.67	120
Resulted products volume, [l]				
- oil	0.18	0.35	0.21	0.38
- flower water	23	35.33	23	37.33

CONCLUSIONS

To eliminate unproductive time, consumed with downloading the charge of used plants from the vessel after its cooling, cleaning and loading a new plant charge was implemented a solution that makes possible to extract oil from plants without breaks, by alternatively switching and supplying with steam of the two distillation vessels.

After experimental data analysis the following conclusions were drawn:

- process duration and the volume of products obtained after distillation with water (oil and flower water) varies proportionally to the mass of processed charge;
- in case of lavender, the oil volume obtained when processing a freshly harvested charge is higher than the one resulted after processing a dry charge;
- in case of mint, the oil volume obtained when processing a dry charge is higher than the one resulted after processing a freshly harvested charge.

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NATURAL AMBIENT LIGHT MONITORING IN GREENHOUSES WITH POLYETHYLENE FILM ROOF
/
MONITORIZAREA LUMINII AMBIENTALE NATURALE IN SERE CU ACOPERIRE DIN POLIETILENA

Lect.. Ph.D. Eng. Ipate G.*[1)], Prof. Ph.D. Eng. Voicu Gh.[1)], Prof. Ph.D. Eng. Ilie F.[1)], Ph.D. Eng. Bogoescu M.[2)], Ph.D. Eng. Vintila M.[2)], Ph.D.Eng.Marin E.[3)]
[1)] Universities Polytechnic Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
[2)]HORTING Bucharest; [3)]INMA Bucharest
Tel: 0766445321; E-mail: puiuipate@yahoo.com

Keywords: *ambient light, greenhouse, Arduino, Android*

ABSTRACT

The advantages that modular electronic devices offer nowadays are almost unlimited and, to a great extent, this diversity is based on the existence and usability of different types of sensors to some low costs. In our work, the combination of Arduino, different light digital sensors, a Bluetooth module and a mobile device, can provide valuable assistance to small entrepreneurs in vegetable and horticulture industry. The results indicate that this system of monitoring natural ambient light in a greenhouse with a sensitivity similar to other electronic devices, however without purely scientific accuracy instruments, but enough for someone without much experience. This shows that robust research prototypes today can obtain promising results with a very low cost, offering an alternative to limited budgets.

REZUMAT

Avantajele pe care dispozitivele electronice modulare le oferă in zilele noastre sunt aproape nelimitate şi, într-o mare parte, această diversitate se bazează pe existenţa si uşurinţa in utilizare a unor diferite tipuri de senzori, la niste şi costuri reduse. În lucrarea noastră, combinaţia dintre Arduino, diferiti senzori digitali de lumina, un modul bluetooth si un dispozitiv mobil, poate oferi un ajutor insemnat micilor intreprinzatori din domeniul industriei legumiculturii sau horticulturii. Rezultatele indică faptul că acest sistem de monitorizare a luminii ambiante naturale dintr-o sera are o precizie similară cu alte dispozitive electronice, cu toate acestea, fără acurateţea instrumentelor pur ştiinţifice, dar suficient pentru un utilizator fara prea multa experienta. Acest lucru arată că astăzi prototipuri de cercetare solide pot obtine rezultate promitatoare la un cost foarte scăzut, oferind o alternativă pentru bugete limitate.

INTRODUCTION

Horticultural crops represent an important sector of the economy, generating approximately 25% of total crop production in our country. The vegetable food and ornamental crops in the greenhouse industry impose their own needs, which significantly affect their ambient conditions in a nonlinear way. Product supply and market demand determine wholesale prices that growers can expect to receive for their horticultural products. The contribution of smart technology device to agriculture has been a real revolution to traditional agriculture that has made possible the increases of productive areas of the world with the incorporation of areas with unfavourable climatic conditions.

According to several papers from the specialty literature *(*Kolhe et al., 2011*;* Fitz-Rodriguez et al., 2010; Montoya et all., 2013; Hastriyandi et al., 2014*)*, advances in the field of Internet has opened up new challenges as well as opportunities to fulfil the increasing needs for up-to date and precise information in agriculture. Nowadays web tools have been developed for numerous applications in agriculture such as the diagnosis of diseases of the oilseed-crops, and for modelling and simulation of greenhouse environments under several scenarios. The developed web application allows improving the quality of life of farmers; due they do not need to be in situ so long to control their greenhouse climate parameters.

As described in the paper *(Ipate, 2015)*, plants respond strongest to blue and red light for **photosynthesis** and to red and infra-red light wavelengths for photoperiod growth responses and germination control. Within the chloroplasts of plant cells, light energy is used to convert atmospheric carbon into carbohydrates in a process called photosynthesis (Raven, 1999). Photosynthesis, flowering, climate response and plant shape are strongly influenced by the intensity, duration, direction, and spectral quality of light radiation that plants receive. Because light is essential to plant growth and life it is absolutely necessary for us to know, maintain or improve its quality.

This paper presents an independent mobile system based on Arduino and Android app for monitoring natural light ambient quality in the greenhouse. The system was designed based on analysis of the existing solution. Open source software such as MIT App Inventor was used to develop the Android application. The app stores some of the most common field test parameters in a greenhouse like air humidity and temperature, natural light intensity, light spectrum, UV radiation. The data are saved and stored online in an experimental data visualization web application from Google Research named Fusion Table. Our application, as a part of the national agriculture strategy, provides to farm managers a wide range of possibilities in computer modelling and data storage. For this reason, the decision makers in government must find mobile apps like App LightGreenhouseData a supplement to keep farmers informed. It is also an example of the versatility of personal mobile computing and its use in research, education and outreach. Cloud systems in urban agriculture settings also allow high efficiency and high utilization of pooled resources. The success of these new approaches will be decided, by the viability of the agricultural strategy models. Field testing conducted in our campus verified the functionalities of the mobile network and its practical application in the actual environment, and they meet greenhouse management standards. Results show that proposed solution is able to collect and present data in a mobile environment.

MATERIAL AND METHOD

Light is a form of electromagnetic radiation that is visible to the human eye. A small fraction of the total electromagnetic spectrum that includes gamma rays, x-rays, and radio waves (fig. 1), is the radiation that we perceive as sunlight or the visible spectrum. Plants respond strongest to blue and red light for **photosynthesis** (fig. 2) and to red and infra-red light wavelengths for photoperiod growth responses and germination control (Ipate, 2015).

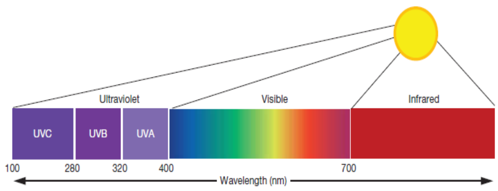


Fig. 1. Electromagnetic light spectrum

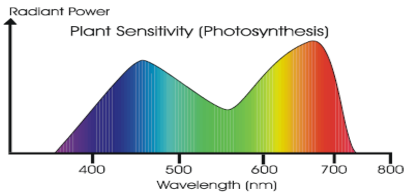


Fig. 2. The emission spectrum of plant receives

In the real world the terms intensity and irradiance are sometimes used interchangeably, but from scientific standpoint irradiance is the UV arriving at a particular (cure) surface based on a specified area – in our case of a square centimetre (cm^2).

The proposed monitoring system presented in fig.3 has two main parts, hardware and software. The main component of hardware section is the **Arduino Mega 2650**, a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The microcontroller ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the boot loader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library). The main board can be programmed flexibly to provide specific features regarding requirement function in the intelligent system, such as data handling (averaging, calibrating and smoothing), data transfer (HTTP protocols) and SD-card storage.

Light sensor information is a key factor in integrated control systems, since the amount of light received influences all growth variables. The ***VEML6070* UV Light Sensor,** provided by Vishay Semiconductors**,** is an advanced ultraviolet (UVA) light sensor designed with a CMOS process and featuring an I2C protocol interface. The VEML6070 incorporates a photodiode, amplifiers, and analog/digital circuits into a single chip (fig. 4); shows linear sensitivity to solar UV light, which can easily be adjusted by selecting the proper external resistor (Scharr, 2015). The ***BH1750FVI Sensor*** is a digital Ambient Light Sensor IC for I2C bus interface. This IC contains an integrating analog-to-digital converter (ADC) that integrates currents from photodiode for obtainment Digital 16bit data. It is possible to detect wide range at High resolution (1-65535 lx)**.** The ***TCS34725*** device (fig. 5) provides a digital return of red, green, blue (RGB), and clear light sensing values. An IR blocking filter, integrated on-chip and localized to the colour sensing photodiodes, minimizes the IR spectral component of the incoming light and allows colour measurements to be made accurately. The high sensitivity, wide dynamic range, and IR blocking filter make the TCS34725 an ideal colour sensor solution for use under varying lighting conditions and through attenuating materials. ***Air Temperature and Humidity Sensor (DHT22)*** is a high accuracy sensor used in various conditions. It consists of a capacitive sensor element used for measuring relative humidity and a negative temperature coefficient (NTC) thermistor used for measuring temperature. Small dimension, ultra-low power consumption, more than 20m's signal transmission distance makes it a good selection for various application environments. The accuracy of this module can gets up to 0.3 degree in temperature and 2% in relative humidity.

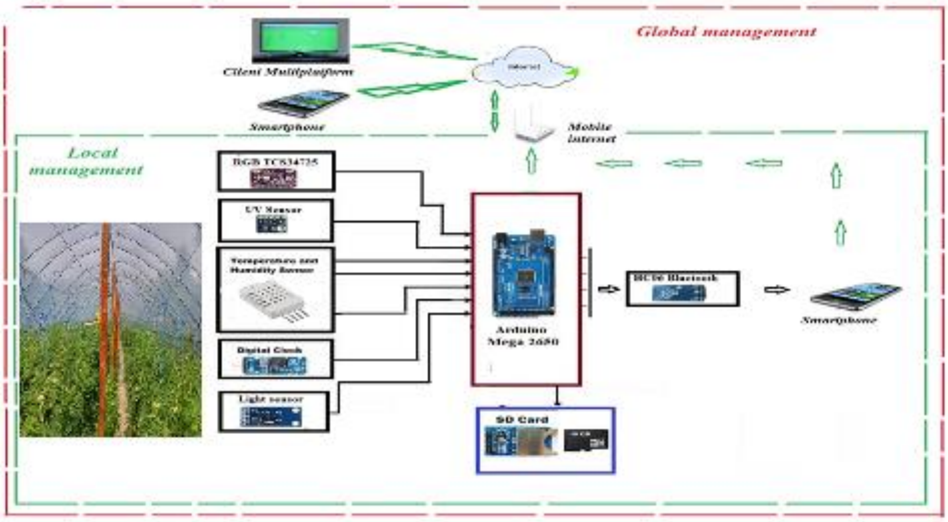


Fig. 3 - Block diagram of ambient light monitoring system

The ***DS3231 RTC chip*** is a low-cost, extremely accurate I²C real-time clock (RTC) with an integrated temperature-compensated crystal oscillator (TCXO) and crystal. The device incorporates a battery input, and maintains accurate time keeping when main power to the device is interrupted. The integration of the crystal resonator enhances the long-term accuracy of the device as well as reduces the piece-part count in a manufacturing line. ***HC-06 Bluetooth module*** is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Blue core 04-External single chip Bluetooth system with CMOS technology and with Adaptive Frequency Hopping Feature (Ipate, 2016).

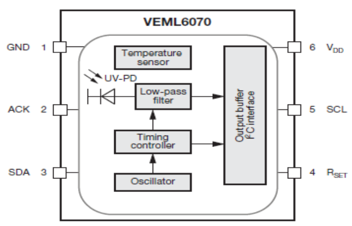


Fig. 4 - Block Diagram of VEML 6070 UV sensor

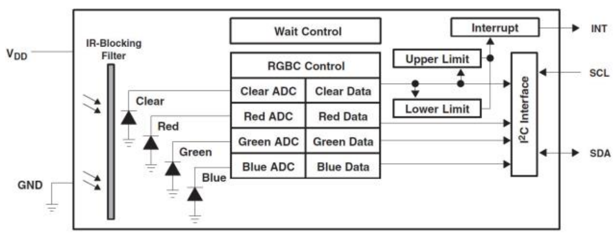


Fig. 5 - Functional Block Diagram of TCS 34725 Colour Light-to-Digital Converter sensor

Software implementation of our control system uses Arduino software and MIT App inventor. The program code is writing in Arduino Software, which supports the Arduino packages. The MIT App inventor software is used to develop the Android apps. The data are saved and stored online by using the mobile app which is designed for this project.

The ArduinoCode is implemented in the Arduino software. Firstly, we initialize the variables that control the input pins of the sensor signal and declare variables that will be used for communication with the mobile app. Then we define the pins which are used to serial communication. The communication must setup to 9600bps because we configured the Bluetooth module to that speed.

MIT App Inventor apps implementation. To implement and test this sample code we use a Xiaomi RedmiNote2 phablet (2.1GHz Octa-core CPU, 2GB RAM and 32GB Internal memory) running Android 5.0. We also tested this code using a Samsung Galaxy Young 2 smart phone running Android 4.4.2.
For example, GPS coordinates are entered when GPS is turned on in mobile devices settings and a signal is available. If a GPS signal is not available, triangulation methods using cell towers and known wireless networks are used to estimate position. Sequence of commands that specifies the action to be performed is shown in figure 6.

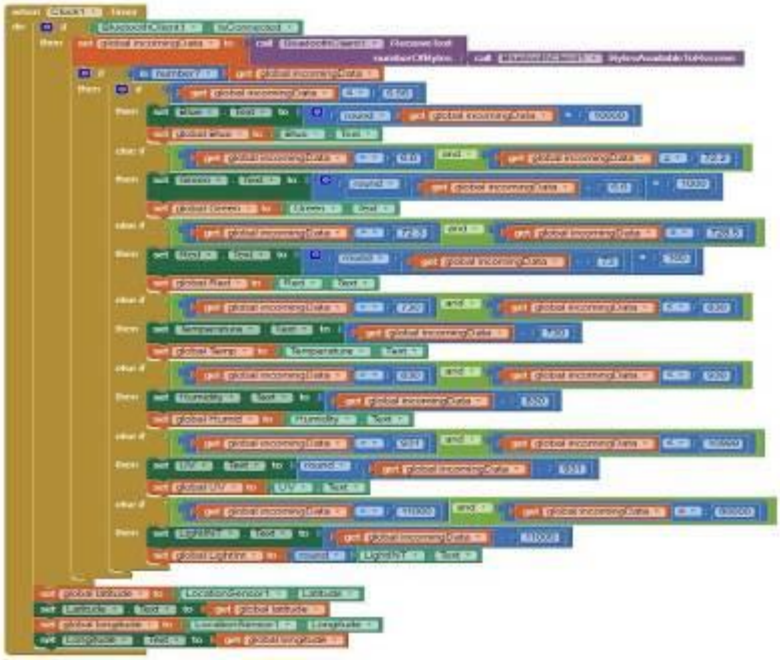


Fig. 6 - Sequence of block code in App Inventor 2

RESULTS

In order to test the use of sensors, we have conducted several series of measurements to check the system and data accuracy. When a change in temperature occurs, optical elements physical size changes, the same as their refractive index. Both changes contribute to an apparent change in distance. This measurement error is a fixed value and is only a function of the change in sensor temperature, not the distance measured.

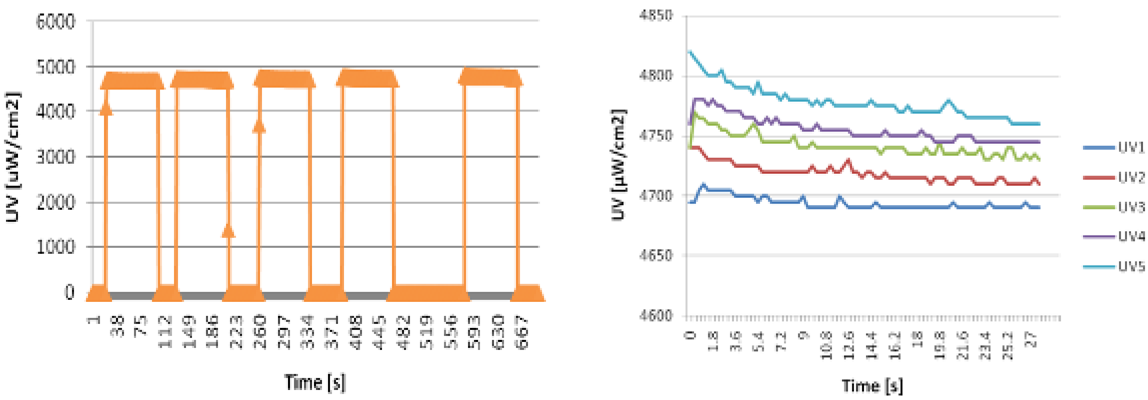


Fig. 7 - The measurement accuracy and repeatability of VEML6070 UV sensor

Fig. 7 depicts the VEML 6070 UV sensor test measurements with respect to time. Thermal drift are also presented in the same figure. For this example, accuracy, and short-term repeatability will be determined. This type of optical sensor has a typical thermal drift value of 41.5 µW/cm^2 per degree C. Optics thermal drift can be reduced by either controlling the temperature of the measurement environment or by using sensor that are insensitive to temperature changes.

The Android app main screen is shown in Fig. 8. The main screen displays a sensor values transmitted via the Arduino board and Bluetooth device, location and risk index measurements of ultraviolet radiation exposure.

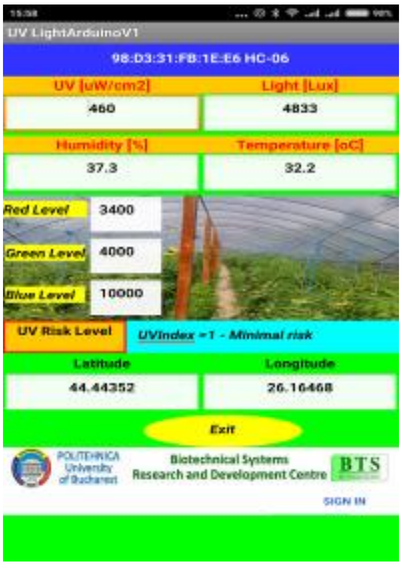
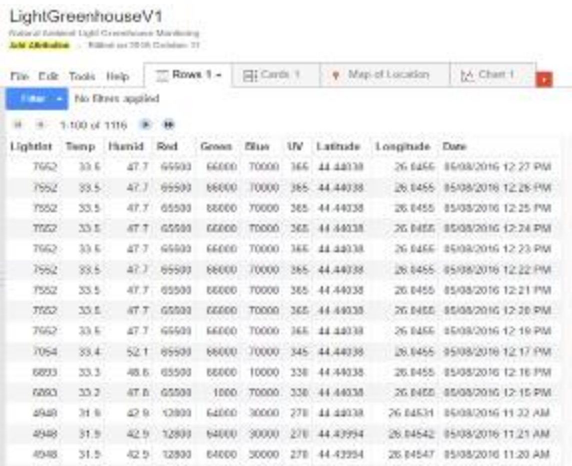


Fig. 8 - Main screen of LightGreenhouseV1 Android app

Data are saved to a local database, on SD memory card, and an online Google Fusion Table (fig. 9) until the "Reset" button is pushed with a long click. To use the Google Fusion Table, users will need a Gmail account. Users don't have permission to edit the source code of this app. In the Google Fusion Table all associated data will be saved in rows under light intensity, air temperature, air relative humidity, RGB light spectrum, latitude, longitude, and date columns. The rows will be repeated for each data entered. To retrieve data from Google Fusion Table, the file can be downloaded as a csv file. To view the demonstration online Google Fusion Table go to: https://fusiontables.google.com/DataSource?docid=1I4QjFGFiUKZ9UaJpkER8ntbNYuFtrIMJQ7BQBwgV#rows :id=1.



LightGreenhouseV1

File Edit Tools Help | Rows 1 | Cards 1 | Map of Location | Chart 1

No filters applied

1-100 of 1116

Lightlnt	Temp	Humid	Red	Green	Blue	UV	Latitude	Longitude	Date
7562	33.6	47.7	65500	66000	70000	366	44.44038	26.0456	05/08/2016 12:27 PM
7552	33.5	47.7	65500	66000	70000	365	44.44038	26.0455	05/08/2016 12:26 PM
7552	33.5	47.7	65500	66000	70000	365	44.44038	26.0455	05/08/2016 12:25 PM
7552	33.5	47.7	65500	66000	70000	365	44.44038	26.0455	05/08/2016 12:24 PM
7562	33.6	47.7	65500	66000	70000	366	44.44038	26.0456	05/08/2016 12:23 PM
7552	33.5	47.7	65500	66000	70000	365	44.44038	26.0455	05/08/2016 12:22 PM
7552	33.5	47.7	65500	66000	70000	365	44.44038	26.0455	05/08/2016 12:21 PM
7552	33.5	47.7	65500	66000	70000	365	44.44038	26.0455	05/08/2016 12:20 PM
7562	33.6	47.7	65500	66000	70000	366	44.44038	26.0456	05/08/2016 12:19 PM
7054	33.4	52.1	65500	66000	70000	345	44.44038	26.0455	05/08/2016 12:17 PM
6893	33.3	48.6	65500	66000	10000	338	44.44038	26.0455	05/08/2016 12:16 PM
6893	33.2	47.6	65500	1000	70000	338	44.44038	26.0455	05/08/2016 12:15 PM
4948	31.9	42.9	12800	64000	30000	278	44.44038	26.04531	05/08/2016 11:22 AM
4948	31.9	42.9	12800	64000	30000	278	44.43994	26.04542	05/08/2016 11:21 AM
4948	31.9	42.9	12800	64000	30000	278	44.43994	26.04547	05/08/2016 11:20 AM

Fig. 9 - Light Greenhouse Google Fusion Table

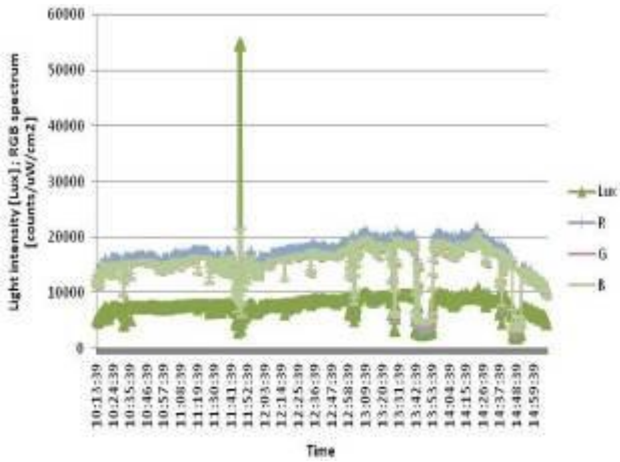


Fig. 10 - Variations of the average values of static friction

Figure 10 contains natural ambient light spectrum measurements conducted in the greenhouse located on the campus of Polytechnic University of Bucharest for several hours (10.00-15.00), on 07/21/2016.

CONCLUSIONS

Our light monitoring system is a community of stackable, modular and autonomous component modules that combine to create a community of smart sensing instruments that is unfettered by the limits of traditional optical sensing instrumentation. Autonomous instrument modules allow users to customize the system to their changing application needs, and Wireless connectivity plus SD card data storage capability facilitate remote operation.

Results of experimental tests have shown that the proposed wireless light monitoring system ensures optimal working conditions. This is particularly important for farmers, especially on weekends, because without a monitoring system, the farmer should go in the greenhouse to ensure that everything is working properly. However, in its current state, this prototype system is already prepared for deployment in real-world test beds and is an adequate low-cost alternative for highly expensive industrial light measurement instrument. As a future directive, full implementation of the proposed system must be taken into consideration.

Following the philosophy of open knowledge, anyone interested in the field, specialists or students, can use and/or adapt those presented in this study, because all components are open, hardware and software is open source.

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STUDY ON FODDER HUMIDITY LOSS UNDER THE INFLUENCE OF THE AERATION AGENT / *STUDIUL PIERDERII DE UMIDITATE A FURAJULUI SUB INFLUENTA AGENTULUI DE AERARE*

PhD. Stud Eng. Zaica A.*[1], PhD. Eng. Nedelcu A.[1],PhD. Eng. Ciupercă R.[1], PhD. Eng. Popa L.[1], PhD.Stud.Eng. Zaica Al.[1], PhD. Eng. Sorică C. [1]
I.N.M.A. Bucharest / Romania
Tel: 0728977317; E-mail: acanpeanu@yahoo.com

Keywords: *fodder, drying, humidity, temperature, drying time*

ABSTRACT

Livestock farmers in mountainous or hilly areas are interested in the fact that the meadow surface they operate provide the necessary feed for animals throughout the calendar year. The essential characteristic of fodder plants is the full use of plant mass; therefore, it was aimed to apply technologies of harvesting, conservation and storage to reduce losses and to maintain nutritional qualities of animal feed.

This paper addresses some experimental issues regarding the influence of conditions to realize the drying process through fodder ventilation for preservation and storage. In the research, the environment parameters have been analysed: temperature, solar radiation, humidity, obtaining information about their influence on the drying time.

REZUMAT

Crescătorii de animale din zona colinară sau montană sunt interesaţi ca suprafaţa de pajişti pe care o exploatează să asigure necesarul de furaj pentru animale pe întregul an calendaristic.Plantele furajere audrept caracteristică esenţială utilizarea integrală a masei vegetale, de aceea s-a urmărit aplicarea detehnologii de recoltare,conservare şi depozitare care sa reducă pierderile şi sa menţină calităţile nutritive alefurajelor.

Lucrarea de faţă abordează unele aspecte experimentale privind influenţa condiţiilor de realizare aprocesului de uscare prin ventilare a plantelor furajere, în vederea conservării şi depozitării.În cadrul cercetărilor au fost analizaţi parametrii mediului ambiant: temperatura, radiaţia solară, umiditatea, obţinându-se informaţii privind influenţa acestora asupra duratei de uscare.

INTRODUCTION

Over the time, the grass was the first and most important source of food for domestic animals and later cultivated fodder was added. In the current modern and sustainable agriculture, farming occupies an important place, providing a big part of the food to people, but the development in this area depends on providing the necessary fodder (*Mocanu V. and Hermenean I*., *2013*).

Harvesting, preparing and fodder crops preserving as hay is basic and is the traditional method with the most common occurrence in our country to capitalize fodder on meadows and fodder crops, especially in hilly and mountainous areas.

Due to the specific conditions of climate and relief, our country has a surface area of approx. 1,500,000 hectares of meadows situated on natural or cultivated pastures and approx. 770,000 ha are planted with fodder crops, grasses and legumes. Natural grasslands, located mainly in hilly and mountainous areas, are a national wealth, providing over 25% of the fodder necessary. (*Hermenean I. et al., 2006*).

Obtaining fodder, particularly valuable, in these fields requires a focus on the rational use of grasslands by using methods and technologies of harvesting and preservation with minimal losses and reduced costs, while weather conditions allow cultivating forage grasses and legumes which through conservation as hay contribute to fodder necessary throughout the year.

Livestock farmers from hilly or mountainous area want that the grassland surface they exploit provides the necessary fodder for the entire calendar year. The problem arises with the increasing altitude; the number of days required for indoors maintenance of animals in cold weather also increasing and the unfavourable weather conditions. Thus, at altitudes above 900 m, indoors period during the winter is equal to the pasturage (*Frederiksen H.et al., 2010*).

To get the desired floristic composition, it is necessary to establish the proportion between the two groups of plants (grasses and legumes) to take into account the duration and the use of grasslands, as well as biological peculiarities of the species components. (*Samuil C.*, *2009*).

Among other determinants that influence the quality of the hay meadows besides the floristic composition are also the harvest time, the way of forage preparation and storage and the weather conditions during harvesting and preparation (*Mocanu V. and Hermenean I*., *2013*) which will be presented in this article. Therefore, special attention is necessary for plants harvesting, drying and storage to keep as much of the foliage mass, thus ensuring a richer content in nutrients and vitamins.

Green forage, freshly mowed, contains a large quantity of water between 70 and 85%. Shortening the time period until fodder preservation as hay is possible by reducing as fast as possible the initial humidity of the fodder so that it reaches, in the end, less than 18%. In order to reach this objective it's necessary to actually facilitate the evaporation of water from the green mass.

In order to reduce the drying time and the loss of nutrients, a series of processes of hay collecting, preparation and preservation have been developed. The biggest losses of nutrients are registered when fodder is traditionally dried in the field, reaching, in case of bad weather, even 50 ... 60%, the drying time increasing to more than 6 ... 8 days, and the smallest losses of 4 ... 5% are obtained in case of green fodder dehydration in special drying and briquetting stations.

Air relative humidity has a considerable influence on the rate of dehydration. Increasing air relative humidity reduces its ability to absorb water vapour in the fodder, slowing the evaporation, while a low air relative humidity causes a water forced removal from the product, generating ruptures of cell membranes *(Cioabla A., 2010)*. Hay preparation using cold or warm air ventilation in the drying process using aeration by means of the ventilation installation consists in removing water from the feed in the shortest time possible by using the air currents introduced by a fan. Thus, the loss of nutrients and vitamins, as well as the mechanical losses are much lower, and the harvested hay is green, it has pleasant flavour and is rich in vitamins *(Nedelcu A.et al., 2011)*. This method is used to prepare the most valuable fodder of alfalfa, clover, fodder from sown meadows, high productivity permanent pasture.

MATERIAL AND METHOD

Description, component parts

The installation for finalising hay drying is designed to reduce the humidity of stored fodder, from a humidity of 35 ... 40% to approx. 17%, by cold or heated air ventilation, for long time conservation under optimal conditions and for obtaining quality fodder which falls in the last phase of fodder drying technology (Fig.1).

Fig. 1 –The phases of fodder drying technology by air ventilation

The experimental model of the installation (Fig.2) uses free air, both cold and heated; it was produced at INMA Bucharest being destined to finalising drying by cold / hot air ventilation in fodder aeration process. In order to heat the air necessary for ventilation, the installation uses solar radiation which is transformed into heat with the help of solar panels (Fig. 2, position 1) and transported through aluminium tubes (Fig. 2, position 5).

Fig. 2 - The experimental model of the installation for fodder aeration

1. Assembled solar panel; 2. Electrical installation; 3. Ventilation equipment;
4. Ventilation tubes placed in the fodder; 5. Pipes for hot air circuit;
6. Drying platform (uniformity chamber).

Installation functioning

The fodder gathered on the grassland (after drying in furrows) at a humidity of 35 ... 45% is placed evenly on the net-grid of the drying platform. Simultaneously, the vertical tubes with stopper are placed evenly in the fodder mass (Fig.2, position 4).

Before starting ventilation, the thermal resistance and the humidity sensor are introduced into the fodder mass and connected to the electrical installation (Figure 3).

Fig. 3 – Command and control panel with temperature and humidity sensors location

1. The temperature and humidity sensor; 2. Electric meter; 3. Thermal resistance.

The ventilation can start as soon as the grid in the uniformisation chamber was covered with a layer of material thick enough, approx. 1.5 ... 2 m, to prevent air loss. After successive loading of forage layers on the drying platform, the very operation of completing the drying process by ventilation is started. At first, the ventilation is made with cold air for about 24 hours, followed by hot air. For cold air ventilation the hot air flap in the tubes is closed (Fig.2, position 5), the air being taken directly from the atmosphere.

The ventilation equipment (Fig. 2, position 3) is made of an axial fan, and has the role of sending air under pressure through the main channel, the secondary channels and the stopper tubes in the mass of forage stored on the drying platform.

Methodology of experimental measurements

Depending on the time of harvesting and preserving forage as hay (spring, summer or fall) and the weather conditions specific to the harvesting period (rainfall, temperature and air humidity) is determined the drying process of the forage stored on the installation platform, following a number of decisive stages (Fig. 4). Given that a number of variable parameters influence the fodder drying process for optimum storage, in the study we'll determine the influence of aerating agent parameters.

Loading forage on the platform
- Fodder sits on the platform installation to a height of 3.5 ... 4 m, the work is recommended to be performed one day after the fan is turned on.
- If drying is done in several stages, when the first layer of forage reached the height of 1 ... 1.5 m, the fan is turned on, the layer of feed is filled to a height of 3.5 ... 4 m and piping vent up / extended up to the maximum height so as to be at the same level.

Drying time
- The duration of drying a layer of hay is a function of the size layer, the type of feed and the atmospheric conditions.
- Drying requires a layer 40 ... 60 h for ventilation, and a total of 4 layers, 160 ... 240 h, which is 10 ... 15 days.

Finish drying
- Drying fodder is considered completed when the last layer humidity fell below 20% or when the internal temperature stabilizes at 20 ° C after an interruption for 12 ... 24 h no longer heating up the feed.

Forage control
- After a break for 12 ... 14 hours is turned on the fan if the air is released from the feed is cold means that drying was complete and the feed will remain without loss.
- If the air exiting the feed is hot continue ventilation until completely dry.

Fig. 4 - Ventilation drying stages

If the air temperature is high and air humidity index is low, the completion of the drying process is carried out by cold air ventilation, since the water content of the plant is smaller and the drying process starts as soon as the plants were mowed. When air temperature is low and atmospheric humidity is high, completing the process of plants drying is carried out by ventilation with heated air. The ventilation program is adapted to weather conditions and fodder parameters when stored on the platform of the experimental installation (temperature, humidity). Within the technology for hot air drying of fodder, it is necessary, during the aeration process, to continuously monitor the temperature in the fodder mass, max. 30º C. When for ventilation drying hot air was also used, the drying process of drying completion ends with cold air, to ensure a balancing of the temperature in the fodder mass with the free air temperature, thus avoiding condensation.

The experiments consisted in conducting tests and measurements during the process in order to determine the influence of some parameters in the aeration drying process, namely: - the temperature and humidity of free air used as aeration medium in the drying process; - the temperature and humidity of the solar panel, part of the installation; - the temperature and humidity in the fodder mass placed on the installation platform for drying; - duration of aeration drying process.

During the tests of the experimental research were measured the parameters (temperature and humidity) of the air in the solar panel, which is a structure made of five solar collectors, positions 1, 2 and 3, mounted in series, one after the other, on a metal profile frame. The air necessary for ventilation is heated in the panel solar collectors by greenhouse effect. During ventilation, the cold free air is absorbed through the hole, position 4, it goes through the solar panel and is evacuated through the special hole (position 5) of the solar panel, continuing the route through the flexible suction pipes (position 6), towards the fan inlet hole to the platform uniformisation chamber. How measurements were made and their values are shown in Figure 6 and Table 1 while the graphical representation is presented in Figure 7.

Fig.5- Details for solar panel assembly

1. final collector; 2. intermediate collector; 3. air inlet-outlet collector; 4. air inlet port into panel; 5. air exhaust outlet from panel; 6. tubing.

Fig. 6 - Measurement of the air in the solar panel

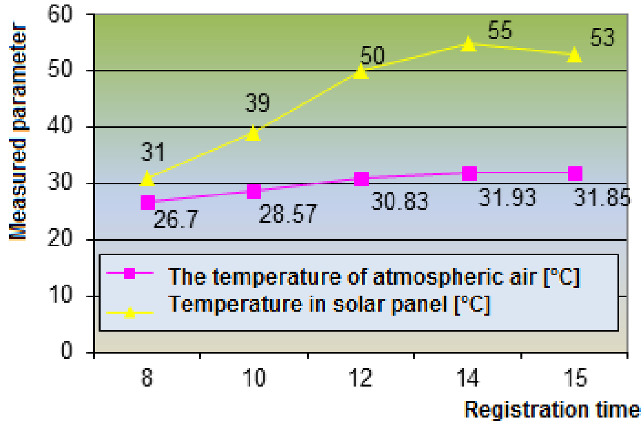

Fig. 7 - The variation of measured parameters during a day

Table 1

Measured parameters of air in the solar panel

Measured parameter	UM	Hour				
		8	10	12	14	15
Solar radiation	kW/hm^2	0.399	0.6632	0.7904	0.7008	0.5344
Free air temperature	°C	26.7	28.57	30.83	31.93	31.85
The temperature in the solar panel	°C	31	39	50	55	53

In order to measure fodder humidity during the aeration process, samples were collected from four different areas of the platform, to monitor whether the fodder dries evenly in the measured atmospheric conditions during the aeration process, Table 2.

Table 2

The results of measurements for determining fodder humidity

Data	Name of the sample/ harvesting time	fodder humidity [%]	Measured Parameters				Obs.
			atmospheric pressure [mm Hg]	average temperature [°C]		average humidity [%]	
				In the air	In the hay	In the air	
0	1	2	3	4	5	6	7
Day1 (20.06)	Fodder sample / 11^{00} taken from: zone 1: zone 2: zone 3: zone 4:	35.15 34.25 34.15 32.10	753.5	29.31	25 26 26 27	49.68	Ventilation 8 h
Day2 (21.06)	Fodder sample / 12^{00} taken from: zone 1: zone 2: zone 3: zone 4:	32.02 29.17 31.14 28.61	753.0	26.27	26 26 26 27	56.44	Ventilation 5 h (of which 1h hot air)
Day3 (22.06)	Fodder sample / 9^{30} taken from: zone 1: zone 2: zone 3: zone 4:	26.63 26.40 29.62 23.44	748.5.0	25.88	25 26 26 26	49.79	Ventilation 4 h (of which 1h hot air)

0	1	2	3	4	5	6	7
Day4 (23.06)	Fodder sample / 15^{30} taken from: zone 1: zone 2: zone 3: zone 4:	23.12 19.89 26.55 20.05	748.5.0	25.95	24 24 25 24	59.28	Without Ventilation
Day5 (24.06)	Fodder sample / 9^{30} taken from: zone 1: zone 2: zone 3: zone 4:	19.62 18.56 17.64 17.48	750.5	26.75	23 24 24 24	50.32	Ventilation 1 h
Day 6 (25.06)	Fodder sample / 8^{30} taken from: zone 1: zone 2: zone 3: zone 4:	14.89 15.57 15.66 14.46	752.0	30.05	22 23 20 20	40.94	Ventilation 1 h
Day 7 (26.06)	Fodder sample / 8^{00} taken from: zone 1: zone 2: zone 3: zone 4:	14.32 15.88 15.92 15.03	751.5	29.80	20 21 20 20	43.79	Ventilation 1 h
The hay drying process is considered completed							

RESULTS

The experimental research for the analysed period were carried out for 7 days, 21 hours of effective drying of the material deposited on the installation platform (Table 3) and interpreted graphically in Figures 8 and 9, show the variation of temperature and humidity of the air used as drying agent.

Table 3

The measurement results of aeration agent parameters

Day	U [%] atmospheric air		Day	T [°C] atmospheric air	
	Hour 8	Hour 14		Hour 8	Hour 14
1	57.95	41.42	1	26.7	31.93
2	70.55	42.34	2	23.5	29.05
3	63.64	35.94	3	21.65	30.11
4	69.25	49.32	4	23.5	28.4
5	60.52	40.12	5	24.1	29.4
6	52.33	29.56	6	26.5	33.6
7	50.61	36.98	7	26.4	33.2

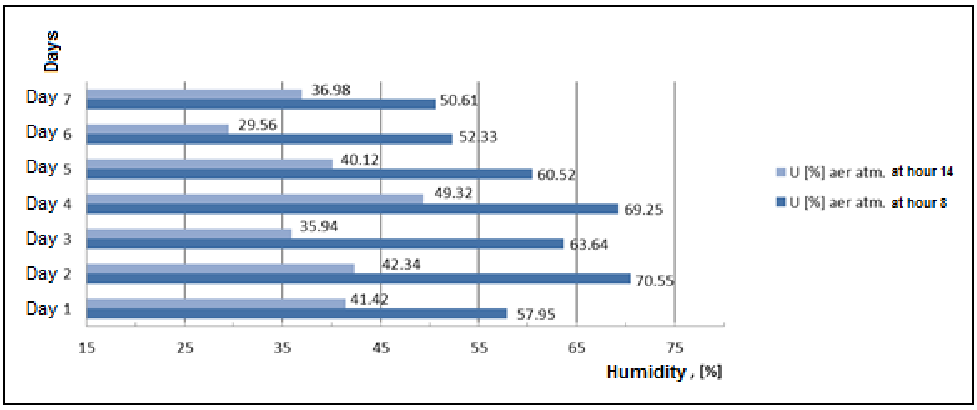

Fig. 8 - Humidity variation of aeration agent during the process

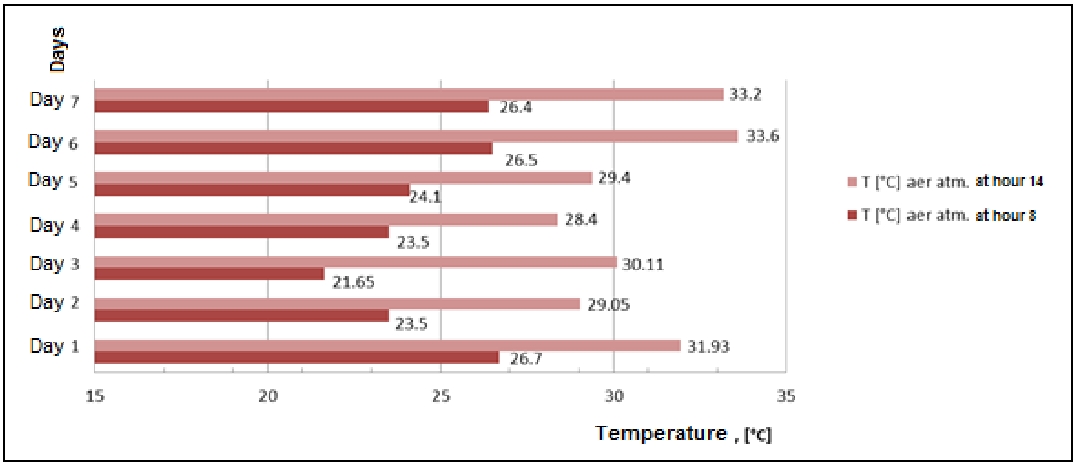

Fig. 9 - Temperature variation of aeration agent during the process

Table 4

The results of fodder humidity measurements

Day	No. hours of ventilation	U [%] of the samples by forage mass	
		Hour 7	Hour 15
1	8	35.15	34.15
2	13	32.1	27
3	17	26.63	23.44
4	18	22.32	20.13
5	19	19.62	18.56
6	20	17.64	17.48
7	21	17.3	15.66

Atmospheric parameters of the drying agent used in the aeration process directly influences the evolution of the temperature in the fodder mass causing uniform loss of fodder humidity in the four areas of the platform, while the analysis of data taken from Table 3 and the results of fodder humidity determination in the laboratory, using the existing measuring instruments and drying chamber, table 4, aims is aimed at decreasing the humidity of the stored fodder.

In Figure 10 is showed the decreasing variation of moisture in the material subjected to drying (fodder) throughout the duration of the process, which is an objective in optimizing the aeration process.

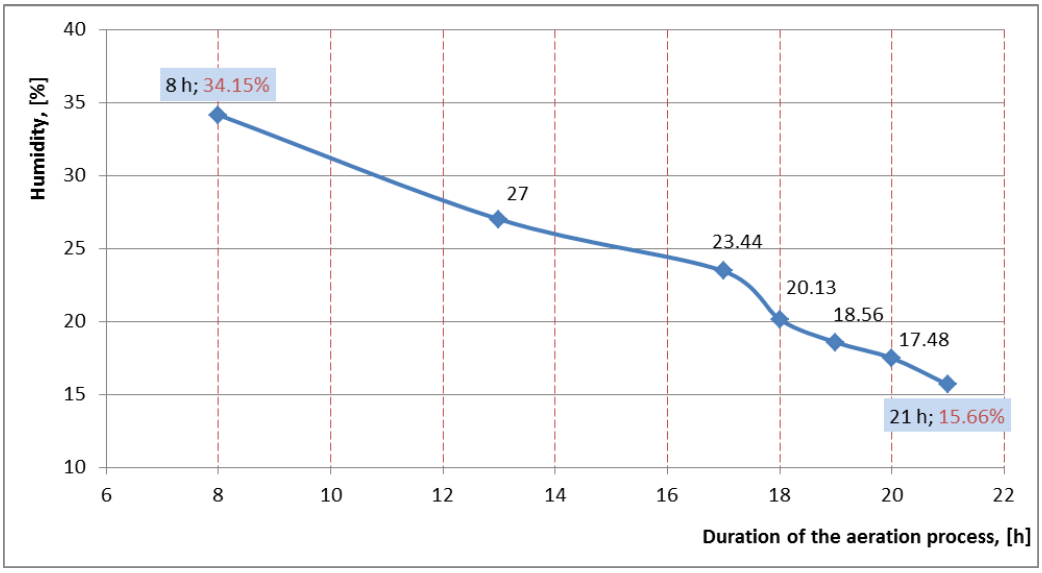

Fig. 10 - Variation of fodder humidity throughout the process

CONCLUSIONS

Analysing the variation of free air parameters in the period of the drying process, we found that humidity ranged between 30 and 70% during the day, while the air temperature ranged from about 22 to 33 °C, which reflect an influence on humidity loss trend of about 14% of the deposited material, being observed during the first 4 days, after about 18 hours of ventilation.

Favourable weather conditions during the drying completion phase allowed reducing the ventilation duration to only 21 hours, of which only 2 hours by using hot air. The weather being characterized by high air temperatures and low air humidity, and the material subjected to aeration process consisted of a mixture of fodder harvested in the hay field.

Installation testing under operation conditions generated the following results: in the drying phase, on the aeration installation an amount of about 816 kg of water was eliminated from the fodder; hay average humidity at the end of the drying process was about 16%; the uniformity of hay drying on the ventilation platform was high, namely 97.5%.

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INSTALLATION FOR PRODUCING ORGANIC CERTIFIED SEEDS AND PLANTING MATERIAL FOR FIELD CROPS
/
INSTALAŢIE DE CONDITIONATSĂMÂNŢĂ ŞI MATERIAL DE PLANTAT, CERTIFICATE ECOLOGIC, LA CULTURILE DE CÂMP

PhD.Eng. Păun A., PhD.Eng. Marin E., Eng. Milea D., Eng. Bogdanof. G., Eng. IonitaGh.,Eng.Bunduchi G.
INMA Bucharest / Romania
E-mail: ani_paun@yahoo.com

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ABSTRACT

Ecological agriculture (biodynamic, organic or biological) has emerged as an alternative to intensively chemicalized agriculture (industrial or conventional). This farming:

- *aims unconventional resources and recycling, thus returning nutrients from waste to the soil;*
- *ensures plant and animal growth as natural as possible;*
- *observes nature's self-adjusting systems in the fight against plant pests and diseases, avoiding the use of pesticides, herbicides, synthetic fertilizers as well as of growth hormones or genetic changes;*
- *uses techniques that favour the establishment of sustainable ecosystems, reducing pollution.*

The paper presents a pilot installation (which includes cleaning and calibration operations) to improve the cleaning and sorting technology of leguminous cereals for grains, oilseeds, industrial plants and fodder, aromatic and medicinal plants, at agricultural producers in order to reduce losses on processing chain links (cleaning, sorting, storage, transport, processing, packaging, pre-commercial storing, distribution and marketing) and the production of seed and planting material, organic certified.

REZUMAT

Agricultura ecologica (biodinamica, organica sau biologica) a aparut ca o alternativa la agricultura intensiv chimizata (industriala sau convenţionala) .

- *vizeaza resursele neconventionale si reciclarea, restituind astfel solului elementele nutritive din deseuri;*
- *asigura o dezvoltare cat mai naturala a plantelor si animalelor;*
- *respecta sistemele de autoreglare a naturii in lupta contra daunatorilor din plante si a bolilor plantelor, evitand folosirea pesticidelor, erbicidelor, a ingrasamintelor sintetice , precum si a hormonilor de crestere sau modificarilor genetice;*
- *utilizeaza tehnici care favorizeza crearea unor ecosisteme durabile , care reduc poluarea.*

În lucrare este prezentata o instalatie pilot (care include operatiile de curatire si calibrare), în vederea perfecţionării tehnologiei de curăţire si sortare a seminţelor de cereale leguminoase pentru boabe, oleaginoase, plante tehnice şi furajere, plante aromatice şi medicinale, la producatorii agricoli in vederea reducerea pierderilor pe verigile lanţului de procesare (curăţire, sortare, stocarea, transport, procesare propriu-zisă, ambalarea, stocarea pre-comercială, distribuţie şi comercializare), si producerea de sãmânță şi materiale de plantat, certificate ecologic.

INTRODUCTION

Field plants culture is a basic agricultural area, not only by the surface occupied and the contribution to the population nutrition, but also because it is the foundation that ensures the development of animal husbandry and of a good part of the food industry. Production and quality of any crop is determined both by factors acting from sowing to harvesting, as well as by those that directly influence the seed before sowing. Maintaining and raising quality assurance biological seed harvested during the various stages that they go through in order to obtain the finished product represents a challenge for scientific research for organic agriculture.

To ensure the maintaining and raising the level of harvested seed biological quality, during the various stages that they go through, in order to obtain the finished product represents a challenge for scientific research in ecological agriculture.

According to several works in literature (*Bucurescu N., Roman D.1992 and Ţenu Ioan, 1999*), obtaining satisfactory results in the *production of seed and planting material, organic certified*, depends to a great extent on the functional quality of seed conditioning equipment and installations but also on the quality of the staff involved in the production process (*Păun A. et al., 2014*). Animal nutrition is perceived today as a domain with multiple connections in biological sciences and beyond, with a share of over 60% in the cost price of livestock production, with a huge impact *on the livestock sector, the animal and human health state and the environment protection*.

Ecological agriculture involves changes:

ecological: own physicochemical support and application of specific principles - biodiversity, stability, preservation of ground, plant and animal health, replacing conventional technological elements with ecological ones;

economic: high and constant productions as well as high efficiency, the higher product price being compensated and overcome when marketed, due to the biological, nutritive and hygienic qualities;

social: ensuring the producer a decent living, the consumer a normal health state, creating jobs and ensuring a clean environment;

The material obtained after combine harvesting is under the form of a mixture consisting in main crop seeds and foreign bodies.

The foreign bodies that are frequently found among cereals are:

- inert organic foreign bodies (chaff, straw residues and leaves, dead insects, etc.)
- inert mineral foreign bodies (earth, as lumps, free dust or adherent to the grain, sand, gravel, metal pieces of different sizes or small metal parts etc.)
- seeds of weed considered harmful
- seeds of weed considered unharmful
- grains from the basic culture degraded by various fungal diseases that are also considered harmful (smut, bunt, ergot etc.)
- seeds of other cultures, different from the basic one, undergoing processing (for example, for wheat: rye, barley, oat, corn, bean, etc.)

In ecological agriculture, the seed is used untreated, without herbicide, therefore a series of problems appear:

- cultures with lower purity because of the inefficient removal of foreign plants by weeding and hoeing;
- cultures with high incidence of specific pests.

These aspects require:

- increasing the importance of seed precleaning processes - removing from the product all foreign bodies or seeds by using a wide variety of precleaning equipment (separators, classifier aspirators, cleaners, etc.);
- increasing the attention for removing from product mass the pests through mechanical (entoleters) or thermal (dryers).

Given the importance of knowing the conditioning process of different culture seeds an appropriate technology was applied, technology that is the basis of achieving a seed conditioning installation.

MATERIAL AND METHOD

Seed conditioning technology in figure 1 uses in the cereal seed precleaning process two combined principles: counterflow aspiration of product to be processed and separation on cylindrical sieves.

The product introduced in seed precleaning module is levelled by the feeder roller and the setting flap, reaching the main sieve drum where the separation, as plus material, of raw foreign bodies (big lumps, paper, strings, chaff, etc.) takes place.

Raw foreign bodies are headed for a second sieve drum where the product grains removed in the first sieve drum are recovered. Raw impurities are discharged outside the machine through a discharge hopper, and the precleaned product from both drums, is subjected to an intensive aspiration of a fan incorporated in the machine.

The air is directed through a lateral air intake toward a purification installation outside the equipment (cyclone, bag filter, etc.) belonging to the beneficiary, or it can be expelled directly into the atmosphere if the environment conditions allow it.

The product, precleaned of raw foreign bodies and light impurities, reaches the cylindrical sieve where the separation in several fractions takes place. The cylindrical sieve is formed of a cylindrical drum on which are mounted three sieves adapted and interchangeable, with different sieve opening diameters, those with smaller dimensions being mounted toward the supply of product, depending on technological requirements.

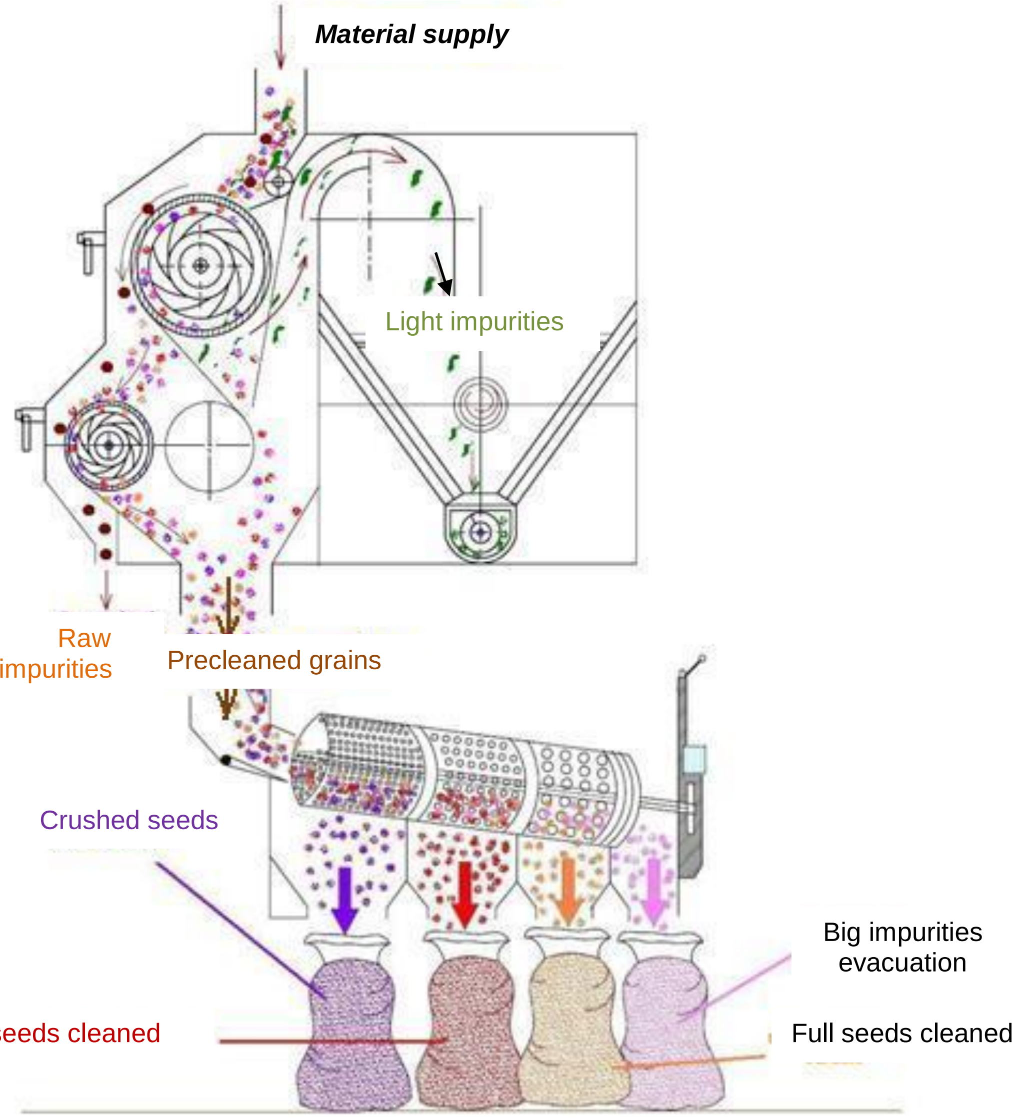


Fig.1 - Seed conditioning technology [8]

The sieve drum receives the rotation movement from a shaft gear motor. In the working process, the seed with smaller size than the holes will go through them and those remaining as plus material will pass on the second sieve (if the cylindrical sieve is equipped with cylindrical sieves of different sizes, the smallest size being toward the supply).

Some of them will pass through the holes of the second sieve (if they have the sorting size smaller than holes) and those that will remain as plus material will go to the third sieve. On this sieve the seeds having the sorting size smaller than the sieve holes will go through and the ones remaining as plus material will be evacuated through the discharge hopper.

RESULTS

Based on the technology in Figure 1, an installation for seed conditioning ICS was produced, figure 2.

To elaborate the documentation and produce the installation a series of theoretical considerations in literature (*Găgeanu P., 2001; Voicu Gh., N.Orăşanu, 2009*) were taken into account namely that a seed, or any material particle, placed on the inner surface of a horizontal cylinder, rotating with uniform speed, can receive one of two movement types, different in principle, depending on certain conditions.

The difference between these types of movement is determined by the absence or presence of particle relative rest state in relation to the sieve in the general cycle of its movement on the cylinder inner surface. In respect to the cylindrical sieves the following specifications can be mentioned (*Găgeanu P., 2001; Voicu Gh., N.Orăşanu, 2009*):

Fig. 2 - Seed conditioning installation ICS [8, 9, 10]

- the speed of the sorting cylindrical sieve is calculated using the formula:

$$n = \frac{m}{\sqrt{R}} \tag{1}$$

where:

m – coefficient with a value between 8 and 20 for cylindrical sieves with reduced speed and 28 for high speed sieves;

R – cylinder radius.

- Propeller pitch described by the particle(seed) on the cylinder inner surface is calculated applying the formula:

$$t = \frac{2..\pi.R}{v} v_0 \tag{2}$$

where:

R – cylinder radius;

v – cylinder peripheral speed;

v_0 – seed speed along cylinder longitudinal axis

- length of the spiral covered by the particle on cylinder inner surface is calculated using the formula:

$$S = \sqrt{(2.\pi.R)^2 + t^2} \tag{3}$$

- cylindrical sieves diameter, should be between400 and800 mm;

- report between cylinder length L and diameter D should be:

$$\frac{L}{D} = 3.75 - 4 \tag{4}$$

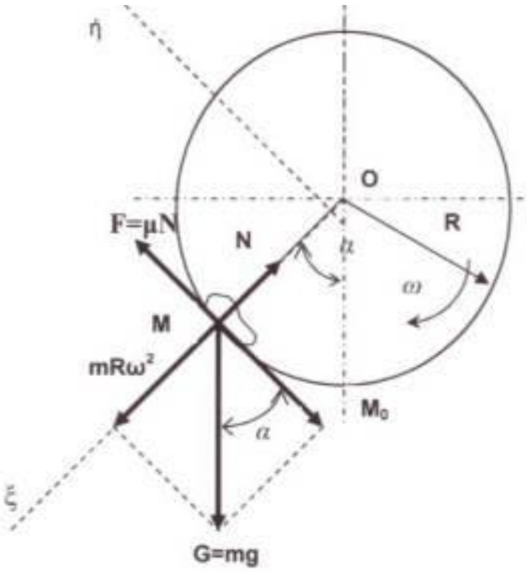
- cylinder peripheral speed, should be 0.65 – 0.75 m/s; there are also higher speed for cylinders with larger diameters. For horizontal axis cylinders (fast sorting cylinders) the recommended peripheral speed is 0.9 – 2 m/s;

- **hourly flow rate Q, reported to the entire surface S of the cylindrical sieve**, should be:

$$\frac{Q}{S} = (230 - 300) kgf / m^2 \tag{5}$$

- **Cylinder inclination reported to the horizontal line** should be of maximum 4 – 5 º.

Figure 3 presents the forces acting on a seed when the angular value ω = constant [2, 3], while figure 4 presents the determination of seed free movement trajectory.



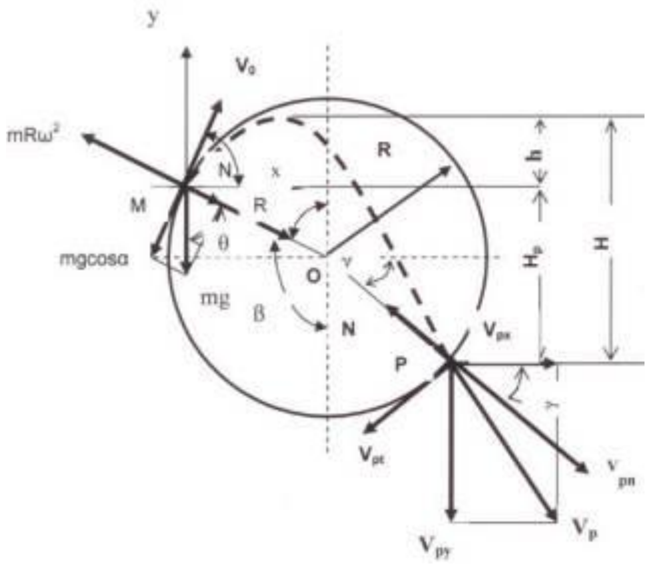


Fig. 3 - Forces acting on a seed (2, 3) Fig. 4.Determination of seed free movement trajectory [4, 5]

The following conclusions can be drawn analysing data presented in respect to cylindrical sieves (*Găgeanu P., 2001; Voicu Gh., N.Orăşanu, 2009)*:

-*the particle detached from the cylinder surface at a height corresponding to the central angle $\pi/2$ - θ, gets back on the cylinder surface to the height determined by the π - γangle value. Angle θ is the angle the particle makes when detaching from the cylinder surface with the horizontal line. π - γangle value is measured from the horizontal diameter in a direction opposite cylinder rotation;*

-cylindrical sieves are made usually with oblong holes realizing the separation depending on thickness;

- so far, in the construction of agricultural machines for cleaning and sorting, the cylindrical sieves with uniform speed have been used sporadically because of the low productivity compared to flat sieves for the same work surface;

- the cylindrical sieve with uniform speed, without any other interior devices, cannot ensure an increased productivity (productivity is directly proportional to its speed) because the attempt to increase the speed above a certain limit generates seeds relative rest on the sieve surface, reducing a lot its work capacity because of hole clogging;

- sieve speed can be increased (also its productivity) without relative rest appearance by using certain special devices: interior cylindrical shields, inner inclined planes, interior cylindrical shields with brushes, etc.

Using this type of solutions, speed can be increased 2-3 times compared to the speed of a simple cylindrical one, thus also increasing its productivity. Given the advantages of the cylindrical sieve with uniform rotation compared to the flat sieve with alternative-straight line oscillatory motion (higher compactness of the separation system, smaller gauge, easier balancing of forces of inertia, simpler transmissions, simpler and more efficient mechanism for unclogging the holes, more favourable passing conditions of seeds through holes), as well as the fact that the productivity of the cylindrical sieve can be increased by using special devices fitted inside the sieve, figure 5, the more frequent use in cleaning and sorting machines construction, combines construction or as independent equipment, an important place being occupied by calibrators, is justified.

Fig. 5 - Sieve drum [8, 9, 10]

CONCLUSIONS

Seed conditioning installation is designed to improve production technologies for organic cereal seed, legumes for grains, oilseeds, industrial plants and fodder, aromatic and medicinal plants; to solve practical problems concerning the production of organic seed for field cultures at farmers, in order to produce seed and planting material organic certified.

When producing this installation it was aimed to obtain the following benefits:

- ensuring the maintain and raising the level of biological quality of harvested seeds, during the various stages that they go through, in order to obtain the final product;
- primary processing of products based on group technologies;
- achieving these processes with maximum responsibility regarding the observance of rules of greening the environment in which they are carried out;
- improving the use of material and human base (universal machines adaptable to different works, family work force);
- adapting production structure to local pedoclimatic, market and tradition conditions;
- diversification of economic activities and flattening of workforce use curve;
- obtaining health-giving products, with high biological, nutritional and hygienic value, their capitalization being achieved directly, without intermediary.

ACKNOWLEDGEMENT

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CONSIDERATIONS ON THE DEVELOPMENT OF *ARNICA MONTANA* L. SPECIES IN CROPS AND IN THE SPONTANEOUS FLORA / *CONSIDERATII PRIVIND DEZVOLTAREA SPECIEI ARNICA MONTANA L. ÎN CULTURĂ ŞI ÎN FLORA SPONTANĂ*

Phd. Stud. Eng. Panciu I.-R.*1), Prof. PhD. Eng.Sin Gh.2)
1) University of Agronomic Sciences and Veterinary Medicine of Bucharest / Romania; 2) The Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu-Sisesti"/ Romania
E-mail: lily.panciu@yahoo.com

Keywords: *arnica montana L., development, culture, spontaneous flora, inflorescences*

ABSTRACT
Nowadays, globally, half of the products are based on medicinal plants or include active principles extracted from plants. Arnica montana L. is studied for pharmaceutical purposes due to its active principles and due to its beneficent action on the immunity system [2]. In Romania, the flowers of Arnica montana L. represent an old remedy, well known even today in the traditional medicine of the mountain regions in the country, for the treatment of a variety of diseases [4]. In the spontaneous flora of Romania, we find it in the meadows and grass lands of the mountain and subalpine areas, particularly in the Apuseni mountains, but also in crops, on limited areas [3]. In order to know the management of the plant in a crop, we made researches concerning the development of the species both in a crop and in the spontaneous flora.

REZUMAT
În zilele noastre, pe plan mondial, jumătate din produse au la bază plante medicinale sau în compoziţia lor principii active extrase din plante, Arnica montana L. este studiată în interes farmaceutic datorită principiilor sale active şi acţiunii benefice asupra sistemului imunitar [2]. În România, florile de Arnica montana L. reprezintă un vechi remediu, bine cunoscut şi azi în medicina populară din regiunile muntoase ale ţării, în tratarea multor boli [4]. În flora spontană din România o găsim în păşunile şi fâneţele din zona montană şi subalpină, cu precădere în munţii Apuseni, dar şi în culturi pe suprafeţe restrânse [3]. În vederea cunoaşterii managementului plantei în cultură am efectuat cercetări privind dezvoltarea speciei atât în cultură cât şi în flora spontană.

INTRODUCTION
Researches on the development of the species Arnica montana L. have been carried out in crop and in the spontaneous flora. The crop was set in a private farm, at the altitude of 850 m; the transfer in the field of plants of Arnica montana L, developed in a laboratory, both multiplied in vitro and sowed on various sub-layers, is a complex process.

In order to transfer the plants of Arnica montana L. in the field, it is necessary to know the factors conditioning the success of the crop, such as:
- the degree of favourability of the area;
- the soil requirements (pH and nutritional elements);
- the annual average level of precipitations, the annual temperatures;
- the risk of exposure of the crop to diseases and pests;
- planting and maintenance works.

The growth technology is based on the totality of agricultural-technical and phytosanitary measures, provided and classified in various sub-systems, destined to get profitable harvests [1].

Researches in the spontaneous flora have been made in Gârda de Sus commune, Alba County, Apuseni mountains, and the development of this species has been followed on two areas, the northern area (of limestone) and the southern area (of siliceous).

MATERIALS AND METHOD
The experimental field has been plowed after being fertilized with manure; it has been plowed at the depth of 20-25 cm. Until the plants were grown, the plowed land was maintained by repeated works of harrowing, and before the seedlings were planted, the soil was hoed and levelled by levelling bar.

The crop has been obtained out of 60 plantlets aseptic germinated sowed in various types of environments, and out of 60 plants septic germinated, obtained by sowing directly in the solid sub-layer; they have been grown in the experimental field, at the distance of 25 cm between plants and of 30 cm between rows, directly into the soil, slightly acid - pH 5.5-5.8. In the crop, various measurements have been made as regards the average length of the leaves, the average number of inflorescences on every plant, the average diameter of inflorescences.

In the spontaneous flora, measurements have been made as regards the length of leaves, the number of inflorescences on every plant, and the average diameter of inflorescences; measurements have been made on 100 plants of the spontaneous flora.

RESULTS

- **Results obtained in the experimental field**

The plants grown in the experimental field have been named as follows:

- plant A, plants obtained *in vitro* and acclimatized on a sub-layer of soil and sand;
- plant X, plants sowed on a sub-layer of 50% soil and 50% sand;
- plant Y, plants sowed on a sub-layer of 50% soil and 50% perlite;
- plant Z, plants sowed on a sub-layer of 50% soil, 25% perlite and 25% peat.

The presented researches have been carried out in the 2nd year of harvest, noting the average length of leaves, the average number of inflorescences on the plant and the average diameter of inflorescences.

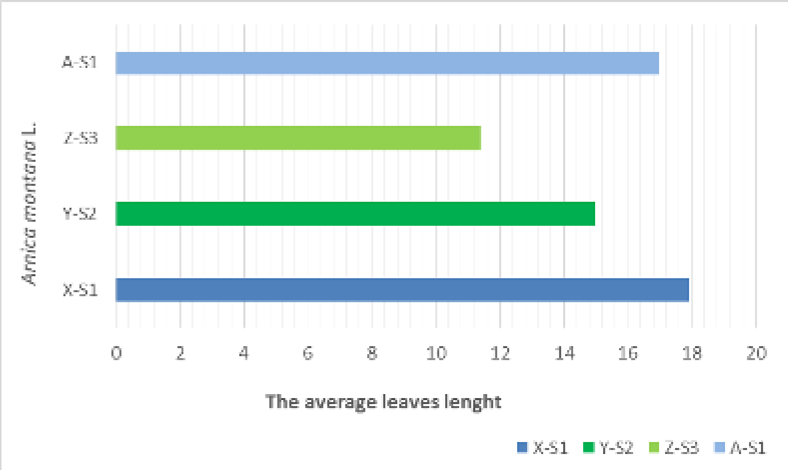

Fig. 1 - The average leaves length after second year on culture (cm) (2016) (original)

Plantlets X germinated on sub-layer S1, made of 50% soil mixed with 50% sand, generated the average length of leaves, in the second year of harvest, of 17.9 cm.

Plantlets Y germinated on sub-layer S2, made of soil mixed with perlite in a 50%-50% ratio, generated the average length of leaves, in the second year of harvest, of 15 cm.

Plantlets Z germinated on sub-layer S3, made of soil, perlite and peat in a 50%-25%-25% ratio, generated the average length of leaves, in the second year of harvest, of 11.4 cm.

Plantlets A obtained in vitro and acclimatized on the solid sub-layer S1 made of soil mixed with sand in the 50%-50% ratio, generated the average length of leaves, in the second year of harvest, of 17 cm.

In 2016, the month of June, the first inflorescences bloomed in the crop. The inflorescences of *Arnica montana* L. are harvested in the months of June-July, when the flowers start blooming, because the mature flowers generate a developed pappus.

Inflorescences are harvested with a very short peduncle, they are placed in baskets, without being pressed, and they are transported to the drying area, where all impurities are removed; then, they are naturally dried in clean and very well aired rooms, or artificially, in drying rooms, at 40-50^{0}C, as the drying output is of 6-7:1.

Once the first flower studs appeared, measurements have been made, concerning the development of the inflorescences. The follow-up of the development of inflorescences has been noted based on the number of inflorescences per plant, and the average diameter of the inflorescences, before harvesting.

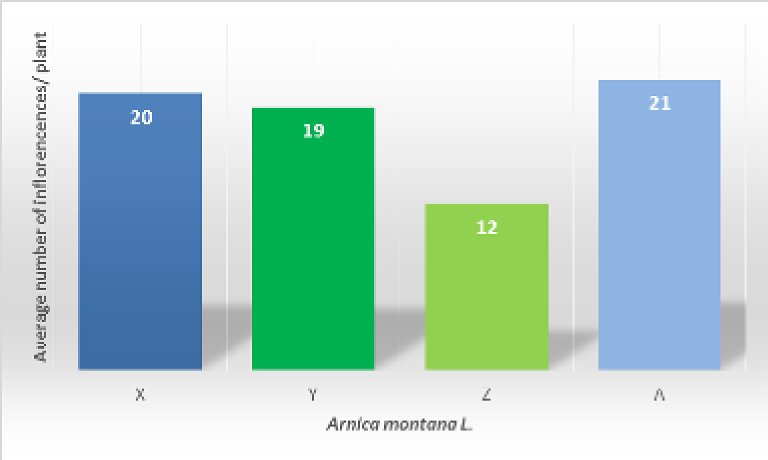

Fig. 2 - Average number of inflorescences on plant (2016) (original)

The plants still unharvested, by their harmonious development and by reproduction, bloomed, generating the average number of 18 inflorescences per plant, as follows:

- plants X, an average number of 20 inflorescences per plant; following plant assessment, on one of X plants, the maximum number of inflorescences has been reached, namely 29 inflorescences for one plant;
- plants Y generated an average number of 19 inflorescences per plant;
- plants Z generated the average number of 12 inflorescences per plant, and it was on these plants that the minimum limit of 6 inflorescences per plant has been reached;
- plants A generated 21 inflorescences per plant.

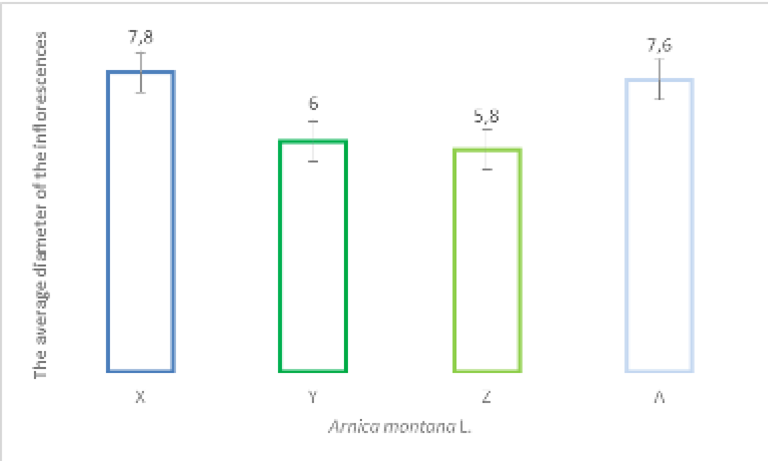

Fig. 3 - The average diameter of the inflorescences (Arnicae flos) (2016) (original)

The inflorescences of plants X developed harmoniously, the plants offering an average number of 20 inflorescences per plant, with the average diameter of 7.8 cm.

Plants Y developed the average number of 19 inflorescences per plant, the average diameter of inflorescences being of 6 cm.

Plants Z developed the average number of 12 inflorescences per plant, the average diameter of inflorescences being of 5.8 cm.

Plants A developed the average number of 21 inflorescences per plant, the average diameter of inflorescences being of 7.6 cm.

One may notice the close number of inflorescences per plant, with close diameters, which shows the uniform development of plants coming from different germination environments.

- **Results obtained in the spontaneous flora**

In the studied limestone area, as well as in the siliceous one, the grass layer may be divided into upper layer, of stems rich in flowers, and respectively the lower layer, of basal leaves. In the upper layer, only two stems of *Arnica montana* L are present, providing the average of 7 inflorescences per plant.

The rosettes of basal leaves of *Arnica montana* L. are numerous, showing various overlapping, spread on the entire analysed area.

After analysing the selected regions, it has been seen that, in the limestone area, a greater number of species is present than in the siliceous area, due to the species existing in the lower grass layer.

The rosettes of the species *Arnica montana* L. generally occupy a very big area in both analysed regions, which is greatly due to the morphology of these leaves, with whole edge and relatively wide surface.

Table 1

Development of Arnica montana L. from spontaneous flora (average data) (2016) (original)

Selected regions	Lenght of the leaves (cm)	Number of the inflorescences/ plant	Inflorescences diameter (cm)
Northen area (limestone)	8.13	20.50	6.18
Southern area (siliceous)	7.25	17.50	6.41

The maximum value of the average length of the leaves has been obtained in the northern area, according to table 1, being of 8.13 cm, also getting the maximum number of inflorescences – 20.50.

The maximum value of the inflorescence diameter has been obtained in the southern area, which was of 6.41 cm

CONCLUSIONS

The area of the experimental field meets the favourable conditions for the growth and development of the species *Arnica montana* L., both in terms of climate and in terms of soil features. The crop obtained from septic and aseptic germinated plants has been normally developed, obtaining a high quality production.

The areas with *Arnica montana L.* of Gârda de Sus commune and from both regions that were studied, and the crop of Corbeni commune, depend on the preservation of certain values of soil acidity; the improvement of the soil with basic compounds would also limit the habitats of *Arnica montana* L.

Both in the natural environment, and in crop, the fertilization is made only by manure, and any chemical fertilizer would cause the extinction of the plant in 2-3 years; the correct maintenance of the meadows increases the chances to preserve the species in the spontaneous flora.

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CONSIDERATION ON APPLYING PHOTOVOLTAIC SYSTEMS IN AGRICULTURE / CONSIDERAŢII PRIVIND APLICAREA SISTEMELOR FOTOVOLTAICE ÎN AGRICULTURĂ

Eng. Epure M.*, PhD. Stud. Eng. Găgeanu I., PhD. Eng. Sorică C.
INMA Bucharest
Tel: 0770890750; E-mail: secretariat@inma.ro

Keywords: *photovoltaic cell, autonomous photovoltaic system, solar radiation, thermal conversion, solar plane collector, solar concentrator*

ABSTRACT

Solar energy represents the energy from the sun. The heat and light given to us by the sun are essential for life. In only three days, the earth receives from the sun the equivalent of energy existing in fossil fuels reserves. The true revolution in the field of renewable energy emerged when solar energy became accessible for agriculture and home use. Romania has an important solar energy potential determined by the favourable geographic placement and climate conditions. In this paper is presented the importance of photovoltaic systems as well as their applications in agriculture.

REZUMAT

Energia solară reprezintă energia venită de la soare. Căldura şi lumina pe care soarele ni le oferă sunt esenţiale pentru viaţă. În numai trei zile, pamântul primeşte de la soare echivalentul energiei existente în rezervele de combustibili fosili. Adevarata revoluţie în domeniul energiei regenerabile a venit momentul în care dezvoltarea energiei solare este accesibilă pentru agricultură şi pentru utilizatorul casnic. România dispune de un important potenţial energetic solar determinat de un amplasament geografic si condiţii climatice favorabile. În această lucrare se prezintă importanţa sistemelor fotovoltatice precum şi aplicaţiile acestora în agricultură.

INTRODUCTION

Solar energy has brought significant improvements in all the sectors of industry today. Everyone tries to use it as much as possible, and to exploit its services to a maximum. No industry could survive without the sun. There are many sectors that rely on the benefits of the sun, but the agriculture and horticulture industries will not thrive without sunlight. These two branches have no other options, if the sun would disappear, agriculture and horticulture would disappear. The sun is necessary for these two processes to be able to grow their products. The productivity of these sectors will depend on the amount of energy they receive from the sun. This must be balanced in all manners; it can never be too little but it also shouldn't be too much.

The use of alternative energy systems is recommended especially in areas where infrastructure is underdeveloped. The use of photovoltaic panels is more indicated in agriculture than the use of generators or wind turbines mainly due to maintenance (weatherproof, large distances compared to specialized units, lack of qualified personnel for supervision). The cost of energy produced by photovoltaic systems continues to decline. However, the cost of photovoltaic energy is generally higher than that of conventionally produced energy. Also, although the initial cost of photovoltaic equipment is higher, there are still some applications where photovoltaic systems are the most efficient financially. The number of photovoltaic systems increases annually due to their benefits. A well built photovoltaic system can operate unwatched and requires minimal routine maintenance. The savings coming from labour costs and transportation costs may be insignificant.

The areas of particular interest for electric power applications of solar energy in Romania are:

• Romanian Plain, Western Plain, Banat and part of Transylvanian and Moldavian Plateaus. These areas have average annual solar energy flows between *1000* and *1250 kWh Y* m^{-2Y} $year^{-1}$.

• Dobrogea, Romanian coast of the Black Sea and the Danube Delta, which present special features, where the annual flow of solar energy average is particularly favourable, of over 1200 - 1250 KWh Y m^{-2Y} $year^{-1}$, as well as a number of over 2200 sun hours per year.

MATERIAL AND METHOD

In human energy options, electricity has won a privileged place. Even if some unconventional or conventional energy sources may be used directly in heating or mechanical installations, the concern to obtain electricity on their account remains on the first place. As is known, intermediate conversions produce large losses or are limited by very "rough" laws and regulations - Carnot cycle and thus the desire to reach a direct conversion of primary energy into electricity is justified. There are many such generators, based on physical or chemical phenomena that are more or less studied, out of which the future will retain the most effective or perhaps the cheapest ones and the ones using materials more common on earth.

Among generators that can achieve direct conversion of electric energy and on which high hopes are placed are the photovoltaic cells, also called solar cells, when the primary energy is represented by sun radiations. Good products should not only satisfy the needs of the final consumer, but must also present advantages for the environment where the product will be used. Electricity is no exception to the rule. Solar electricity can bring an important contribution to maintaining the earth's energy reserves and, in the same time, can contribute to slowing general climate modifications: reduces the consequences of the greenhouse effect of polluting gases in the atmosphere. [1]

Among the main characteristics of photovoltaic systems:

- ***Modularity*** – a photovoltaic system can be designed for easy expansion. If the power demand would increase, the only obstacle that can intervene in expanding the photovoltaic system is the lack of space necessary for placing the additional modules (spaces that have direct sunlight);
- ***Autonomy*** – they do not require an additional consumption and maintenance expenses. Conventional fuel supply and its storage can cost more than the fuel itself, whereas solar energy comes for free;
- ***Durability*** – the large majority of photovoltaic modules today are based on technologies that have proven a minimum degradation after 20 years of operation, having a 30 year guarantee.

Generally, there are two types of solar panels: those that convert solar energy into electricity and those that convert solar energy into heat. Both have many agricultural applications, making life easier and helping increase productivity. Agricultural technology is changing rapidly. Agricultural machinery, farm buildings, and production are constantly improved.

If the energy coming from the sun is not sufficient, plants will not develop properly. Farmers will not reach crop big enough to feed the population. Also, too much sun will damage crops. This will also lead to negative effects on human health. But in the second case, people can think of ways to get energy required, manually trying to reduce the amount of heat that will be directed to plants. Farmers need to know when the sun is up and shining, when sunny days are long, and similar factors in order to determine what kind of plants to cultivate in order to survive in such weather conditions [4].

RESULTS

Some photovoltaic panels are specially designed for landowners and farms and have brought substantial, measurable savings for them. The installing for these panels is completed with minimal impact on the land and without harming the environment and soil, crops and grazing animals. For a farmer or landowner, solar energy enables to save money on energy bills, protects businesses against rising costs, maximizes the value of buildings and land poorly utilized and demonstrates care for the environment as a supplier. Photovoltaic panels can provide the necessary energy where is needed and when is needed. These panels were tested and verified worldwide to ensure they are cost effective are reliable and already throughout the world has been registered an increase in the agricultural productivity.

Among the most efficient applications, the ones destined for agriculture are:

Heating the habitat (water, spaces)

In the animal husbandry activity, a big part of the energy is consumed by heating the water necessary for the cleaning equipment. Photovoltaic systems for solar water heaters are available for offering hot water with low to medium temperature to be used in the desired purpose. These systems require a solar collector, a storage reservoir, sanitary installations and pumps. For example, in cattle farms, 40% of the energy used is destined for heating water. [2]

Ventilation

In the view on maintaining a constant temperature, especially during summer, solar panel systems (photovoltaic) can be used for air ventilation applications. Supplying the necessary energy for air circulating ventilators is another use of photovoltaic systems. Modern poultry and pig farms have doubled or even tripled their production by raising animals in closed spaces. [2]

Illuminating

Another use of photovoltaic systems is the illuminating of agricultural buildings. Production hours and productivity can be significantly improved in an illuminated room. This applies especially for those who use the hours in the evening for equipment repair and maintenance operations. Photovoltaic systems can represent a better solution compared to conventional illuminating systems or fossil fuelled lamps. Additionally, they offer more light that has good quality and does not release any smoke in the air. [2]

Systems for pumping water / irrigations (fig. 1)

It represents one of the most attractive applications of solar energy. In high heat periods, when water requirements are high, photovoltaic panels have maximum yield. If the water necessary has to be covered permanently (day and night, clear or cloudy weather) and there isn't a possibility to accumulate water during this interval, energy generated by photovoltaic panels will be accumulated in batteries.

It the necessary water can be covered by depositing water in basins, it is not required for the systems to include batteries for storing energy.

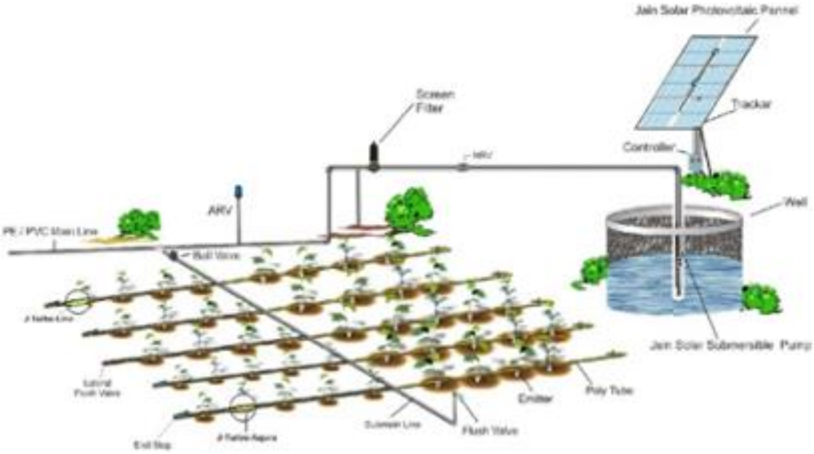

Fig.1 - Application of the solar technology for achieving water pumping systems [10]

Drip irrigation (fig. 2)

Solutions for achieving irrigation systems should take into account that the demand is not constant throughout the year. The maximum demand is generally twice as large as the annual average and coincides with the period when groundwater level is low, making the system to be oversized for the rest of the year [3].

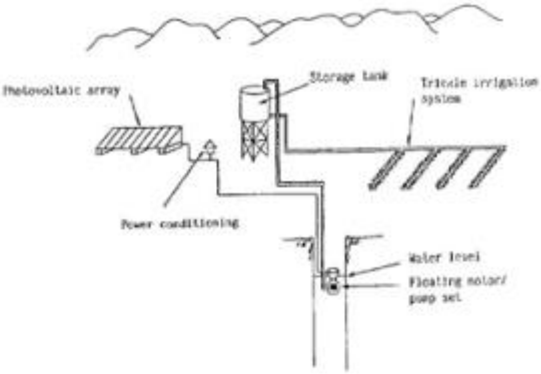

Fig.2 - Application of the solar technology for achieving drip irrigation systems [2]

Drying installations

Farmers do not use sun just for energy. The sun's heat is also very important in the agricultural sector. Crop and grain drying by simply exposing them to the sun's heat is one of the oldest and most widely used applications of solar energy. But allowing crops to dry naturally in the field exposes them to the hazards of contamination or to attack from birds and insects. Modern solar dryers are still very simple, but also, more efficient and more hygienic. The basic components of a solar dryer consist of a warehouse where crops will be placed on racks or trays for drying and a solar collector. The collector can be as simple as a box with windows with a dark coloured interior to absorb the solar energy that heats the air. The photovoltaic panel is placed at the entrance, the heated air in the collector moves naturally or is moved by using a fan to the material that needs to be dried.

Solar dryers have some advantages over sun drying when correctly designed. They give faster drying rates by heating the air to 10-30º C above ambient, which causes the air to move faster through the dryer, reduces its humidity and deters insects. They can be constructed from locally available materials at a relatively low capital cost and there are no fuel costs. Thus, they can be useful in areas where fuel or electricity are expensive, land for sun drying is in short supply or expensive, sunshine is plentiful but the air humidity is high. Moreover, they may be useful as a means of heating air for artificial dryers to reduce fuel costs (*Fellows P., 1997*).

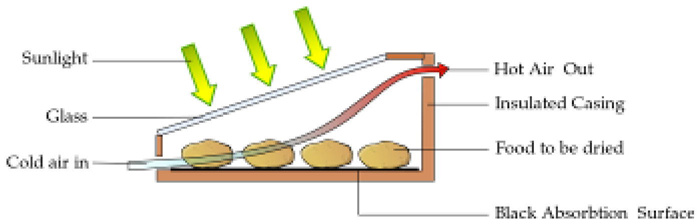

Fig. 3 – Direct solar drier [7]

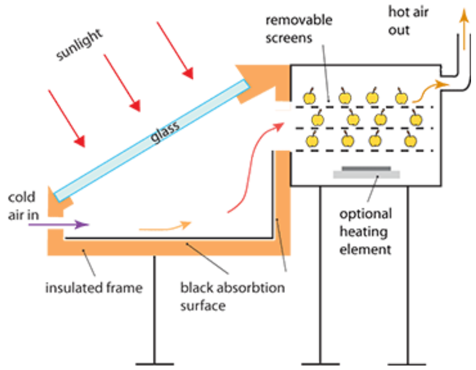

Fig. 4 – Indirect solar drier [8]

Greenhouse Heating

Commercial greenhouses often rely on the sun for lighting, but on gas or oil heaters to maintain constant temperatures. A solar greenhouse uses building materials to collect and store solar energy as heat. Insulation retains the heat for use during the night and on cloudy days. To capture the most sunlight, a solar greenhouse generally faces south, while its northern side is well insulated, with few or no windows. A gas or oil heater may be used as a backup. [9]

CONCLUSIONS

Solar panels can change the future energy. Renewable energy has the advantage of an efficient and inexpensive innovative technology. Photovoltaic systems can change energy supply in the agricultural sector.

The advantages of photovoltaic systems are:

- They produce electric energy without any polluting effects of the environment (+ complete recycling);
- They don't have a moving component;
- No phonic pollution;
- High reliability, long service life, easy and low cost exploitation;
- Production and consumption are situated in the same place (for small productions);
- Low energy transport costs, Reduced production and transport spaces;
- They do not cause and changes in the environment [7].

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EXPERIMENTAL RESEARCH ON WORKING QUALITATIVE INDICATORS OF THE COMBINED SEPARATOR
/
CERCETARI EXPERIMENTALE PRIVIND INDICII CALITATIVI DE LUCRU AI SEPARATORULUI COMBINAT

PhD.Stud.Eng. Birsan M.*[1)], Prof. PhD. Eng. Casandroiu T.[2)], PhD. Eng. Sorică C. [1)], Eng. Bunduchi G. [1)], PhD. Eng. Ciobanu V. [1)], PhD. Stud. Eng. Rosu (Nitu) M. [1)], PhD. Stud. Eng. Zaica A. [1)], Ph.D. Stud. Eng. Pruteanu A.[1)]
[1)]INMA Bucharest / Romania; [2)]University Politehnica of Bucharest / Romania
E-mail: marymmsa@yahoo.com

Keywords: c*leaning, impurities removal, separator, wheat, seeds.*

ABSTRACT

The paper presents the experimental research regarding the wheat seeds separation on the plane sieves and the airflow of the TC 600 Combined separator technical equipment based on the following parameters: product feed rate, oscillation amplitude of the screen, the angle of the screen and speed of the airflow. The use of this equipment enables to reduce significantly, the impurities from the cereal seeds to be easily stored or used as raw materials in agriculture and food industry, the number of equipment that cleaning operation requires and also the power consumption.

REZUMAT

În lucrare sunt prezentate cercetarile experimentale privind procesul de separare al seminţelor de grau pe site plane si in curent de aer pentru echipamentul tehnic Separator Combinat TC 600 în funcţie de urmatorii parametrii: debitul de alimentare, amplitudinea oscilatiilor sitei, unghiul de inclinare al sitei şi viteza curentului de aer. Utilizarea acestui echipament reduce semnificativ impurităţile din seminţele de cereale pentru a fi usor pastrate sau folosite ca materii prime in agricultură şi industria alimentară, numărul de echipamente necesare operatiei de curatit si consumul de energie.

INTRODUCTION

Before agricultural products capitalization in different fields, they are subject of a process of conditioning that includes preparatory operations, impurities cleaning, drying, wetting, depending on the purpose they are intended to be used (*Uthayakumaran S., Wrigley C.W., 2010*).

In the first agricultural processing operations in order to obtain finished products of superior quality is cleaning operation or foreign bodies' removal, particularly in the agricultural material obtained after harvesting by combine.

This material is in the form of a mixture of main crop seeds, other crop seeds, weed seeds and various impurities of inorganic or organic origin (straw remains, chaff, dust, sand, etc.), and the seeds besides the main crop seeds contain the normally developed and dry whole grains, shrivelled or broken, etc., that is why cannot meet the required quality standards in force (SR ISO 7970/2001, SR 13548: 2013 wheat) where the permissible foreign bodies content for food wheat is up to 3%, this content is limited to a maximum 0.5% chaff and other harmful objects to 0.2% (*Nedeff V., Moşneguţu E., 1999; Wrigley I.L. Batey, 2012*).

However, for main crop seeds use as seeding material is necessary both removing foreign bodies, which differ from seed agricultural culture in general by their physical characteristics and removing seeds with germination low capacity, of those underdeveloped or leak, which are less resistant to being easy storage being light attacked by fungi and pests (*Nedeff V., Moşneguţu E., 1999; Wrigley I.L. Batey, 2012*).

These operations involve a suitable technological process for cleaning and sorting seeds (their calibration).

The cleaning operation, as a first operation within the technological flow of processing the agricultural products requires cleaning and sorting installations whose working process is based on the difference between the physical characteristics of seeds and those of foreign bodies (*Panasiewicz M. et al., 2012; Rus Fl., 2001; Stoenescu G. et al., 2010*).

The most common used cleaning and sorting installations are those comprising vibrating screens with oscillating movement (vibratory),that have to achieve a certain stage of sieving, in order to remove the foreign bodies based on the difference between seeds dimensions and impurities size (big or small).

In order to increase the gravitational separation degree, at the majority of cleaning installations based on this principle, the oscillating movement of working surface is combined with air flow action, thus joining the separation based on specific mass to separation based on aerodynamics principle, achieving a concomitant separation of several categories of impurities. That is why, the number of technical equipment necessary to cleaning, energy consumption and technological halls designed to separate impurities out of cereal seeds aiming to be stored or used as raw material in agriculture and food industry, could be reduced (*Geankoplis Chr., 2003; Miskelly D. et al., 2010; Rus Fl., 2001)*.

MATERIAL AND METHOD

The experimental researches were carried out in laboratory conditions and designed at separating process of seeds on plane sieves and under air current for the separation unit of the modern equipment Combined Separator TC 600 existing in the laboratory of Agricultural Machinery of the Milling Collective of the National Institute of Agricultural Machinery Bucharest, aiming the following parameters: feeding flow, amplitude of sieve oscillation, sieve slope angle and air current speed.

Material subjected to separation is represented by wheat seeds of Dropia variety, coming from Ialomita County, from 2014 production, obtained after the combine threshing.

For the correct study of the process of separation it was necessary to analyse the material to be processed, carrying of the following steps:

a) taking samples- sample extraction was achieved from the product for processing (wheat) that was in bulk state, according to current standards.

b) determining the characteristics of particles of cereals subjected to research, namely: seed size (l, b, c), seed humidity u (%), mass of one thousand seeds(MTS), purity [%], hectolitre weight [kg/hl], respecting recommendations from literature and from a series of authors .

For the experimental tests, the Combined Separator TC 600 (figure 1) was used. Combined Separator uses in its working process two combined principles: sieving on sieves with product aspiration in counter-current.

Fig. 1 **- Diagram for the equipment Combined Separator TC 600**

1. - Framework; 2. – feeding funnel; 3. – system for adjusting the flow; 4. – vibrating sieve (separation plane); 5. – adjustable wall; 6. - valve for adjusting the sizes of the vertical suction channel; 7. – valve for adjusting the flow of the air aspirated from the sieve; 8. - valve for adjusting the air flow in the vertical channel; 9. – aspiration inlet; 10. – Funnel for evacuating small impurities; 11. – Funnel for evacuating clean product; 12. – Electro-vibrator; 13. – elastic elements; 14. – side view; 15. – inspection cover; A – product feeding; B – evacuating clean product; C – evacuating small impurities; D – evacuating light aspirated impurities.

Combined Separator is made of a framework (1) and a vibrating sieve (4) mounted on 4 flexible rubber supports (13) and driven by two electro-vibrators (12).

Product to be clean or pre-clean enters the installation through the feeding funnel (2) that allows charging the product by bag and assures a uniform supply on the whole width of the equipment (sieve). The product supply is controlled by the system of flow regulation (3) made of an inclined plane which is adjustable (throttle) and a device adjusting the flow. Once on the sieve, driven by the two electro-vibrators, the material is subjected both to separation by size and under air current.

Impurities removal is performed step by step, starting with the product slipping on sieve (elimination of small impurities - C) , under the action of ascending air flow (light impurities placed on sieve- D) , and in the second channel of aspiration (vertical), where the product already cleaned is subjected to another process of removing the light impurities (D).

RESULTS

At national and international level, numerous theoretical and experimental researches regarding the constructive-functional improvement of cleaning installations were made. They were performed by renowned research institutes and also by the research departments of companies manufacturing cereal combines and cleaning equipment. Nevertheless, in order to thoroughly study the processes related to cleaning installations behaviour, these theoretical and experimental researches must be continued in order to optimize the systems performances.

Therefore, the primary experimental data obtained during tests with the equipment named Combined Separator TC 600 are shown in the following tables.

For the product to be processed-wheat seeds of Dropia variety, from 2014 production, a series of qualitative characteristics have been determined and their average values are presented in table 1.

Table 1

No.	Characteristic	MU	Parameter value	Obs.
1	Mass of one thousand seeds (MTS)	[g]	38.76	
2	Humidity	[%]	12.96	
3	Purity	[%]	93.74	
4	Hectolitre weight	[kg/hl]	74.2	
5	Light foreign bodies (plant scraps, straws, weeds, husk, dust, etc. with a thickness < 1.5 mm), C_{sui} **and** C_{sue}	[%]	2.69	Total foreign bodies [%]: **4.09**
	Small foreign bodies (< 2 mm), C_{smi} and C_{sme}	[%]	0.15	
	Large foreign bodies (> 2 mm), C_{sMi} and C_{sMe}	[%]	1.25	
	Broken seeds	[%]	1.0	
	Shrivelled grains	[%]	0.96	

In figure 2 are shown the components of material to be processed.

Fig. 2 – The content of material to be processed

In order to accomplish the experimental research, the mass of material and airspeed were maintained constant and were varied following factors: the angle of the screen (α_i = 2.4 °, 3 °, 4 ° and 5 °), the amplitude of sieve oscillations (A_i = 10 mm, 7 mm, 5 mm) and the seed feed rate, Q, between 1407 kg / h and 4501 kg / h. With these data the experiments were done and the results obtained were centralized in the following figures.

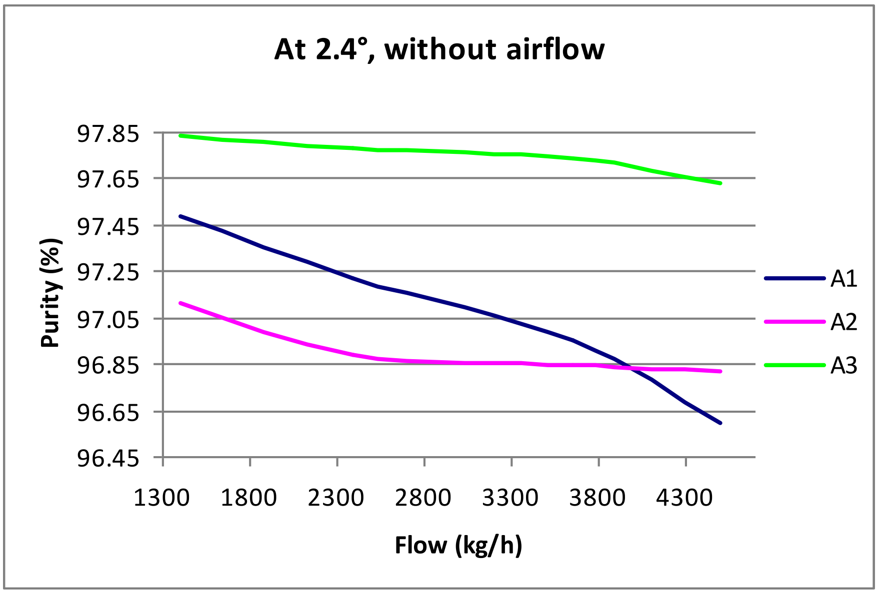

Fig.3 – For the tilt angle α_1 = 2.4°, without air current

Analysing the data shown in figure 3 for the tilt angle α_1 = 2.4°, without air flow, it was noticed that for amplitude A_3 = 5 mm the maximum purity, namely of 97.83 % was obtained at a minimum rate.

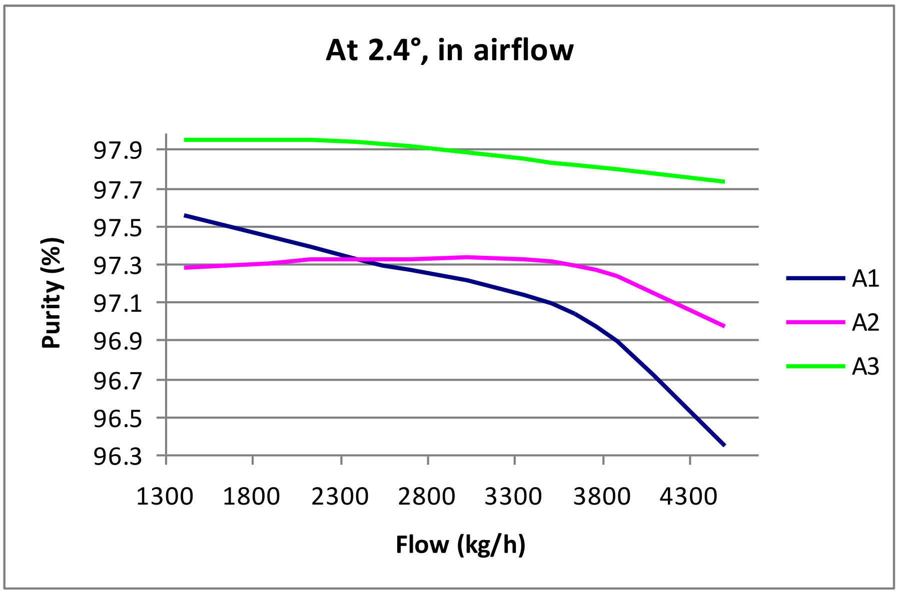

Fig.4 – For the tilt angle α_1 = 2.4°, under flow air

Analysing figure 4, for the tilt angle α_1 = 2.4°, under air flow, it was noticed that for amplitude A_3 = 5 mm the maximum purity, namely of 97.95 % was obtained at a minimum rate.

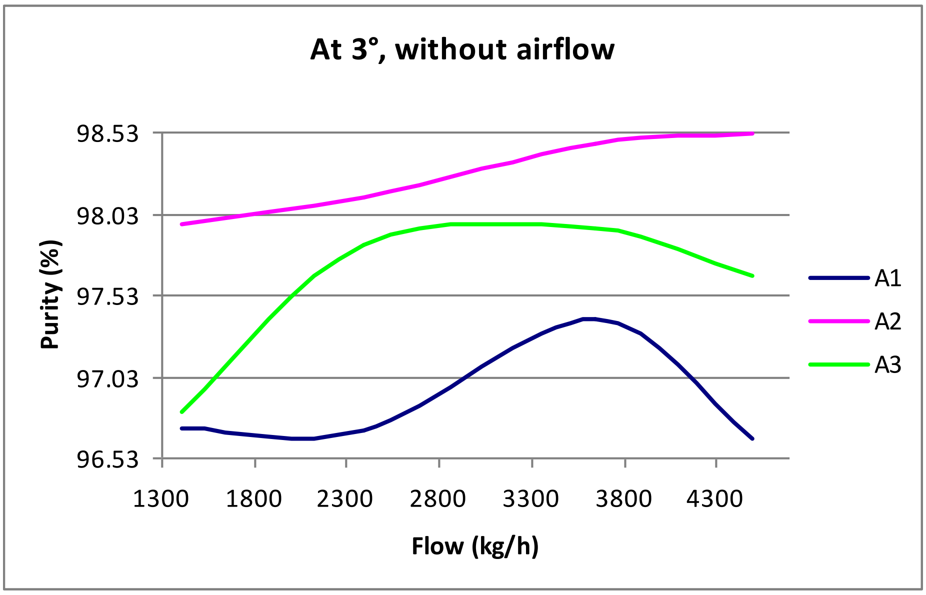

Fig.5 – For the tilt angle $\alpha_2 = 3^\circ$, without air flow

In this figure, it can be observed that for the amplitude A_2 = 7 mm the maximum purity, namely of 98.52 % was obtained at a maximum rate of 4501 kg/h.

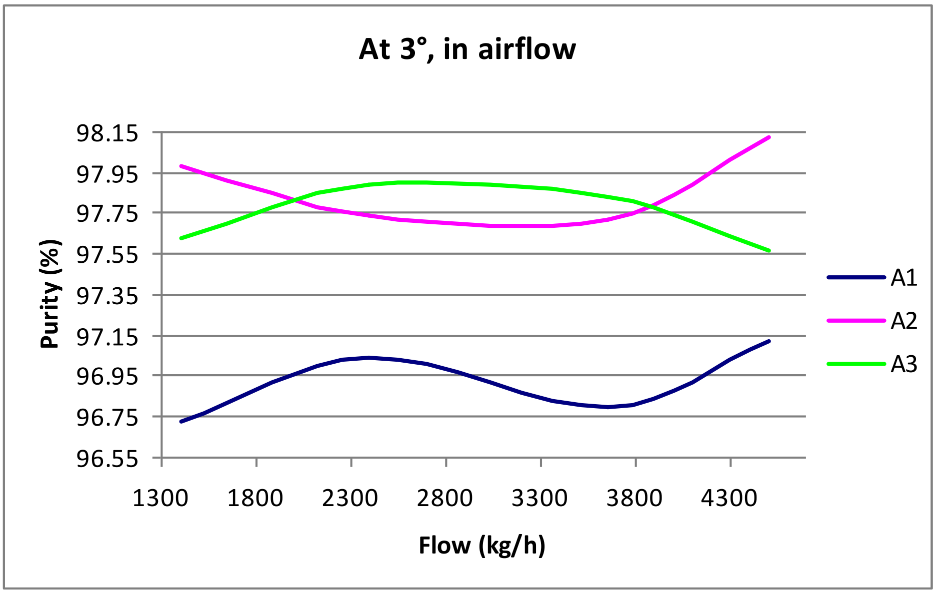

Fig.6 – For tilt angle $\alpha_2 = 3^\circ$, under air flow

For the tilt angle $\alpha_2 = 3^\circ$, under flow air, it can be noticed that a maximum purity of 98.12 % was obtained at the amplitude A_2= 7 mm and maximum rate of 4501 kg/h.

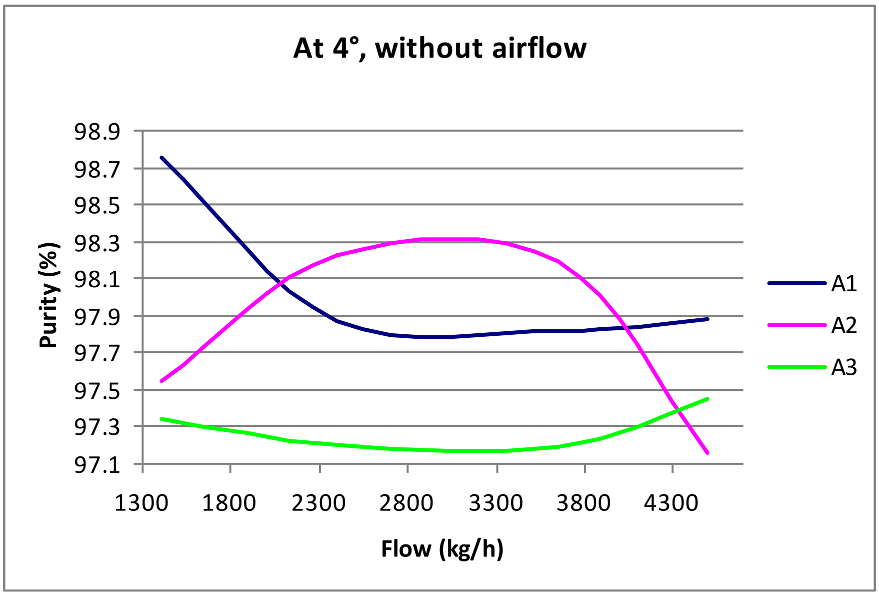

Fig.7 – For tilt angle α$_3$ = 4°, without air flow

Data in figure 7 for the tilt angle α$_3$ = 4°, without air flow have shown that for amplitude A_1 = 10 mm was obtained the maximum purity of 98.75 % for a minimum rate of 1407 kg/h, and for amplitude A_2 = 7 mm was obtained the maximum purity of 98.22 % for an intermediary rate of 2399 kg/h.

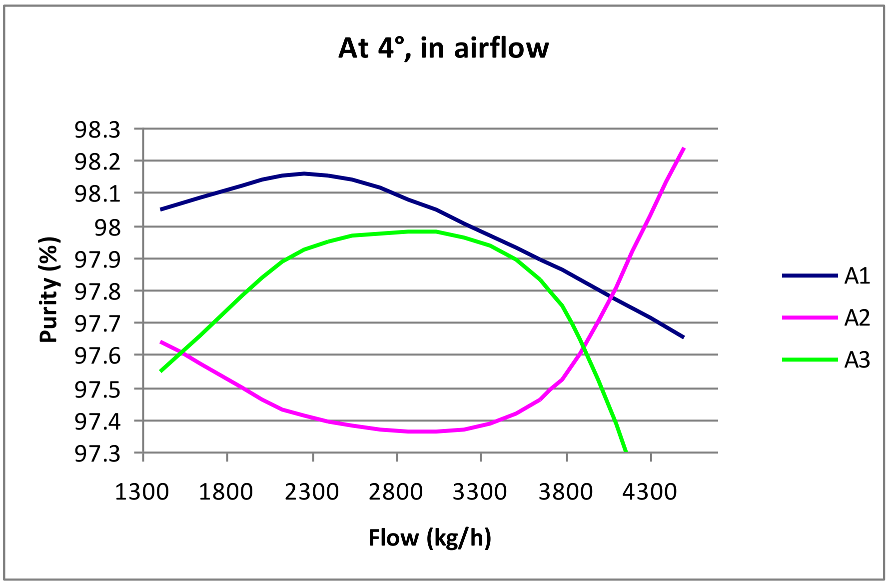

Fig.8 – For the tilt angle α$_3$ = 4°, under air flow

Figure 8 shows two superior values of purity that were obtained, namely: 98.15 % for amplitude A_1 = 10 mm and intermediary rate of 2399 kg/h and 98.24 % for amplitude A_2 = 7 mm and maximum rate of 4501 kg/h.

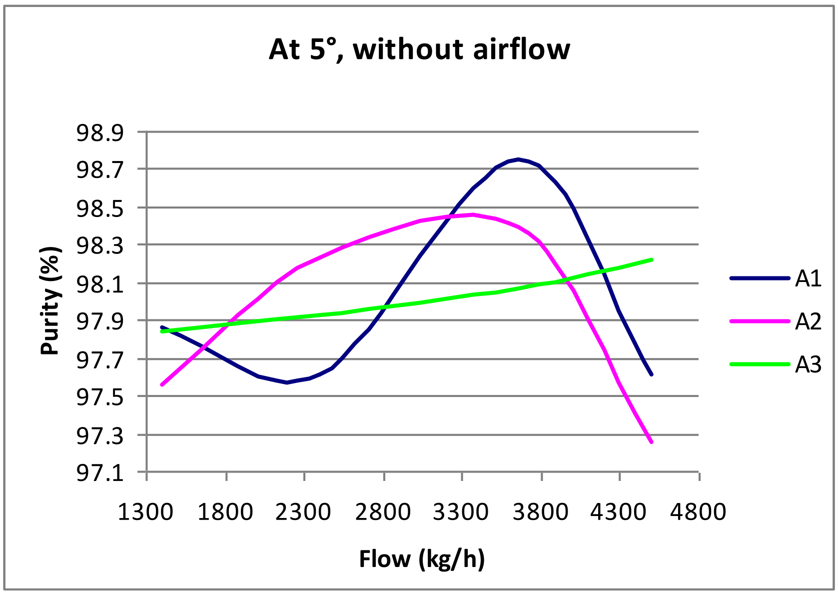

Fig.9 – For tilt angle α₄ = 5˚, without air flow

Analysing this figure, for the tilt angle α_4 = 5°, it was noticed that for amplitude A_1 = 10 mm it was obtained a maximum value of purity of the material processed without air flow, namely 98.75 % at the intermediary rate of 3653 kg/h.

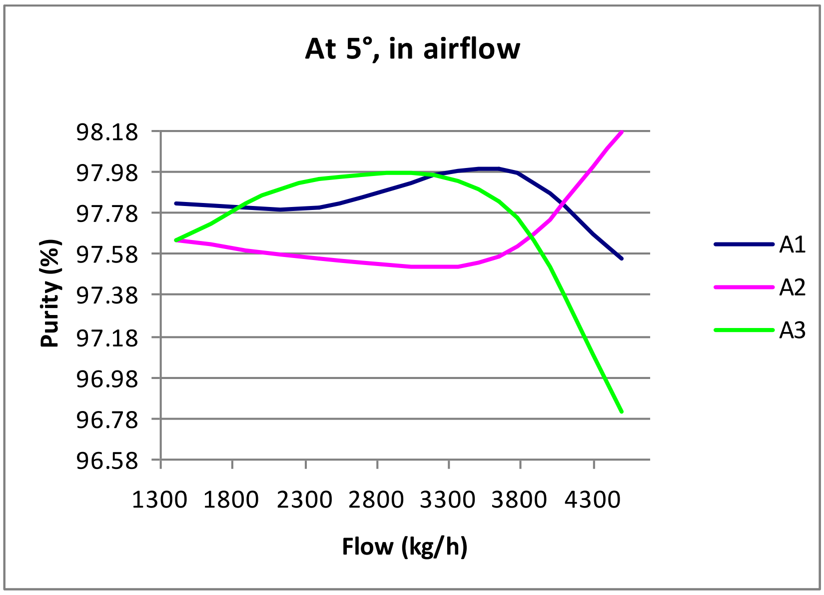

Fig.10 – For the tilt angle α_4 = 5˚, under air flow

Analysing figure 10, for the tilt angle α_4 = 5°, it was noticed that for amplitude A_2 = 7 mm it was obtained the maximum purity of material processed under air flow of 98.17 % at maximum rate of 4501 kg/h.

CONCLUSIONS

When the screen tilt angle and air flow speed were maintained constant, there have been correlations between amplitude and purity, thus obtaining the maximum value of purity of 98.75 % for the amplitude A_1 = 10 mm, both for angle α_3 = 4° and minimum rate of 1407 kg/h and for α_4 = 5° and intermediary rate of 3653 kg/h.

Experimental data obtained may represent the basis for improving the working process of existing equipment, by optimally adjusting its working parameters aiming to significantly diminish the impurities contained by cereal seeds and, at the same time, reduce the number of cleaning equipment and necessary energy consumption.

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INTELIGENT ROLLING SYSTEM FOR ROAD TRANSPORT MEANS. A REVIEW / *SISTEM DE RULARE INTELIGENT PENTRU MIJLOACELE DE TRANSPORT RUTIERE*

Ph.D. Eng. Ciuperca R.*[1], Ec. Mindru D.St.[2], Eng. Iftime M.[2], Ph.D.Eng. Nedelcu A.[1], Ph.Stud. Eng. Zaica A.[1],Ph.D.Eng. Matache M.[1], Ph.D.Eng. Visan A.[1], Ph.D.Eng. Popa L.[1]
[1]INMA Bucharest / Romania; [2]S.C. ELECTROPUTERE VFU PASCANI S.A.
Tel: 0726719726; E-mail: ciupercaradu@yahoo.com

Keywords: *road transport, intelligent rolling system*

ABSTRACT

The performance of transport means essentially depends on the rolling systems, these having major economic and environment implications generated by loads to be transported, travel speed, characteristics, air pressure in tires with direct implications on road wear, tire rolling belt wear. This paper presents an intelligent rolling system composed of transport load permanent monitoring installation, which provides information on the necessary air pressure in tires, according to the load and the travel conditions.

REZUMAT

Performanta mijloacelor de transport, depinde intr-un mod esential de sistemele de rulare, acestea avand implicatii majore economice si de mediu, cauzate de sarcinile de transportat, vitezele de deplasare, caracteristici, presiunea aerului din pneuri cu implicatii directe asupra tasarii si uzurii caii de rulare, a uzurii benzii de rulare a pneurilor. In aceasta lucrare se prezinta un sistem de rulare inteligent, care are in componenta o instalatie de monitorizare continua a sarcinilor de transport si care furnizeaza informatii asupra presiunii aerului din pneuri necesare, in concordanta cu sarcina si conditiile de deplasare.

INTRODUCTION

Transport in general and road transport in particular have an important place in the economic and social life of any economic entity, often determining important changes in the price of marketed products and materials.

As any other economic activity, transport must take place in optimum quality and efficiency conditions and with as low as possible price and energy consumption so that the transport activity have, in the end, an influence, as reduced as possible, on product price increase.

On the other hand, transport has a specific functional side requiring that it takes place in the best conditions, protecting the equipment, the environment, health and life of the persons involved.

When it comes to transport means performance, a key element is represented by the rolling systems; they have major economic and environment implications generated by loads to be transported, travel speed, constructive and functional characteristics, air pressure in tires with direct implications on road wear, on tire rolling belt wear, rolling resistance and implicitly on the transport operation cost.

Currently, at national and international level, the field of rolling systems fitting road transport means is well developed, the systems having varied constructive, functional and dimensional variants, depending on the mean of transport type, size and destination, the nature of goods transported, travel speed and road nature.

As we mentioned above, the rolling systems fitting road transport means had a continuous constructive development, regarding the type of axle, brakes, suspensions and functional development in respect to workloads, travel speed, type of rolling surfaces.

MATERIAL AND METHOD

In the case of a road transport mean, the drivetrain has an important role, both from constructive and functional point of view. The constructive role is to support the entire mass to be transported (own mass + load mass), the total mass it transfers to the road, and from the functional standpoint, the drivetrain accomplishes the movement of the transport mean. These can be of engine type (transmits the moment from engine, through the gear, to wheels and road) and non-engine, having the role to support the load to be transported.

This paper analyses only the non-engine drivetrain.

Drivetrain constructive type influences, to a great extent, the driving mode, soil compaction degree, rolling quality, the shocks transmitted to the towing vehicle, behaviour in road curves, etc. (*Ciuperca et al., 1998*).

Drivetrains encountered on road transport means are of several types[5,6,7,8,9]:

- single axle;
- two grouped axles; balancer type; bogie type; tandem;
- three grouped axles – tridem.

In their turn, axles can be with breaks or without breaks.

The most common type of brake axle is made of a full square profile beam, with the spindles processed from it, simplex type brake, drum and inside shoes brake driven by a camshaft. (fig.1)

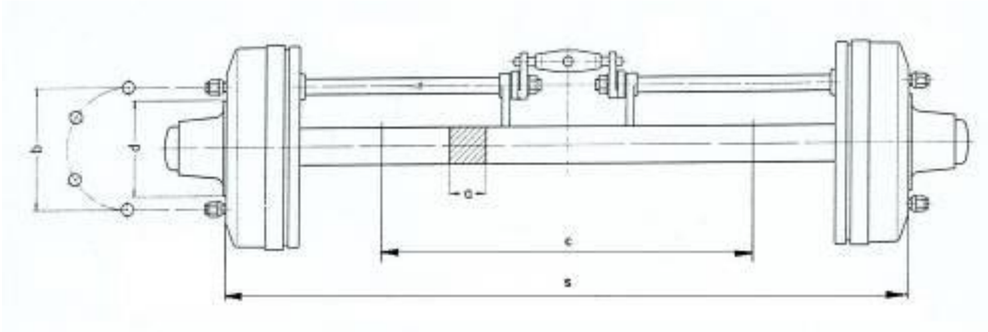

Fig.1 - Break axle

Among the advantages of this type of axle we mention:

- eliminating the operation of welding the spindles on the axle beam, which involves removing the stress relief operation;
- achieving the coaxiality of spindle ends;
- easier fastening on the framework, compared to round beam axle;
- lowering trailer mass centre;
- lower mass and price.

- balancer type, fig.2 – two-axle system, without suspensions, easier from the constructive point of view, with a reduced use rate, especially used for equipment ensuring short-distance transport, on routes inaccessible to public transport, equipment that in general also perform other works except for transport (especially agricultural woks) and are driven with low speed;

- tandem type, fig.3, - “tandem” type drivetrain is a group of two axles provided with four leaf spring suspension and with a three-point mounting on the chassis, thus making a more uniform loading of it. Instead, it has a number of disadvantages compared to bogie, disadvantages which led to its gradual replacement from the construction of agriculture transport means. Thus, the tandem is less oscillating, in case of bumps existing the risk that one of the axes lifts off the ground; it has a mass and a price higher than the bogie. It is recommended mainly on paved roads (highways, modernized roads).

Fig.2 - Balancer type drivetrain

Fig.3 - Tandem type drivetrain

“Bogie” type drivetrain (fig.4) is a group of two axles provided with suspension made of two leaf springs, attached to the axles at the two ends and in the central part articulated on a support fixed to the chassis.

Bogie type drivetrain is currently the most widely used in the construction of agriculture transport means because of the advantages it presents such as:

- ensuring a permanent contact with the road also when going over some bumps or obstacles;
- a permanent load transfer from one axle to the other;
- raising the stability of the load trailer by increasing the wheelbase, due to suspension way of fixing;

Nevertheless, it also has a disadvantage namely that, at overturning, in case of more adherent materials, which are more difficult to overturn, there is the tendency, because of load transfer towards the back, beyond bogie axle, to unload the back axle of the tractor.

"Tridem" type drivetrain (fig.5) is recommended for big loads, over 20 tons and is made of three axles with suspensions, similar from the constructive and functional standpoint to the tandem.

Because of the pronounced slippage problems and very high stress in road curves, the self-directed axle, placed in the front and in the back, is used on tridem and often on bogie or tandem (*Ciuperca et al., 1998)*.

Fig.4 - "Bogie" type drivetrain

Fig.5 - "Tridem" type drivetrain

The advantages of using self-directed axles are:

- the slippage in road curves is reduced a lot; tires and roads wear is substantially reduced; the stress in axle bearings and in other connecting elements is reduced.

There are solutions to mount the drivetrain on the chassis in several positions (fastening with screws or more rapidly with bolts), thereby adjusting the load on the chassis and the position of the body mass centre related to the drivetrain axle, with favourable implications on overturning.

Also, the suspensions can be of leaf spring type, parabolic spring, with air tubes or combinations of all these, as well as with telescopic buffers to attenuate vertical oscillations.

RESULTS

As we mentioned above, it is very important, for transport means, to be a correlation between the load to be transported and air pressure in tires, an optimal relation between these parameters leads certainly to an optimal driving of the respective mean of transport. For this, an innovative rolling system was created, equipped with a load permanent monitoring installation, called "Intelligent rolling system".

The "**Intelligent rolling system**" proposed (fig. 6), "bogie" type, is mainly made of two axles equipped with brakes, pos. 1, leaf spring suspension, poz.2, elements and components to connect with transport mean superstructure, pos. 3..9.

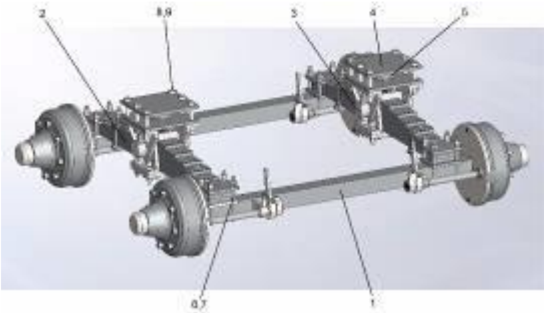

Fig. 6 - Intelligent rolling system

The novelty of the product is given by transport load monitoring installation, fig. 7, mainly made of Force transducer RTN, position 5, Bipolar fuse of 6A, position 6, Strain gage amplifier RM4220 type, position 7, Operation terminal GT1020-LBDW2 type, position 8, Micro PLC Alpha 2 type AL2-14MRD, position 9, afferent connecting elements, position 2 as well as the accumulator battery of 24V, position 1.

The installation continuously monitors the transport loads and provides information on the necessary air pressure in tires, according to load and driving conditions.

By applying the proposed system, a number of advantages will be obtained:

- Avoids overloading the mean of transport infrastructure and tires;
- Offers the possibility to adjust the air pressure in the tire, depending on load on the tire determined by the specific weight of the material transported and the nature and condition of the rolling surface;
- Avoids potential problems that may arise with exceeded transport load when driving on certain infrastructures (highways, national or European roads, bridges, viaducts etc.)

- Reduces lands compaction, especially agricultural ones, by correlating the pressure in the tire with transported load;
- Reduces fuel consumption in transport and the expenses for prematurely worn-out tires.

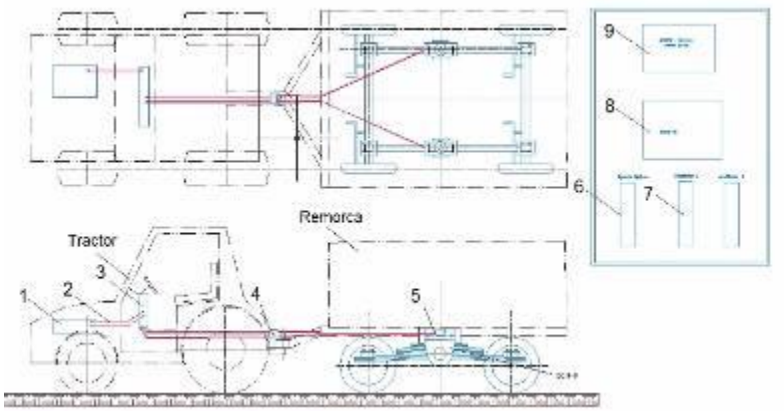

Fig. 7 - Transport load monitoring installation

CONCLUSIONS

- The rolling system is an important part of transport means components.
- For road means of transport, the most used types of rolling systems are: "balancer", "bogie", "tandem" and "tridem" types.
- For an efficient driving of the transport mean, from all points of view, it is very important to be a correlation between the transported load and air pressure in transport wheel tires.
- For this, an innovative rolling system was created, equipped with a load permanent monitoring installation, called "Intelligent rolling system".

ACKNOWLEDGEMENT

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MECHANICAL PROCESSING OF CAMELINA SEEDS FOR ASSURING THE REQUIRED CONDITIONS AT SUPERIOR CAPITALIZATION OF BYPRODUCTS
/
PROCESAREA MECANICA A SEMINŢELOR DE CAMELINĂ IN VEDEREA ASIGURARII CONDIŢIILOR NECESARE PENTRU VALORIFICAREA SUPERIOARA A SUBPRODUSELOR

Ph.D. Eng. Nedelcu A.*, Ph.D. Eng. Găgeanu P., Ph.D. Eng. Popa L., Ph.D. Eng.Ciupercă R., Eng. Zaica A., Eng. Bunduchi Gh.
INMA Bucharest / Romania
Tel: 0212693250; E-mail: nedelcu.ancuta@yahoo.com

Keywords: *mechanical processing technology, vegetable oils extraction, camelina grit, fooder*

ABSTRACT

Current guidlines in exploitation of agricultural production show that useing plants as raw materials for food and nonfood industries continue to grow both at international level and in Romania, which generates large quantities of varied byproducts, available on the market and can be used in animal feed. In the paper are presented experimental researches results regarding to camelina seeds phisical properties, subjected to mechanical processing aiming at superior capitalization of byproducts.

REZUMAT

Orientările actuale în valorificarea producţiei agricole arată că utilizarea plantelor ca materii prime pentru industrii alimentare sau non-alimentare continuă să crească atât la nivel internaţional cât şi în România, ceea ce generează cantităţi mari de subproduse diversificate, disponibile pe piaţă şi care pot fi folosite în furajarea animalelor. În lucrare sunt prezentate rezultatele unor cercetări experimentale privind proprietăţile fizice ale seminţelor de camelină supuse procesării mecanice cu scopul valorificării superioare a subroduselor.

INTRODUCTION

Quality of animal feed assumes besides quantity and quality, a nutritional value to the physiological requirements, specific to each species, breed, age or weight categories.

In animal nutrition, grassland usually provides protein requirements, but some hays and silage and other vegetable fodder have reduced protein content, supplemented with fodder protein food

Some oil seeds and by-products obtained within different stages of technological processes in various industries which process a vegetable raw material, can be additional protein sources for animal feed (*Şara A., Benţea M., 2011*).

Nutritional value, chemical composition and characteristics of these by-products are influenced by industry type from where they come, the used raw material etc. (*Paun A., Pirna I. et al, 2006, Paun A., Gangu V. et. al 2007).*

A secondary product resulted as a result of fat extraction from oil seeds (soy, camelina, flax, pumpkin etc.) is grist. In our country different type of grist are used in animal feed: soy, sunflower, rape, de etc.

These are protein sources of vegetable origin with a significant weight in concentrates mixture structure destined especially for cattle.

Searching for rich feed sources in o mega-3 polyunsaturated fatty acids, the specialists oriented to camelina (Camelina sativa), even if it is seen as a feedstock for the production of biodiesel fuel due to its high in linolenic acid high content (30 - 40%) *(Rokka T, şi col (2002)*.

Due to high oil content and nutrients composition in Camelina grits, according to previous studies (Cherian et al., 2009) which recommend it as a supplement in diets for birds and animals, has increased in recent years the market value of camelina crop *(Putnam, D. H. et al., 1993)*.

From seeds harvested on one camelina hectare can be extracted 70% grist and 30% oil. Grist could be used for animal feed in percentage of 10%, in order to significantly reduce the cholesterol content in the meat.

In addition to its extremely high content in fatty acids, benefit for health, cold pressed camelina oil is distinguished by its rich content in natural antioxidants. In Abramovich et al, 2007 works, was demonstrated that phenolic extracts obtained from camelina oil, added to a lipid model system, for a period of time, significantly delay the oxidation processes. E vitamin is used as an antioxidant to control the oxidation reaction, for example, in poultry feeding *(Meluzzi et al. 2000; and T. Rokka col.2002)*.

In Europe according to Commission Directive 2008/76 /EC, camelina was withdrawn from the list of undesirable substances in animal feed due to its properties discovered in recent years.

Also, according to those reported by American specialists *(Liuping Fan and N. A. Michael Eskin, 2013)* in February 2009, the United States Food and Drug Administration (US-FDA) allowed an interim exception for the limited use of camelina meal as a feed ingredient in feedlot beef cattle and growing swine rations. The US-FDA also expressed no objection to feeding camelina meal to broiler chickens and laying hens up to 10 per cent of their final diet.

Due to the fact that camelina is not pretentious to the ground, being cultivated on land with low fertility can be easily cultivated by farmers.

Growing camelina has a long tradition in Romania too, the first signs related to this fact dating back to antiquity. Currently, is cultivated GP 202 Romanian Camelia variety in Romania, GP 204 variety in Germany, Calena variety in Austria etc. Romanian Camelia variety was created by Fundulea National Research Development Institute and registered in 2011. This variety presents a good winter resistance, drought, shaking, MMB is of 0.94 ... 1.2 g and oil content in the seed is averaging 33. 8%.

Camelina grit in form of pellets or cakes with application in animal feed, resulting from seeds oil remaining after vegetable oil extraction, as a consequence of mechanical processing, carried on with special presses or vegetable oil extraction installations *(Gageanu P et al. 2009 and 2011)*.

MATERIAL AND METHOD

Mechanical processing of camelina seeds was performed on technological flow of the vegetable oils extraction installation, designed and accomplished by INMA Bucharest. Pilot installation structure is presented by the drawing in figure 1:

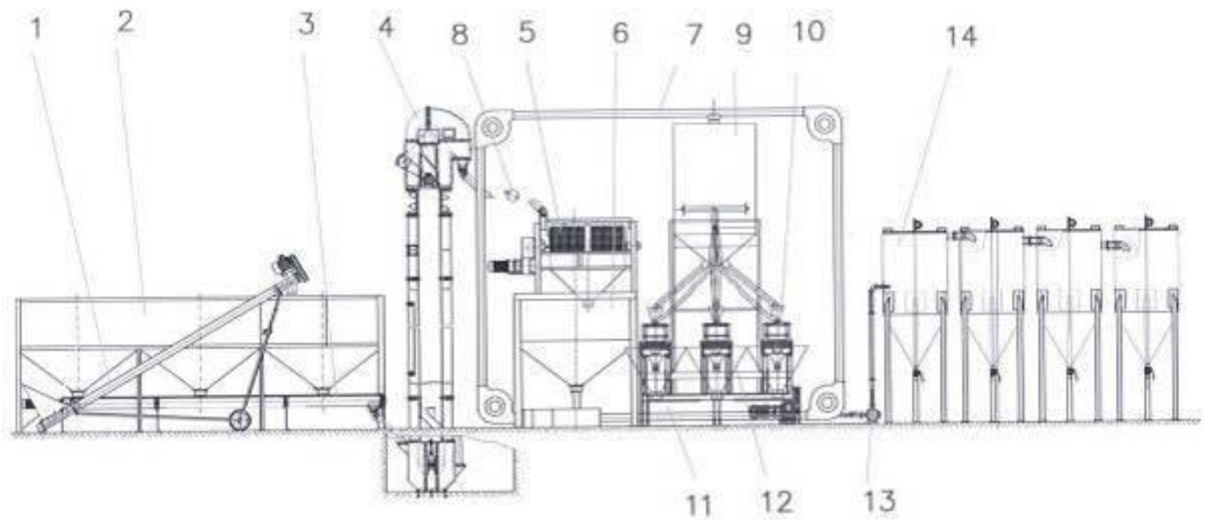

Fig.1 – Installation for vegetable oils extraction

1. TEI 110 inclined screw conveyor; 2. Feeding bunkers, 3. TEO 160 horizontal screw conveyor*; 4. ES 100 simple bucket conveyer; 5. SR 1630 rotary selector; 6. Intermediate bunker; 7. Chain conveyor and knots; 8. Pipe magnetic separator; 9. Preheating bunker; 10. PU-50 9 oil presses, 3 pieces; 11. Oil collector; 12. Pellets collector; 13. Tapping pipe; 14. Decantation-sedimentation pots (4 pieces).*

Pilot installation has 450 kg working capacity of seeds per hour and is destined to vegetable oils extraction from oil plants seeds: rape, soy, sun flower, flax, camelina etc.

Installation is structured on three working modules:

1. *Reception Module, storing and conditioning*, formed by reception bunkers; interfazic transport; conditioning rotary sieve; storing bunkers material to be processed (pressed);

2. *Pressing module* composed of: battery formed of three oil presses; collector basin for the three presses; space for grids storing, figure 2.

3. *Storing and decanting module* contains: inox containers in which waste decanting and sedimenting is done by natural means; filter with filtrates boards.

Seed mechanical processing process carries on in two phases: in preparing first stage the seeds are drying and crashing and in the second stage the seeds are cold processing.

Pressing is operation in which oil is separated from oil plant seeds under an external forces action, results being pressing and raw oil and by-products obtaining, as cakes, pellets.

At the beginning the retained oil at the breach particle surface, which flows through channels among particles, is separated. Then, when under increasing pressure begin particles deformation and compressing, oil elimination takes place, too.

When space among particles becomes very small, oil is no more eliminated and result broken cakes forming.

Pressing may be considered as a capillary filtration, phenomenon which is expressed by mathematical relation (1) *(Banu Ctin, 1998)*:

$$V = \frac{\pi \cdot P \cdot d \cdot \tau}{128 \cdot \eta \cdot l} \tag{1}$$

in which: *V* – separated oil volume, [m³] ;
P – applied pressure, [daN/cm²];
l – capillary length, [m];
d – capillary diameter, [m];
τ - pressure applying time, [s].
η – yield

Separation oil process is positively influenced if values *P, d* and τ increase and if the yield and capillary length decrease. Pressure force at mechanical presses is created by a worm screw, which is rotating in pressing chamber.

Main technical equipment for vegetable oil extraction and grit obtaining is *PU-50* vegetable oil extraction press, figure 3.

Fig. 2 - Pressing module

Fig.3. PU-50, vegetable oils extraction press

To accomplish mechanical processes, the press is preparing having in consideration of seeds type which are processing, achieving specific sets for every seed type. The seed within feeding chamber are took over by worm screw and introduce in pressing chamber. Pressing gradually takes place. In the first segment the seed broken and elimination of a small part of oil carries on. A small quantity of oil remains in grist mass, quantity which may vary between 5 to 8%, in function of seed type and setting done.

Grist is eliminated as pellets (camelina, flex, rape) or cakes (soy, sunflower). Grist can be obtained only in form of pellets, but after an aquarete setting. Grist under pellets form determine a series of advantages due to the fact that is more simple to storage and is more easy to use as fuel as fodder.

For determining physical characteristics of the obtained pellets by camelina seeds processing was used equipment within INMA Bucharest laboratories: AV 220 analytical balance model; UFE 500 draying stove, 100-800 model; CAL 2k calorimeter bomb model; hectolitre balance, Ohaus model, Compact CS 2000 serie.

RESULTS

Within experiments were determined camelina seeds and pellets physical characteristics, extracted from the flow of the installation for vegetable oil extraction.

Quantity of the received camelina seeds of 2830 kg, was subject of a conditioning after which were removed 1298.7 kg of impurities as chaff, sharps, earth, other seeds, and losses amounted to 1.3 kg.

In order to determine the camelina physical characteristics, were performed tests on several samples collected from the seed mass on luxury conditioning technology, the results are presented in table 1.

Table 1

Camelina seeds physical characteristics

Sample	Average purity [%]	Humidity [%]	Hectoliter mass [kg/hl]
I	79.0764	8.84	51.51
II	91.11	8.11	63.79
III	98.89	7.88	69.14

Within table 2 are presented final products obtained as mechanical processing of 1530 kg seeds mass by PU 50 mechanical press.

Table 2

Results of mechanical processing of camelina seeds

Parameter denomination	M.U.	Results
Camelina grist	kg	1046.7
Total oil quantity, out of which:	l	484.6
a. Filtered oil quantity	l	388
b. Oil waste quantity	l	96.6

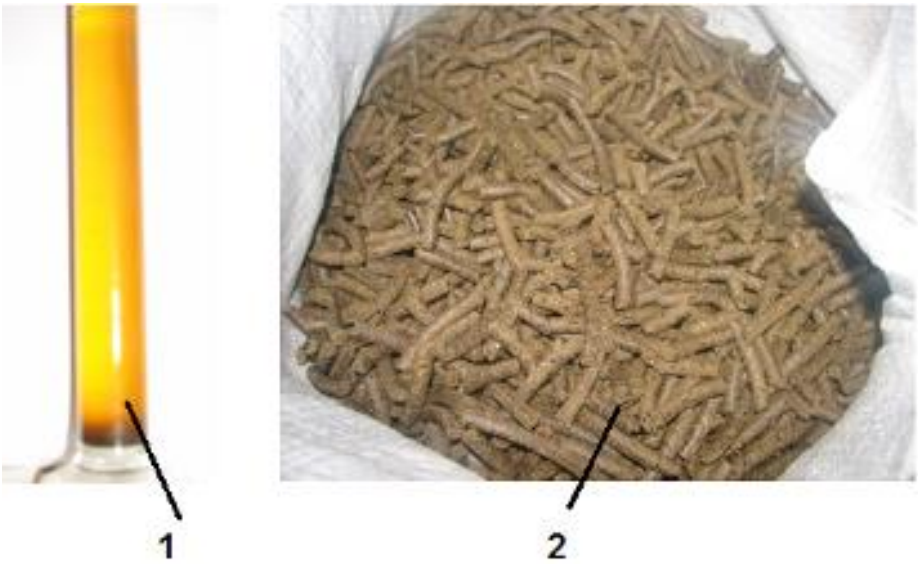

Fig. 4 – Products obtained by mechanical processing of camelina seeds
1. – Decanted camelina oil; 2. – Camelina grist (camelina pellets)

The registered specific energy consume was of about 50.67 kWh/t.

Average values for a series of grist physical characteristics after camelina seeds mechanical processing are synthetized in table 3.

Table 3

Determined values for some technical characteristics of pellets obtained by mean of mechanical processing by PU-50 vegetable oil extraction press

Parameter denomination	M.U.	Results
Caloric power	Mj/kg	19.886
Unburned fuel substance	g/kg	18
Humidity after pressing	%	24.83
Humidity after natural drying	%	10.15

CONCLUSIONS

- Current trends in developing the agricultural production consist in expanding byproducts capitalizing obtained by mechanically processes, as raw material for biofuel production and as a protein source in animal feed;

- *In the last years Camelina* (*Camelina* sativa L.) is in the researchers' attention because is not a plant demanding special conditions from the ground, can be grown on land with low fertility and by seeds processing are obtained camelina oil and grist, with rich content in natural antioxidants and proteins with multiple possibilities of capitalizing;

- The researches conducted with the pilot installation for vegetable oils extraction from oilseeds highlighted some physical properties of camelina seeds and grits under the form of pellets, obtained under certain conditions of purity and humidity;

- Samples collected from camelina seed mass, which were to be processed by mechanical pressing, had purity values from 79.08 to 98.89%, humidity of 8.84 to 7.88% and respectively hectoliter weight of 51.51 to 69.14 kg / hl;

- Camelina pellets obtained by processing a mass of 1530 kg of seeds had the following properties: 19.886 caloric power value of 19,886 MJ/kg; 24.83% moisture after pressing, value which was reduced after a natural drying process to 10.15%. Unburnt combustible substance recording values below 18 g/kg.

The presented data may be important for scientists studying camelina seed processing methods of obtaining and by-products capitalization as feed sources for animals and expanding the use in other fields.

ACKNOWLEDGEMENT

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SPECIFIC TECHNOLOGIES AND TECHNICAL EQUIPMENT USED IN ORCHARDS
/
TEHNOLOGII ŞI ECHIPAMENTE TEHNICE SPECIFICE UTILIZĂRII ÎN PLANTAŢIILE POMICOLE

PhD.Eng. Popa L.[*1)],PhD.Eng. Nedelcu A.[1)], Ph.D.Stud. Eng. Ştefan V., PhD.Eng. Tanăsescu N.[2)], PhD.Eng. Chitu E.[2)], PhD.Eng. Ciupercă R.[1)], PhD.Stud.Eng. Zaica A.[1)], PhD.Eng. Veringă D.[3)]
[1)] INMA Bucharest; [2)]ICDPMaracineni, [3)]ICDIMPH–HORTING Bucharest / Romania
E-mail: lucretia_popa@yahoo.com

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ABSTRACT

The establishment of a plantation involves its designing, which includes establishing varieties, appropriate choice of land, achieving a planting project depending on pedoclimatic conditions, processing the land and then, planting itself. After that, bothuntil fruit bearing and during the exploiting operation, the maintenance works follow.

The present paper represents a review on establishing orchards and the technical equipment that can be used for technologies application. The paper presents the results of a study which defined some technologies applicable at plantation establishment itself, emphasising equipment within technology, their applications, taking into consideration their advantages and disadvantages.

REZUMAT

Infiinţarea unei plantaţii presupune proiectarea plantaţiei, care cuprinde stabilirea soiurilor, alegerea corespunzătoare a terenului, efectuarea unui proiect de plantare funcţie de condiţiile pedoclimatice, prelucrarea terenului şi apoi plantarea propriu zisă, după care, atât până la intrarea pe rod cât şi în perioada de exploatare, urmează efectuarea lucrărilor de întreţinere.

Prezentul articol reprezintă un review privind tehnologiile de înfiinţare a plantaţiilor pomicole şi echipamentele tehnice care pot fi utilizate pentru aplicarea tehnologiilor. Articolul cuprinde rezultatele unui studiu care au definit câteva tehnologii aplicabile la înfiinţarea propriu zisă a unei plantaţii, cu evidenţierea echipamentelor din tehnologie, a aplicabilităţii acestora, luând în considerare avantajele şi dezavantajele lor.

INTRODUCTION

Fruit growing is part of the strategic concerns both at European and national levels and itsdevelopment is important to ensure the fruit necessary in human nutrition.

Fruit offer on the market is correlated with the quantity and quality production, influenced by climatic, pedological and agro-technical factors, whose action is not isolated, these factors being in an interdependence relationship.The variation of these factors generates output fluctuation from one period to another or from one region to another, in conditions of the same variety cultivation.For this reason, the applicable technologies in fruit growing should take into account all these influence factors, climate change determining adaptation of these technologies to specific regional conditions and culture.

To become more competitive in the market, fruit tree farmers have to establish a fruit tree technical equipment park,which includes at least a minimum of agricultural machinery, required for fruit culturesthat they want to establish / maintain / operate.

By equipping the fruit tree farm with the corresponding equipment ensuresan efficient working regime, reducing the need for labour and operating costs, increasing productivity and obtaining the competitive fruit production, qualitative as well as quantitative.

The action to establish a tree plantation (orchards) is of major importance, because it engages financial capital investment in a short period of time.

Certain types of fruit plantations (orchards) differs by the production peculiarities, destination, fruits volume and trees cultivated area to be taken into account in the design of plantations or orchards: commercial–industrial plantations, within family plantations, in family gardens plantations, experimental and didactic plantations.

Systems and plantations types have been improved and could be framed in precise assessment criteria.They are elaborated and improved depending on some criteria: species, variety, rootstock, trees vigour, fruit bearing, works mechanization degree, crown type as well asharvesting phasing of the biological cycle.

Methods and systems of fruit tree culture have evolved toward new modernisation and economic efficiency aspects, for example dwarf fruit tree plantation.

Researches regarding strategies in fruit tree growing (management and plantation design) are known, results proving that development in super-intensiveplantation system is not beneficial for the environment, that unproductive stages are higher in case of super-intensive plantations and smaller in case of semi-intensive ones*(Alaphilippe A.; et al., 2016).* There have been carried out researches regarding physical and chemical soil properties in apple tree plantation (Li LiuYing; et al., (2016), studies regarding increasing the sustainability in agriculture by mixing the animal breeding with cultivating orchards, the influence of this combination on environment (Paolotti L.;et al., 2016), studies regarding economic performance on long term on five apple trees varieties in classical plantation and organiccertified one *(Bradshaw T. L.; et al., 2016).* Studies regarding fruits sorting and conditioning have been made(Tănăsescu et al., 2015; Veringă et al., 2015).

Researches regarding equipment manufacturing carrying out works infruit tree growing were made to determine the influence factors on work quality (Ştefan V. et al, 2014; Jalil Taghizadeh Tameh, et al., 2015; Paraschiv G., Popa L., et al., 2009; Popa L. et al., 2012; Popa L. et al., 2014).

Worldwide, fruit tree growing got a special development, especially in countries as France, Poland, Spain, Italy, Croatia, Finland, Austria, Germany, Czech Republic, U.S.A., development based on new technologies, adequate and a performant machine category. To achieve the techniques fora plantation establishment, a wide range of machines and technical equipment are necessary.

Having in view the special importance of fruit tree growing, new research directions have been opened in Romania too, for development and implementation of new technologies and equipment.

MATERIAL AND METHOD

At establishing a fruit tree plantation, planting can be done manually or mechanized.

Manual planting has the disadvantage of low productivity, while mechanized planting operation ensures high productivity and achieves a reduction of physical effort of the operators.

Average planting rates for manually planting are of 300-500 saplings/day/person and in case of mechanizing planting the average values are of 500-3000 saplings/h.

Mechanizing planting is more economic and productive. The yield depends on used machine model and type, of its fair use and the soil preparing mode.

Planting machines are classifiedaccording to the following criteria:

I- Constructive shape and operations performed:

a) planting machines without wetting the plantedsaplings;

b) planting machines with wetting the plantedsaplings.

Both machine types are divided in:

- Machines for opening ditches;
- Machines for holes digging and manually planting;
- Machines for opening ditches and manually planting;
- Machine for ditches opening and semiautomatic planting;
- Machines for opening ditches and automatic planting;

II. In function of ground condition where planting is made:

a) machines which plant in soil prepared for planting;

b) machines provided with in stripes tillageequipment.

<u>Machines for opening ditches</u> are carried on tractor suspension mechanism and perform opening the ditches where the planting ofsaplings is to be performed. This equipment is made, in general, of a prism ploughshare, allowing making a ditch at a certain depth and two concave discs to finalise the ditch form. It can work in aggregate with tractors of 30 HP and reaching power of 85-100 HP.

Several examples of technical equipment for ditch opening are presented in figures 1, 2 and 3.

Fig.1– "Charlevoix Conservation District" type machine

Fig.2–"RM-50 Fireline Plow" type machine

Fig.3 –"RM-900 Fireline Plow" type machine

Ditch opening is followed by planting itself, using machines that perform strictly planting and closing the ditch, covering the seedlings' roots.

Machines for ditch opening and planting

There are also more complex machines, which have the advantage of achieving more operations in a single pass, reducing soil compaction, fuel consumption and increasing work capacity per shift. This equipment performs the opening of the ditch, planting, followed by furrow closing performed by the same equipment, in the same pass.

Egedal JT Standard machine (Figure 4) is made for planting saplings of small and medium size and works in aggregate with tractors of 85 HP. It is designed to perform the opening of the ditch with prism ploughshare and for manually planting seedlings in two rows, with space between rows of 60 ... 165 cm, at a depth of max. 30 cm. Earth coverage is achieved using two compaction wheels equipped with tire. At the front it also has two wheels for adjusting the working depth.

For planting tall trees or conifers, it is necessary to use a different type of equipment (Figure 5), which is provided with device for opening the ditch and land preparation, and operators are standing on the platform and put the saplings in the ditch.

The width of the ditch made ranges between 30 and 90 cm and their depth between 30 and 50 cm.

Table 1

Equipment type	Tractor	Working capacitytrees/day	Tree circumference	Ground bale diameter
PL-30	40 CP	3,000 – 4,000	8 – 10 cm	-
PL-40	55 CP	3,000 – 4,000	18 – 20 cm	-
PL-75	120 CP	500 – 1,500	20 – 25 cm	60 cm ø
PL-90	165 CP	500 – 1,500	25 – 30 cm	90 cm ø

Fig.4 - Egedal JT Standard type machine

Fig. 5 - PL-30-90plantingequipment

At INMA Bucharest was produced and tested an equipment with one or more workstations, available for planting on one, two, three or four rows (Figure 6). The necessary tractors range from 20 HP to 85 HP, depending on the number of rows the planting is made on. The disadvantage is that only saplings with a height of 40-50 cm can be planted.

These planting machines can be equipped with a device planting at 5, 10, 15 or 20 cm. The working capacity varies between 4,000-5,000 trees per day (PL-10/1 row) and 16,000-20,000 trees per day (PL-10/4 rows).

Fig.6 - PL-10planting equipment

Fig. 7 – Multifunctional aggregate for soil preparing and sapling planting AMP-0

The machine in Figure 7 is complex equipment, having the following components: soil full processing device; sapling semi-automated planting device; device for wetting the planted saplings. The technical devices that are part of the multifunctional aggregate are designed in modulated system allowing both aggregation and their individual use.

The energy source of the aggregate is ensured by a tractor with a power higher than 190 HP.

The aggregate formed by the equipment for soil tillage (EPS-06) + Equipment for sapling planting (MFP1) works only in untilled land making a strip of tilled land, of 60 cm width and 30 cm depth, followed immediately by planting, according to the technological scheme below.

Another planting equipment made at INMA Bucharest is the equipment for sapling planting EPF-1, (Fig. 8), destined to the mechanization of works for establishing plantations in orchards (or nurseries), agroforestry belts, driven by one operator.

Fig. 8 –Technical equipment for sapling planting – EPF 1

The equipment is of type carried on a three-point suspension mechanism of a tractor with installed power of 65 – 100HP. The equipment performs the planting of saplings with size between 25 and 70 cm up to a depth of max. 30 cm in strip tilled field with width of approx. 60 cm or in fully tilled field.

In the context of the same preoccupations was designed a machine for planting forest saplings, MPF-1 (Fig.8), destined to the mechanization of agro-forestation works, carried out to restore lost forest in lowland and hill areas, to establish protective belts and plantations in fruit orchards and nurseries. The machine performs planting of saplings with sizes between 25 and 70 cm up to a depth of max. 30 cm in strip tilled field with width of about 60 cm or in fully tilled field, also ensuring the watering.

Another methodology for planting establishment is preparing the soil with the help of hole digging machines, on one or several rows, followed by manual planting.

Hole digging machines

Currently, there are in construction machines for digging holes in a single row or in several rows, the width between rows varying depending on the tree species. They are mounted on the back axle of the tractor, on the three-point suspension mechanism, and can make holes with diameters between 150 and 1500 mm and depth between 400 and 1000 mm.


Fig. 9 – Hole digging machine Pazzaglia FZ **Fig. 10 – Hole digging machine Damcon**

Automated planting machines

At world level, there are automated planting machines (fig.11), that do not require the operator intervention for taking over and placing the saplings in the planting apparatus, they achieving the mechanized taking over of saplings and thus, reducing the manpower.

Machine of RPK-S type is designed to planting the small size saplings in two rows, being carried on power tractors ranged between 45…65HP. It comprises a ploughshare of prism type for opening the ditch at a depth of about 20 cm, where seedlings are automated placed, being subsequently covered by earth by means of two settling discs with wings. Planting mechanism is made of a roller with rods, easy to dismantle, where are manually placed the saplings, a conveyor with chains endowed with blades for catching the seedlings and transmission. During the operation, each wing from the covering disc acts on the roller with saplings, rotating it at a pace during which a chain blade takes over the sapling and transports it in the ditch where it is released.

Fig. 11 – Machine of RPK-S type [3]

Another variant of establishing a plantation is that of replanting the saplings grown in nurseries. For this operation, specialized equipment able to dislodge saplings, dig the ditch necessary to replanting and eventually replanting the saplings, is necessary.

Such a machine was achieved at INMA Bucharest, namely, EXPLANT 500 (fig.12).

Fig. 12 – Equipment for extracting plants with root earth bale, EXPLANT 500

• Equipment for replanting (extracting plant roots with earth bale), EXPLANT 500, is designed to extraction of saplings from horticulture, ornamental saplings fruit tree saplings with earth bale roots, in order to transplant them in green zones, plantations and/or nursery fields. At the same time, the equipment can be used for previously digging the holes where the material is to be transplanted, either the saplings extracted with earth bale, or those extracted with bare (without earth) root.

Machine for extracting trees with earth bale roots is of carried type behind the tractor, being mounted instead of tensional members. Machine working parts are of hoe type, mounted on supporting arms, being able to slide due to a guiding system. The hoes assembly vertical movement is ensured by means of a sliding body within a guideway. The active parts' driving is performed by the hydraulic installation of the machine driven by the tractor of the aggregate.

CONCLUSIONS

Depending on the plantation type, the technologies and their relevant equipment were analysed emphasizing their advantages and disadvantages and eventually, a few technologies and technical equipment able to be applied to establishing tree plantations in Romania, have been identified.

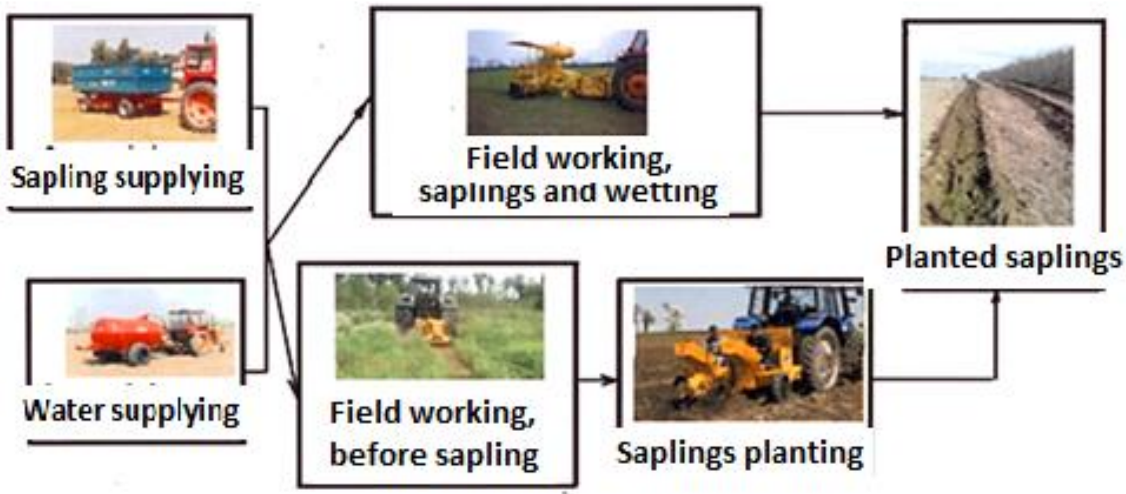

Fig.13 – Establishing technology - variant 1

Technology from fig.1 can be achieved by working the field, planting and wetting at a single passage or by distinct working and planting operations.

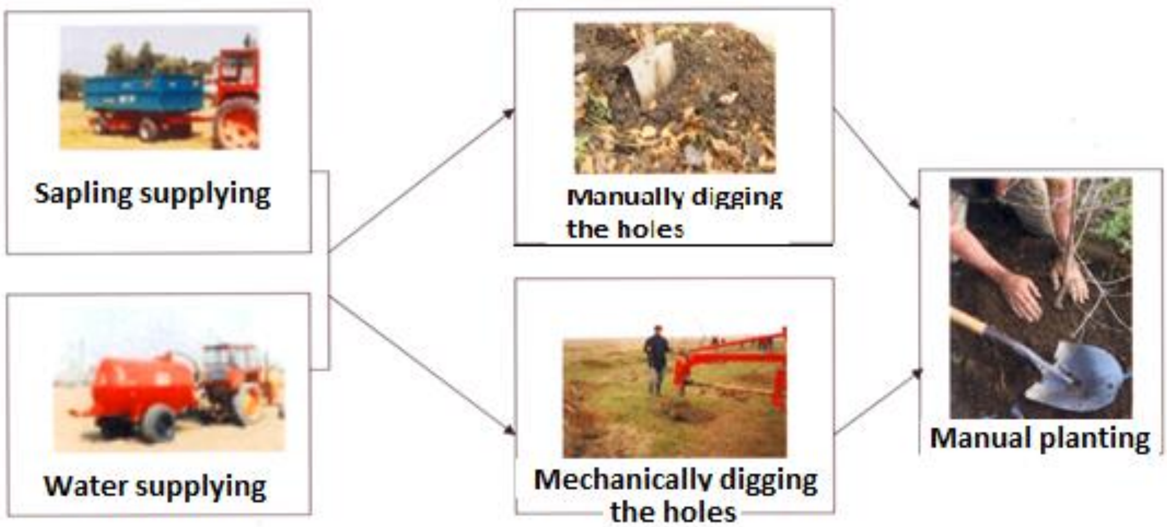

Fig. 14 – Establishing technology - variant 2

Establishing the tree growing plantations according to variant 2 consists in*:*

- digging the holes

- planting.

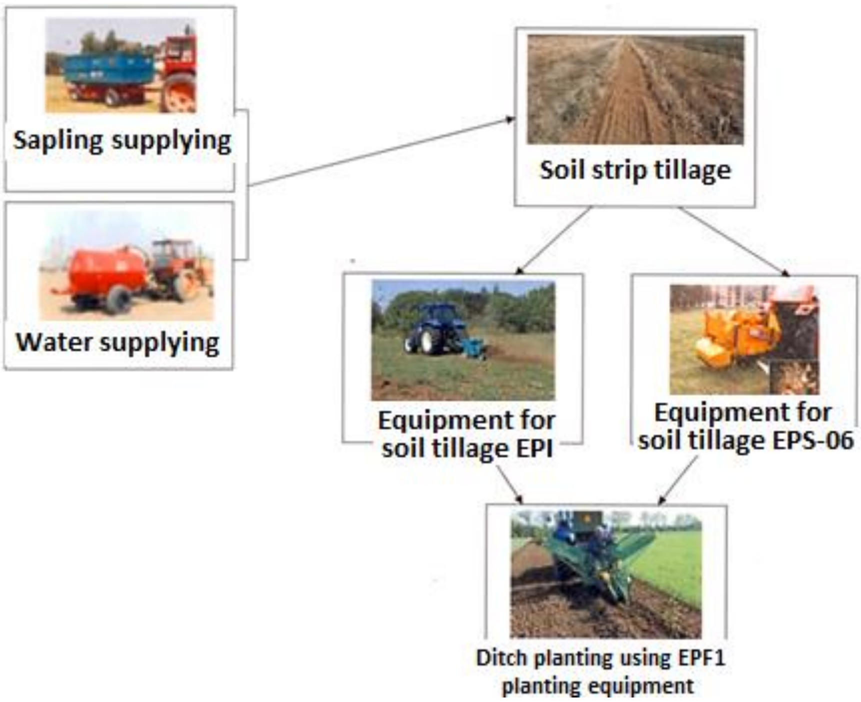

Fig. 15 – Establishing technology - variant 3

Establishing the tree growing plantations according to variant 3 consists in: working the soil in stripes and opening a ditch where saplings are mechanically planted.

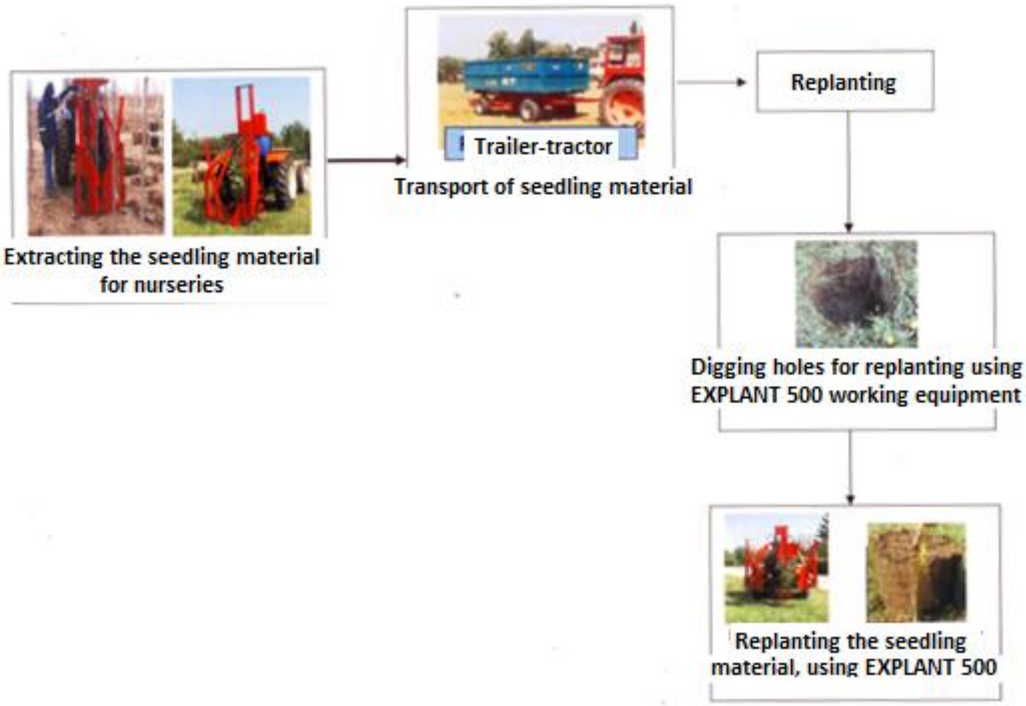

Fig. 16 – Establishing technology - variant 4

Technology for establishing tree growing plantations by transplanting with equipment EXPLANT-500 is designed to transplanting the saplings with soil including from nurseries into the final plantation.

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IMPROVEMENT OF VEHICLE FUEL EFFICIENCY BY OPTIMIZATION OF TRANSMISSION NUMBERS
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ПОЛІПШЕННЯ ПАЛИВНОЇ ЕКОНОМІЧНОСТІ АВТОМОБІЛЯ ОПТИМІЗАЦІЄЮ ПЕРЕДАТОЧНИХ ЧИСЕЛ ТРАНСМІСІЇ

Prof. Ph.D. Sakhno V.P.*[1)], Ph.D. Korpach O.A[1)], Prof. Ph.D. Kuznetsov R.M. [2)], Ph.D. Bodak V.I.[2)]
[1)]National Transport University / Ukraine, [2)]Lutsk National Technical University / Ukraine
E-mail: sakhno@ntu.edu.ua

Keywords: *fuel efficiency, transmission, optimization, transmission number.*

ABSTRACT

The article presents optimization method of transmission's numbers by the indexes of fuel economy. In a result of conducted researches were compiled objective functions dependence of the fuel consumption from the transmission number of gearbox in the modes of steady and unsteady movement. Using the methods of parametric optimization was defined range of transmission numbers for vehicle GAZ-31105 "Volga" with engine ZMZ 40525.10 in condition of minimum fuel consumption during acceleration of the vehicle.

ТЕЗИ

У статті наведено методику оптимізації передаточних чисел трансмісії за показниками паливної економічності. У результаті проведених досліджень було складено цільові функції залежності витрати палива від передаточного числа коробки передач по передачах в режимах усталеного та неусталеного руху. Використовуючи методи параметричної оптимізації було визначено ряд передаточних чисел автомобіля ГАЗ-31105 «Волга» з двигуном ЗМЗ 40525.10 за умови мінімальної витрати палива при розгоні автомобіля.

INTRODUCTION

Selection of the optimal transmission parameters determines largely the operational properties of the vehicle, including its fuel efficiency.

Parametric optimization methods of transmissions numbers reach better match of car construction to conditions of its operation. Such compliance is ensured by the definition of the objective function, optimality criteria, imposing certain restrictions on the objective function that defined probable operating conditions and use of the most appropriate method of optimization.

Various authors implement different approaches to solving the problem of optimizing the transmission numbers. For example, as objective function they use the ratio of hourly fuel consumption $G_п$ by j-th time interval during acceleration of the car with the full opening of the throttle valve to the full weight of the car. After applying to it of certain limitations, the authors get the equation of average density values of series of transmission numbers, that defined by the range of power inputs on the movement of the vehicle in the given conditions (*Faskhyev Kh.A., Shaikhutdynov Y.F., Halymianov A.D., et al, 2007*).

The objective function could also be the dependence of the thermal power capacity which is determined by capacity that the engine has to develop during movement in terms of driving cycle and effective coefficient of performance for universal static characteristic of engine, from transmission number and time of motion on the site. As optimality criteria was used the total fuel consumption for i-th plot cycle (*Gorogankin S.A., Savenkov N.V., 2012*)

In studies of Filkin N.M. and Shakurov D.K. was shown the method of multi-criteria optimization of parameters of energy propulsion transport machines. In this method is used 25 partial criteria of optimality fuel-speed properties of transport machines that resulted to the generalized optimality criteria using the method of expert evaluations. As the objective function take generalized optimality criterion that is considered as a nonlinear function of constructive parameters of machine's transmission. However, other constructive parameters of the machine (speed external and load characteristics of energy propulsion) are unchanged (*Filkin N.M., 2014; Filkin N.M., Shakurov D.K., 2015*).

The above discussed methods are mainly multi-objective optimization tasks. Their solution is complicated process and requires the use enough subjective methods, for example method of expert evaluations. Therefore, more appropriate is to make from multi-criteria task to one-criterion task (one-dimensional) optimization by imposition of restrictions. For example, by bringing the objective time function and the way of machine's acceleration or toxicity of exhaust gases of the engine from the size of transmission number car to look of unimodal continuous function of one variable (Korpach O.A., 2013; Sakhno V.P., Korpach O.A., 2013; Sakhno V.P., Korpach O.A., 2015). This technique is universal and it can be used in the determination of other indicators of vehicle operating properties, including fuel economy.

The purpose of this research is to develop optimization method of transmission numbers of the vehicle by indicators of fuel economy with using the methods of one-dimensional optimization.

MATERIAL AND METHOD

Fuel vehicle's consumption depends on its constructive and operating parameters, so from the mode of movement (acceleration, established speed, deceleration by the engine or braking system; full stop and work of the engine at idle).

The transmission gear ratio does not affect the fuel consumption in idle mode and in braking mode while using the brake system.

When braking by the engine, affect of transmission gear ratio is also insignificant, because the engine operates in the mode of forced idling (or complete shutdown of fuel supply) and it can be neglected. So there are only modes of acceleration and steady motion at a constant speed.

We will consider the influence of transmission numbers on fuel consumption in these modes of motion.

In the mode steady motion at constant speed fuel consumption is determined by dependence (*Farobyn Ia.E., Shupliakov V.S., 1983*):

$$Q = k_Q \cdot Q_{oc} \cdot \tau\,, \tag{1}$$

where k_Q - correction coefficient of fuel consumption;

Q_{oc} – second's fuel consumption, kg/s;

τ – time of vehicle move with constant speed, s.

The second's fuel consumption is determined (*Farobyn Ia.E., Shupliakov V.S., 1983*):

$$Q_{oc} = a_{Qc} \cdot V^2 + b_{Qc} \cdot V + c_{Qc}\,, \tag{2}$$

where

$$a_{Qc} = \frac{a_Q \cdot U_i^{\,2}}{3600 \cdot r_\kappa^{\,2}}, b_{Qc} = \frac{b_Q \cdot U_i}{3600 \cdot r_\kappa}, c_{Qc} = \frac{c_Q}{3600}, \tag{3}$$

U_i – total transmission number on i-th transmission;

r_κ – radius of rolling wheel, м.

a_Q, b_Q, c_Q - coefficients of function approximation hourly fuel consumption of the engine :

$$Q_o = a_Q \cdot \omega^2 + b_Q \cdot \omega + c_Q\,. \tag{4}$$

In the presence of engine speed external characteristics, coefficients aQ, bQ, cQ are defined by using interpolation formula of Lagrange on condition that:

$$Q_o = \frac{g_e \cdot N_e}{1000}, \tag{5}$$

where g_e – specific fuel consumption g/(kW·h),

N_e – engine power, kW.

Finally coefficients a_Q, b_Q, c_Q :

$$a_Q = \frac{((g_N \cdot N_{\max} - g_{\min} \cdot N_{\min}) \cdot (\omega_M - \omega_{\min}) - (g_M \cdot N_M - g_{\min} \cdot N_{\min}) \cdot (\omega_N - \omega_{\min}))}{1000 \cdot ((\omega_N^{\,2} - \omega_{\min}^{\,2}) \cdot (\omega_M - \omega_{\min}) + (\omega_{\min}^{\,2} - \omega_N^{\,2}) \cdot (\omega_N - \omega_{\min}))},$$

$$b_Q = \frac{\dfrac{(g_M \cdot N_M - g_{\min} \cdot N_{\min})}{1000} + a_Q \cdot (\omega_{\min}^{\,2} - \omega_M^{\,2})}{\omega_M - \omega_{\min}},$$

$$c_Q = \frac{g_{\min} \cdot N_{\min}}{1000} - a_Q \cdot \omega_{\min}^{\,2} - b_Q \cdot \omega_{\min}^{\,2}. \tag{6}$$

The highest reliability of fuel consumption at partial use of engine power is achieved with two output graph of dependence torque and hourly fuel consumption of motor shaft angular velocity and position controls fuel supply. These characteristics allow to link hour fuel consumption at partial and full fuel supply for the studied range angular velocity of the crankshaft of the engine. However, to get them is possible only experimentally, identifying loading characteristics of specific engine at various speeds of the crankshaft's rotation.

When determining fuel consumption by condition of partial use of engine power injected correction coefficient of fuel consumption k_Q , determined (*Lytvynov A.S., Farobyn Ia.E., 1989*):

$$k_Q = a_{ki} \cdot k_i^{\,2} + b_{ki} \cdot k_i + c_{ki} \tag{7}$$

where, k_i – utilization coefficient of engine power;

a_{ki} , b_{ki} , c_{ki} –of approximation function $k_Q = f(k_i)$

The utilization coefficients of engine power for determination of fuel efficiency parameters:

$$k_i = \frac{M_a \cdot g \cdot (f_0 + K_f \cdot V) + K_B \cdot F \cdot V^2}{A_i \cdot V^2 + B_i \cdot V + C_i}, \tag{8}$$

where M_a – total vehicle weight, kg;

f_0 – coefficient of rolling resistance at low speeds;

K_f – coefficient that takes into account the change in the coefficient of rolling resistance by increasing the speed of movement;

K_B – streamlining coefficient, Н·с²/м⁴;

F – frontal area, м²;

A_i, B_i, C_i - coefficients of approximation equation circumferential force:

$$A_i = a \cdot \frac{U_i^3 \cdot \eta_м}{r_\partial r_к^2},\; B_i = b \cdot \frac{U_i^2 \cdot \eta_м}{r_\partial \cdot r_к},\; C_i = c \cdot \frac{U_i \cdot \eta_м}{r_\partial}, \tag{9}$$

$\eta_м$ – efficiency coefficient of the transmission;

r_∂ and $r_к$ – dynamical radius of and radius of wheel rolling, м;

a, b, c – approximation coefficients of engine torque obtained experimentally.

Time of movement τ doesn't affect the value of gear ratio during steady motion, so it is possible to move to the equation of second's fuel consumption.

Substituting in (1) dependence (2), (7), with (3), (8) and (9) obtain dependence of second's fuel consumption with steady movement from the transmission number of gearbox, which is the objective function:

$$\begin{aligned} Q(U) = &\left(\frac{a_Q \cdot U_{КП}^{\;2} \cdot U_{ГП}^{\;2}}{3600 \cdot r_к^{\;2}} \cdot V^2 + \frac{b_Q \cdot U_{КП} \cdot U_{ГП}}{3600 \cdot r_к} \cdot V + \frac{c_{Qc}}{3600} \right) \times \\ &\times \left(a_{ki} \cdot \left(\frac{M_a \cdot g \cdot (f_0 + K_f \cdot V) + K_B \cdot F \cdot V^2}{a \cdot \frac{U_{КПi}^{\;3} \cdot U_{ГП}^{\;3} \cdot \eta_m}{r_\partial r_к^2} \cdot V^2 + b \cdot \frac{U_{КПi}^{\;2} \cdot U_{ГП}^{\;2} \cdot \eta_m}{r_\partial r_к} \cdot V + c \frac{U_{КПi} \cdot U_{ГП} \cdot \eta_m}{r_\partial}} \right)^2 + \right. \\ &\left. + b_{ki} \cdot \left(\frac{M_a \cdot g \cdot (f_0 + K_f \cdot V) + K_B \cdot F \cdot V^2}{a \cdot \frac{U_{КПi}^{\;3} \cdot U_{ГП}^{\;3} \cdot \eta_m}{r_\partial r_к^2} \cdot V^2 + b \cdot \frac{U_{КПi}^{\;2} \cdot U_{ГП}^{\;2} \cdot \eta_m}{r_\partial r_к} \cdot V + c \frac{U_{КПi} \cdot U_{ГП} \cdot \eta_m}{r_\partial}} \right) + c_{ki} \right) \end{aligned} \tag{10}$$

where V – established speed of movement.

Fuel consumption at the unsteady movement for full use of engine power that meets regimes of vehicle's acceleration is determined by dependence (Lytvynov A.S., Farobyn Ia.E., 1989):

$$Q_i = M_a \cdot \delta_{об} \cdot \int_{v_n}^{v_к} \frac{a_{Qc} \cdot V^2 + b_{Qc} \cdot V + c_{Qc}}{a_i \cdot V^2 + b_i \cdot V + c_i} dV, \tag{11}$$

where $\delta_{об}$ – coefficient that accounts rotating masses the vehicle;

V_n, $V_к$ – initial and final vehicle speed, m/s;

a_i, b_i, c_i –coefficients of right part of the differential equation of vehicle's movement (*Farobyn Ia.E., Shupliakov V.S., 1983*):

$$a_i = A_i - K_B \cdot F, \quad b_i = B_i - K_f \cdot M_a \cdot g, \quad c_i = C_i - f_0 \cdot M_a \cdot g \tag{12}$$

a_{Qc}, b_{Qc}, c_{Qc} - coefficients of equation (2), which approximated dependence of the second's fuel consumption by engine on the speed of the crankshaft's rotation.

Having substituted in dependence (11) value (2), (3), (9) and (12) were obtained objective function for fuel consumption during acceleration of vehicle from transmission number of gearbox:

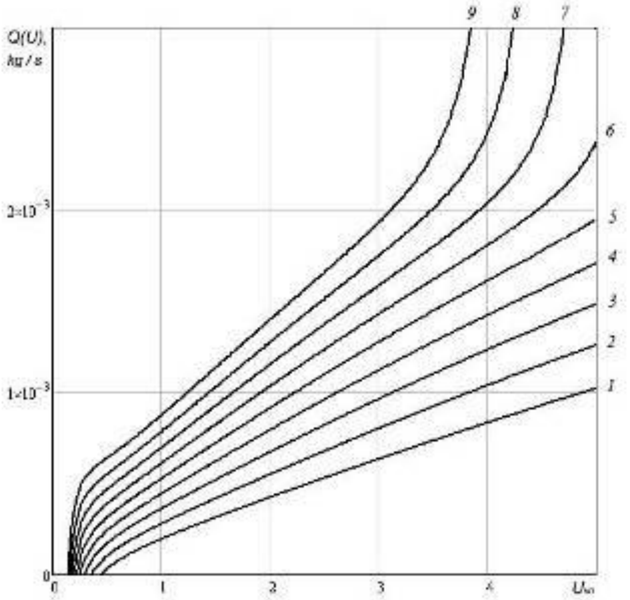
$$Q(U) = M_a \cdot \delta_{o\delta} \cdot \int_{v_n}^{v_\kappa} \frac{\frac{a_Q \cdot U_{K\Pi}{}^2 \cdot U_{\Gamma\Pi}{}^2}{3600 \cdot r_\kappa{}^2} \cdot V^2 + \frac{b_Q \cdot U_{K\Pi} \cdot U_{\Gamma\Pi}}{3600 \cdot r_\kappa} \cdot V + \frac{c_Q}{3600}}{\left(a \cdot \frac{U_{K\Pi i}{}^3 \cdot U_{\Gamma\Pi}{}^3 \cdot \eta_m}{r_\partial r_\kappa^2} - K_B \cdot F\right) \cdot V^2 + \left(b \cdot \frac{U_{K\Pi i}{}^2 \cdot U_{\Gamma\Pi}{}^2 \cdot \eta_m}{r_\partial r_\kappa} - K_f \cdot M_a \cdot g\right) \cdot V + \left(\cdot c \frac{U_{K\Pi i} \cdot U_{\Gamma\Pi} \cdot \eta_m}{r_\partial} - f_0 \cdot M_a \cdot g\right)} dV \tag{13}$$

Then the function (13) is integrated to get the final look of the objective function. Due to the significant massiveness final look of the objective function is not driven.

RESULTS

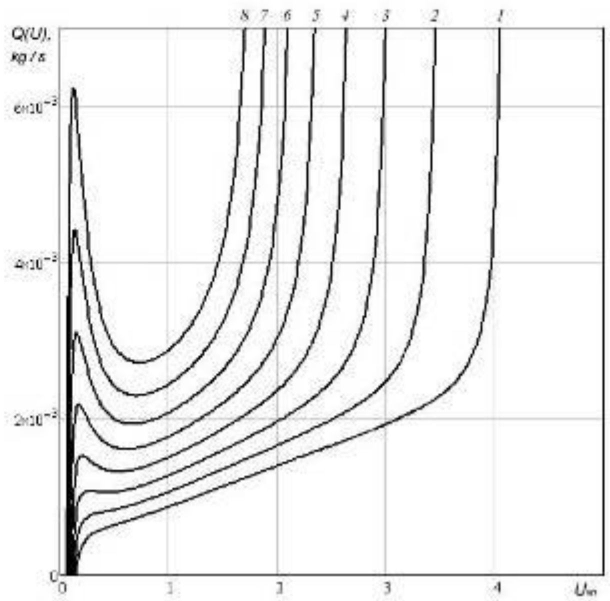
For urban driving cycle according to GOST 20306-90, the established speed of V defined by operating card and is within 20 - 60 km per hour in increments of 5 km/h.

Substituting these values in the function (10) received graph of dependence of second's fuel consumption from the transmission number of gearbox for specified speeds (Fig. 1). Calculations carried out by the example of GAZ-31105 "Volga" with engine ZMZ 40525.10.



1 – 20 km/h; 2 – 25 km/h; 3 – 30 km/h;
4 – 35 km/h; 5 – 40 km/h; 6 – 45 km/h;
7 – 50 km/h; 8 – 55 km/h; 9 – 60 km/h

Fig.1 – Dependence of second's fuel consumption by vehicle of GAZ-31105 "Volga" with engine ZMZ 40525.10 from the transmission number of gearbox



1 – 60 km/h; 2 – 70 km/h; 3 – 80 km/h;
4 – 90 km/h; 5 – 100 km/h; 6 – 110 km/h;
7 – 120 km/h; 8 – 130 km/h

Fig.2 – Dependence of second's fuel consumption by vehicle of GAZ-31105 "Volga" with engine ZMZ 40525.10 from the transmission number of gearbox

From Fig. 1 it is shown that the reduction of the value of transmission number of gearbox leads to a decrease second's fuel consumption. Moreover, with increasing speed of movement, the decrease become is more intense. At speeds over 50 km/h observed sharp increase of second's fuel consumption with an increase in transmission number of gearbox, due to work at higher engine's speeds, or even the inability to achieve that speed of the vehicle.

However urban driving cycle on the road only takes into account speed mode of movement to 60 km/h. Therefore it was built dependence of second's fuel consumption from transmission number of gearbox at speeds from 60 to 130 km/h in increments of 10 km/h (Fig. 2).

Further speeds increase reduces the possible range of transmission numbers, and starting with speed of over 80 km/h, there is appear a bend of the curve (extreme), that correspond minimum of second's fuel consumption. The value of transmission number at this point will be the optimal value.

However, to determine transmission numbers at all gears, using as objective function equation second's fuel consumption is impractical, because to certain speed of extremes functions do not exist. This method should be used with the imposition of additional restrictions, as well as providing recommendations on quantities of transmission numbers, especially for higher degrees.

Therefore, to determine rows of the transmission numbers used objective function of fuel consumption at the unsteady movement (13), corresponding to modes of dispersal.

The objective function (13) is not a function of one variable. It depends on transmission number of gearbox $U_{КПi}$ and initial $V_П$ and final speeds $V_К$ on transmission. All other parameters, with certain assumptions, can be considered permanent.

To bring the function (13) to form of continuous unimodal function of one variable (depending of the time of dispersal of the transmission numbers of gearbox $U_{КПi}$) should set the value of the initial and final vehicle's speed on transmission $V_П$ and $V_К$, that is impose restrictions.

So, for stepped speed gearbox, the first transmission should ensure given conditions to overcome maximum the resistance movement and limited by clutch of driving vehicle's wheels with the roadway. The first transmission appropriate is to accept similar to the basic row of transmission numbers. All other transfers are determined by the speed range from initial $V_П$ to final $V_К$, and moreover with increasing number of transmission increase and value of speeds. Intervals of speeds from $V_П$ to $V_К$ it is advisable to choose using as a basis for base range of transmission numbers and range obtained, by various methods, such as geometric progression, harmonious, dynamic range and others.

For vehicle GAZ-31105 "Volga" with engine ZMZ 40525.10 interval for speeds on transmission, for the base range of transmission numbers is: first gear – 0-11.138 m/s; second gear - 2,965-19,273 m/s; third gear - 4.975-32.337 m/s; fourth gear - 6.487-42.167 m/s; fifth gear - 8.170-53.107 m/s.

In this case is included the entire speed range of transmission from the minimum ω_{min} to the maximum ω_{max} angular speed of the crankshaft rotation of the engine.

Substituting values $V_П$ and $V_К$ for each transmission in dependence (13), constructed graphs of dependence of acceleration time from value of transmission number of gearbox for each transmission (Fig. 3.).

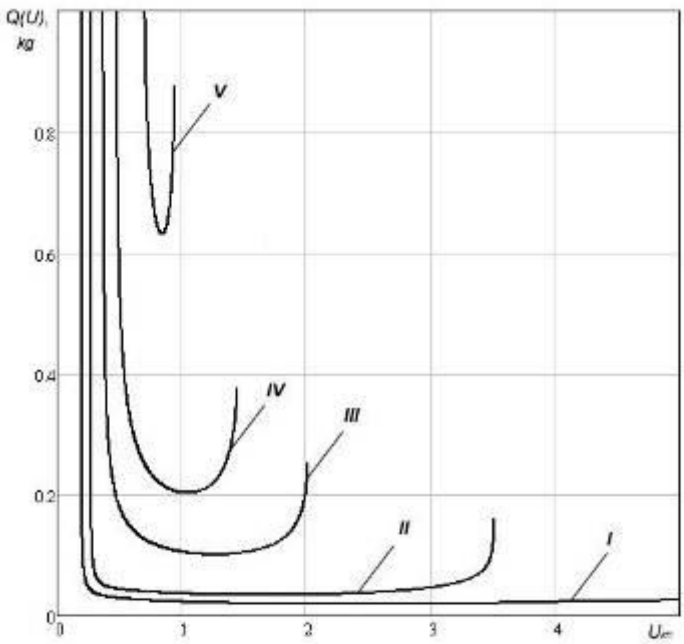


Fig. 3 – Dependence of fuel consumption during acceleration of vehicle GAZ-31105 "Volga" with engine ZMZ 40525.10 from the transmission numbers of gearbox

After entering the restrictions in the objective function (13) remains only one variable - transmission number of gearbox $U_{КПi}$,, which is the seeking value. For its determination is using the method of "golden-ratio". The transmission number is determined for each transfer, except the first, depending on the selected interval of speeds. Search ends after reaching the specified accuracy (E = 0.001), it requires 16 consecutive iterations of reducing search range (Rekleitys H., Reivyndran A., Rehsdel K., 1986).

As a result, it was determined transmission numbers of gearbox GAZ-31105 "Volga" with engine ZMZ 40525.10: first gear - 3.786; second gear - 1,684; third gear - 1.268; fourth gear - 1,046; fifth gear - 0.847.

Having conducted calculations on a mathematical model, it was found that the use of optimized row of transmission numbers leads to decrease of fuel consumption by vehicle GAZ-31105 "Volga" with engine ZMZ 40525.10 in urban driving cycle on the road by 2.7% from 0.4764 l. to 0.4636 l. per cycle.

CONCLUSIONS

In a result of conducted researches was designed the method of optimization of transmission numbers of gearbox by indicators of fuel economy. For this were composed objective functions of fuel consumption in modes of steady and unsteady movement. In the research was found that using as objective function equation of second's fuel consumption at steady motion, to determine transmission numbers on all gears is impossible, because to a certain speed of extremes functions do not exist. With increasing speed of the extremes appears, however to determine after them the range of transmission numbers is not possible. Therefore, was used the objective function of fuel consumption at the unsteady movement that correspond to modes of dispersal.

Using the methods of parametric optimization was defined range of transmission numbers GAZ-31105 "Volga" with engine ZMZ 40525.10 in condition of minimum fuel consumption during acceleration of the vehicle.

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THE ASSESSMENT OF THE MAIN PARAMETERS THAT INFLUENCE THE EFFICIENCY OF A SOIL REMEDIATION TREATMENT
/
EVALUAREA PRINCIPALILOR PARAMETRI CE INFLUENŢEAZĂ EFICIENŢA UNUI TRATAMENT DE REMEDIERE

Lect.Ph.D.Eng. Istrate I.A
[1)] Universities Polytechnic Bucharest, Faculty of Biotechnical Systems Engineering / Romania;
Tel: 0723542609; E-mail: ia_istrate@yahoo.com

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ABSTRACT

According to the European Environmental Agency, the estimated number for the contaminated and possible contaminated sites is more than 1.5 million. At national level, according to the National Strategy for the management of the contaminated sites, Romania has over 1600 contaminated and possible contaminated sites. Due to the existence of this problem, it is important to identify the best technologies that can be applied for soil remediation. Also the main parameters that could influence the application and the efficiency of a remediation technology are a key factor for a successful implementation of these remediation methods.

REZUMAT

Conform Agenţiei Europene de Mediu, numărul estimate pentru siturile contaminate şi posibil contaminate este mai mare de 1,5 milioane. La nivel national, conform Strategiei Naţionale pentru managementul siturilor contaminate, Romania are peste 1600 de situri contaminate şi posibil contaminate. Datorită existenţei acestei problem, este important să se identifice cele mai bune tehnologii ce pot fi applicate pentru remedierea solurilor. De asemenea, principalii parametri care ar putea să influenţeze aplicarea şi eficienţa unei tehnologii de remediere, reprezintă un factor cheie pentru implementarea cu succes a acestor metode de remediere.

INTRODUCTION

In the context of European and national concerns for the protection of soil, its sustainable use, conservation, and where possible capacity / properties restoration necessary for attaining as many functions, recorded a significant upward trend.

Industrial activities had released to the environment many toxic chemicals, that is, heavy metals and persistent organic pollutants, due to accidental spills or improper management. It was noticed that many conventional in situ remediation technologies are found to be ineffective and/or expensive to remediate sites with low permeability and heterogeneous subsurface conditions and contaminant mixtures (*Oprea, 2009*).

Lack of attention to soil degradation can be seen not only in the lack of European directives or soil protection targets, but also in the scarcity of data. While, for instance, 300,000 sites across the EU have been identified as definitely or potentially contaminated, the best estimate is that there are 1.5 million contaminated areas (*EEA, 2007*).

The definition of a contaminated site/area can be found mentioned in different manners from one author to another. Some examples of these alternatives are given in the following:

- a site at which hazardous substances occur at concentrations above background levels and where assessment shows it poses, or is likely to pose, an immediate or long-term hazard to human health or the environment (*Australian Government, 2001*);
- land which has harmful contaminants caused by previous land use;
- contaminated land occurs where substances in, or under the land mean that it is actually or potentially hazardous to human health or the environment. Land contamination usually results from past industrial and business use, however, in some situations hazardous substances may be naturally occurring.

Regarding the environmental contaminants, these can be defined in several ways:

- as harmful or hazardous matter introduced into the environment.

- as a substance that is not naturally present in the environment or is present in unnatural concentrations that can, in sufficient concentration, adversely alter an environment. In United States federal regulations (40 CFR 230) for the discharge of dredged or fill material into navigable waters regulated by Section 404 of the federal Clean Water Act define a contaminant as a chemical or biological substance in a form that can be incorporated into, onto, or be ingested by and that harms aquatic organisms, consumers of aquatic organisms, or users of the aquatic environment.
- as an undesirable substance not normally present, or an unusually high concentration of a naturally occurring substance, in water, soil, or other environmental medium.
- as any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

A wide range of contaminated sites exists as historical contaminated sites. This type of contamination of soils often occurs because of their use by industry and by processes and practices, which by current environmental standards would be judged inadequate. Although much of the contamination caused by these methods occurred since the beginning of the Industrial Revolution, some examples of much older contamination are known (*Oprea, 2009; Cairney, 1993; Soesilo and Wilson, 1997*). These include the sites of copper and lead workings dating back to Roman times. When contaminants accumulate over so long a period at a relatively slow rate, their effects tend to become subsumed into the general environmental changes that take place over time in any area. As such, the contamination may after many years appear to have little discernible impact on the local environment, which has become adapted to the presence of contaminants. Evidence of direct effects, whether adverse or otherwise, due to the presence of the contaminants may be hard to obtain in such circumstances (*Oprea, 2009*).

The potential damage to an ecosystem or to a community's health can be significant and the financial costs of cleaning up the site can be high (*EEA, 2007*).

Contamination commonly becomes a problem when a contaminated site is rezoned or redeveloped. The change of land use results in new exposure pathways being established that can, in some circumstances, adversely affect public and occupational health as well as the environment. A typical example is the rezoning of a contaminated site from an industrial to a residential zone (*Oprea, 2009*).

MATERIAL AND METHOD

It is important to use a remediation technology in order to reduce the pollution level, due to the effects that could appear on human health from the exposure to the contaminants.

Exposure to contaminants can be caused by inhalation of dust or gasses, contact with soil, or through food grown on the land. Leachates (pollutants draining from the site in liquid form) can pollute groundwater and rivers or ponds. Some contaminants may be corrosive, and some can pose a risk of explosion or fire. It is used a risk assessment bases on a conceptual model using a Source-Pathway-Receptor methodology like the one shown below (*Oprea, 2009; Soesilo and Wilson, 1997*). The methodology takes into account all the possible and plausible pathways through which contaminants can reach receptors. The exposure pathways for human living targets are represented in figure 1.

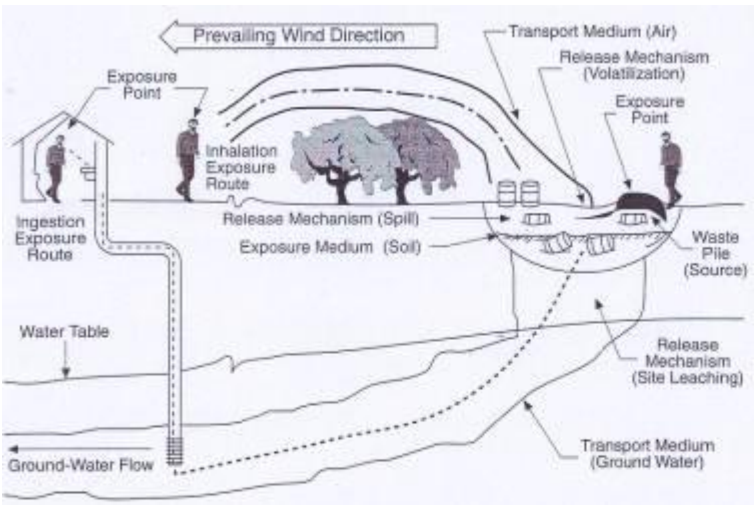

Fig 1 - Illustrations of exposure pathways (*Oprea, 2009; Soesilo and Wilson, 1997*)

Soil contamination is in Europe as a widespread problem of varying intensity and significance. Cleaning up all historically-contaminated sites, commonly of industrial origin, to background concentrations or levels suitable to all uses often is not viewed as technically or economically feasible (*EEA, 2009, Algreen et al, 2015*). As a result, clean-up strategies increasing are designed to employ sustainable, long-term solutions, often using a risk-based approach to land management aimed at achieving "fitness for use" appropriate to the location. In the absence of specific EU legislation to address the clean-up of contaminated soil, Member States apply the "polluter pays" principle to varying degrees in clean-up programs.

Although the range of polluting activities and their relative importance may vary considerably in each country, several main local sources of soil contamination can be clearly identified across Europe (fig. 2).

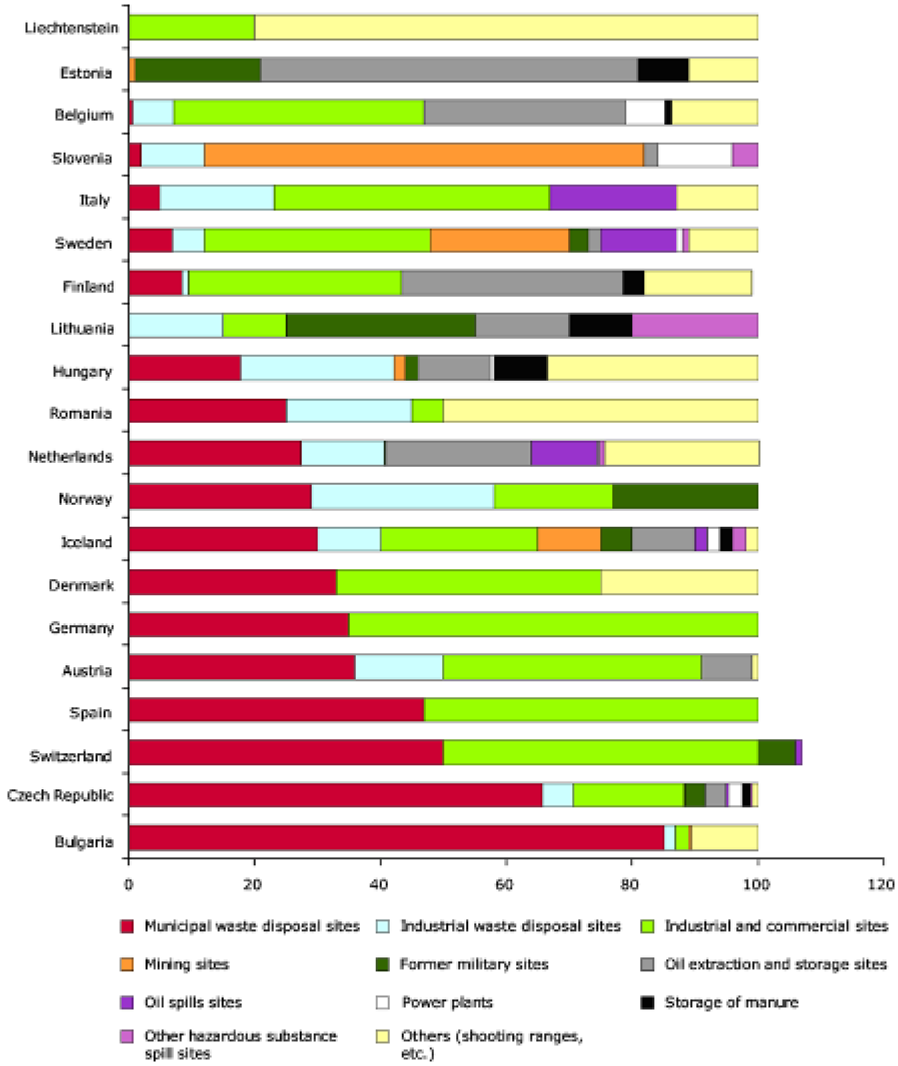

Fig 2 - Soil polluting activities from localised sources as % total sites where (preliminary or main) site investigation has been completed (*EEA, 2007*)

In the last years, the field of contaminated soils remediation has received an important attention, and many remediation technologies have been developed.

Cleanup methods are techniques to treat or contain pollution in order to make it less dangerous for human health or for the environment (E. Ferrarese, 2005; Narong et al, 2016)).

Remediation techniques can be divided into:

- **ex-situ treatments:** when the contaminated soil is excavated before being treated; they are called:
  - *on site treatments*: if the extracted material is excavated and then treated in the same contaminated site (for example in reactors that are build in the contaminated site);
  - off-site treatments: when the contaminated material is extracted from the subsurface and then is transported to a site where it is decontaminated (e.g. a specific treatment plant);
- **in situ treatments**: when a contaminated soil or groundwater is treated in place, without excavation.

A second type of classification can be based on the principle of remediation as follows: *chemical and physical treatments; biological treatments; thermal treatments*.

Moreover, the remediation techniques can be distinguished based on their effect on the polluting agents. From this point of view these techniques can be classified as (E. Ferrarese, 2005; Reddy et al 2009; Huang et al, 2015):

- treatments finalized to pollutants destruction: this treatments intervene by changing chemical structure of polluting agents, in the way which needs to be made it harmless or to reduce danger of it. Those include thermal, chemical and biological treatments, and can be applied in situ and also ex situ.
- treatments of extraction or separation of pollutants: they include the thermal desorption of the land, the soil washing, the soil flushing, the extraction with dissolvent, the soil vapour extraction (SVE) beyond to all the treatments for waters (separation of phase, adsorption on active carbons, air stripping, ionic exchange or combinations of such techniques). The choice of the participation more adapted depends strongly on the volatility of the polluting ones, as an example, for the polluting volatiles agents and relatively insoluble, participations similar to the preferable SVE will be respect to a soil flushing or soil washing.

The known technologies at the moment for the remediation of contaminated soils are presented in table 1 where the technologies are classified in function of how the treatment can be applied, in situ or ex situ:

Table 1

List of potential remediation technologies applied on contaminated soils (*Oprea, 2009*)

Remediation technology	In situ	Ex situ
PHYSICAL		
Electrokinetics	X	
Electroosmosis	X	
Ground freezing	X	
Hot water displacement	X	
Mechanical soil aeration	X	X
Metal precipitation	X	X
Soil vapour extraction	X	
Soil flushing	X	
Soil washing		X
Solvent extraction		X
Supercritical extraction		X
STABILIZATION/CONTAINMENT		
Containment	X	
Drains and trenches	X	
Vertical wells	X	
Horizontal wells	X	
Secure landfilling		X
Slurry trench cutoff wall	X	
Sheet pile cutoff wall	X	
Soil-mixed wall	X	
grouting	X	
capping	X	
STABILIZATION		
Cement-based fixation	X	X
Glassification		X
Polymerization		X
Pozzolanic-based fixation	X	X
Silicate – based fixation	X	X
Thermoplastic microencapsulation	X	X
Vitrification	X	
BIOLOGICAL		
Bioslurry reactor		X
In situ biostimulation	X	
Air sparging	X	

Bioventing	X	
Colloidal gas aphrons (O_2)	X	
Engineered soil piles		X
Bioseedings	X	X
Recirculating leachfield	X	X
White rot fungi		X
Yeast strains		
Land treatment (general)		X
Land farming		X
Composting		X
Mycorrhizas		X
Phytoremediation	X	
CHEMICAL		
Chlorination		X
Dehalogenation		X
Dechlorination		X
Hydrolysis	X	X
Lignin adsorption		X
Neutralization	X	X
Chemical oxidation-reduction	X	X
Polymerization		X
THERMAL		
Desorption	X	X
High temperature indirect desorber		X
Low temperature thermal desorbers		X
Radio frequency heating	X	
Steam/hot-air soil stripping	X	
Steam/vacuum extraction	X	
Electric reactor		X
Fixed hearth		X
Fluidized bed incinartor		X
Industrial boiler		X
Industrial kiln		X
Infrared incineration		X
Plasma systems	X	X
Pure oxygen burner		X
Rotary kiln		X
Thermal/catalytic oxidation		X
Liquid injection		X
Molten glass		X
Molten salt		X
Multiple hearth		X

In the 1990s, viable technologies of bioremediation and phytoremediation became available as alternatives for environmental repair and especially for the treatment of PCBs contaminated soils. Phytoremediation is a process that uses plant for biological treatment of both contaminated soil and water. Operating costs are very low, ranging from 0.02 to 1.00 € per m^3 of soil. The method may be applied in situ and used the sun as an energy source (*Borba da Cunha et al, 2012*).

In the present paper, the main parameters that influence the efficiency of an electrochemical treatment, will be presented.

ELECTROCHEMICAL TREATMENT – DESCRIPTION AND PARAMETERS

Electrochemical remediation technologies (ECRTs) are part of a broader class of technologies known as direct current technologies (DCTs), a class that can be introduced in the second category – chemical and physical treatments. These technologies use an electric current in the treatment process to either mobilize or break down contaminants in soils or sediments. ECRTs work rapidly, on the order of months, at costs well below excavation and disposal (*F.Doering et al, 2005*) and can be applied to both organic and inorganic contaminants (*Oprea, 2009*).

Empirical evidences indicate that the reaction rates are inversely proportional to grain size, such that this remediation technique is particularly effective in saturated low permeability soils (like clays and silts), which are often more difficult to treat with conventional chemical methods (such as chemical oxidation or soil flushing), because of their low permeability and their high sorption capacity. Usually, for in situ DCT applications, the current density is of the order of milliamperes per square centimetre ($1mA/cm^2$) and the electric potential difference is on the order of a few volts per centimetre across the electrodes placed in the ground (1V/cm) (*U.S.AEC, 2000*). The electrodes can be made of different materials, as stainless steel or carbon, and they can be placed in the soil either in a vertical or horizontal array.

Till nowadays, there are several examples of application of DCT to real cases of contamination across Europe and America, but a deep knowledge of the phenomena ruling the remediation process has not been reached. Therefore, at the moment the calibration of the remediation action is mainly based on empirical data and on the results of field preliminary tests.

The electrochemical remediation depends on several important factors, as it will be presented in the following:

- soil chemistry, or soil-contaminant interaction: the kinetics of the removal of contaminants is bound to adsorption phenomena, ion-exchange, buffering capacity;
- water content: inhomogeneous distribution of humidity and consolidation may take place during an elecrokinetic treatment;
- soil structure: clogging of the soil porous texture and blocking of the electro-osmotic flow may take place due to hydroxide formation (presence of heavy metals);
- positioning of the electrodes and electrode structure: solidity of the structure, easy workability, chemical stability, costs, are major actors. Silicon pig-iron, graphite, activated titanium are electrode materials of practical interest.

The electrode distribution when electrochemical remediation is applied can vary from the bench scale to commercial installations as it is presented in fig. 3.

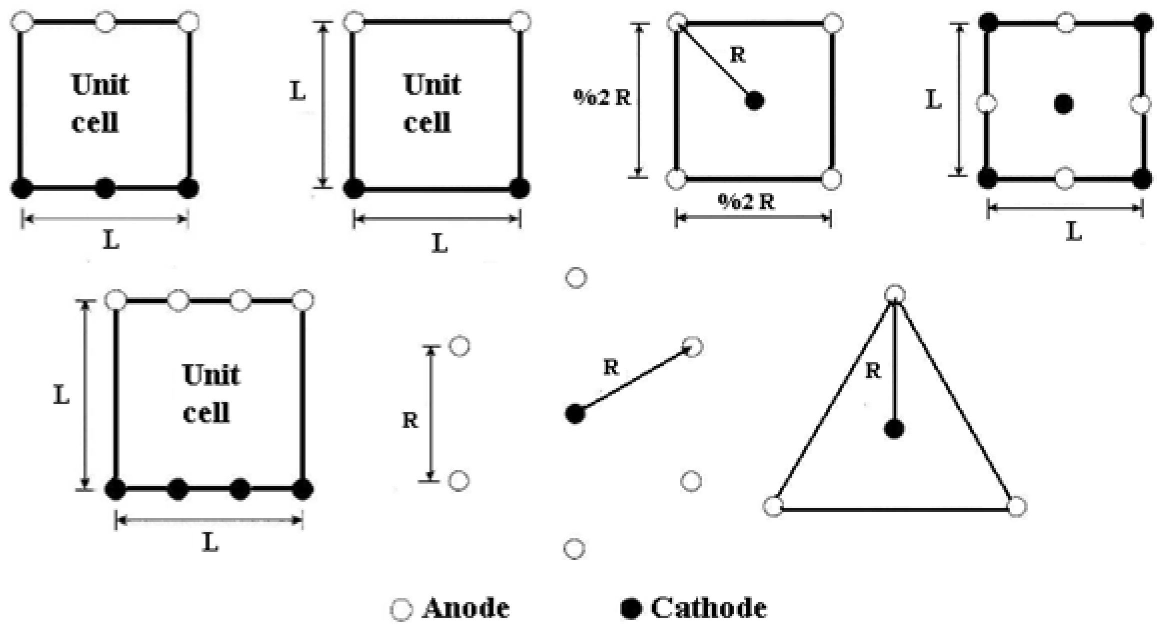

Fig 3 - Possible electrode distribution for the application of electrochemical remediation (De Battisti, 2008)

Electric fields as well as electron transfer processes have been used for the decontamination of soils and underground water containing unwanted organic or inorganic substances. The main phenomena involved here are: electrolysis, geochemical reactions, electrophoresis, electroosmosis, and electromigration. When suitable anodes and cathodes are strategically buried in the ground or placed in contact with slurry and an electric field from a DC source is applied, one or more of these phenomena occur and the resulting effect is used for the removal of polluting substances. The technique has also been called electroreclamation, electroosmotic purging, electroremediation, electrorestoration and electrokinetic processing (*Oprea, 2009*).

According to the researches in the field of electrochemical remediation applied on polluted soils, the following information can be withdraw (Oprea, 2009; Istrate, 2015):

- the electrochemical treatment has a higher efficiency if the time needed to apply this technology is increased;
- better results are obtained if the redox potential (ORP) is maintain at a high value in the case of organic pollution;
- the treatment efficiency is influenced also by the soil humidity, due to the fact that a high humidity value can help with the electrochemical processes;
- the soil pH is another parameters that can assure the uniform removal of the pollutants;
- the electroconductivity is another important factor that influence the electrochemical processes, and thus the treatment efficiency.

CONCLUSIONS

The efficiency of a soil remediation treatment is influenced by several parameters that can affect the overall implementation. The main parameters are the pollutants type, the depth were is located the contamination, the type of soil, and the affected surface.

Each type of remediation treatment can have other specific parameters that can be considered important for the treatment efficiency. This paper was focused on discussing a certain type of treatment, which is the electrochemical one, a treatment that is considered an alternative for the existing methods that are applied with success in nowadays.

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VARIATION OF MISCANTHUS AND ENERGETIC WILLOW CHIPPINGS DEPENDING ON TWO FUNCTIONAL PARAMETERS
/
VARIAŢIA TOCĂTURII DE MISCANTHUS SI SALCIE ENERGETICA FUNCŢIE DE DOI PARAMETRII FUNCŢIONALI

PhD. Stud. Eng. Chiţoiu M*[1)], Prof. PhD. Eng. Voicu Gh. [1)], Prof. PhD. Eng. Paraschiv G. [1)], PhD. Eng. Moiceanu G. [1)], Lect. PhD. Eng. Dincă M. [1)], Eng. Bunduchi G. [2)], Eng. Grigore I. [2)], Eng. Găgeanu G. [2)], PhD. Eng. Vlăduţ V. [2)],
[1)] University Politehnica of Bucharest, Faculty of Biotechnical Systems Engineering/Romania; [2)] INMA Bucharest/Romania;
E-mail: chitoiu_mihai@yahoo.com

Keywords: miscanthus, energetic willow, shredding, speed of revolution

ABSTRACT

Biomass grinding operation is a part of the preparation process through which the material size is reduced. Each stage of the preparation process is analyzed by researchers in order to obtain the optimum process. These tests targeted the study of establishing the influence of biomass properties on the process as well as for designing the equipment used for preparation process. Starting from these assumptions in this paper are presented experimental research regarding variation of miscanthus and energetic willow chippings depending on two functional parameters, the same type of hammer and the variation of the speed revolution. Hammer mills are equipment used in general on the second stage of processing process.

REZUMAT

Realizarea operatiei de mărunţire a biomasei face parte din procesul de prelucrare prin intermediul căruia se urmăreşte reducere volumului acesteia. Fiecare etapă a procesului de prelucrare este analizată de către cercetători astfel ca procesul să fie optim. Aceste analize au vizat atât studierea influenţei diferitelor proprietăţi ale plantei asupra echipamentului utilizat cât şi realizarea unui design corespunzător al maşinilor folosite în procesul de prelucrare. Pornind de la aceste premize în cadrul acestei lucrări sunt prezentate cercetări experimentale privind variaţia tocăturii de miscanthus şi salcie energetică folosind acelaşi tip de ciocan dar şi variaţii ale turaţiei rotorului. Morile cu ciocane sunt echipamente care în general sunt folosite în cadrul celei de-a doua etape de prelucrare a biomasei.

INTRODUCTION

Global warming represents today a major concern for our planet, taking into consideration the negative effects like climate change. Greenhouse gases are believed to be the main problem when it comes to an increase in Earth temperature. CO_2 produced by burning fossil fuels is the most influential factor in global warming. Seeking and implementing new sources of energy besides fossil fuels is the only way to decrease the effects of global warming, and protect the climate and the environment [5].

According to the E.U Strategy 2020 climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right). Thus alternative energy is an important source of energy that needs to be considered, studied and innovated at all times. In order to fulfill this target it is necessary to obtain alternative energy from agricultural biomass such as pellets and briquettes. For these to be used by the consumer biomass needs to be chopped/shredded [6].

Biomass size reduction process changes the particle size and shape, increases bulk density, improves flow properties, increases porosity, and generates new surface area [1].
Hammer mills are considered to be the best equipments used in order to finely grind a greater variety of materials than any other machine [3]. Himmel et al. [2] observed that total specific energy for size reduction of wheat straw using 1.6 mm hammer mill screen was twice that for a 3.2 mm screen. In order to measure the electric power they used an indirect method using a wattmeter. Then the electric power was corrected with power factors , though motor efficientcy was unaccounted.

Biomass particle size produced by a hammer mill depends on the mill's operational factors. Himmel et al. 1985 observed that retaining straws on a 60 screen decreased with a decrease in screen size from 3.18 to 1.59mm, fact that shows the distribution curve towards a lower size. They observed a change in the distribution curve towards larger sizes for wood when negative pressure was applied. This negative pressure of 25 mm lead to a rise in feeding with 50% without high rises in consumed power.

AR Womac et al. researched this subject using three types of mills: hammermill, disc mill and knife mill, looking for data acquisition regarding energetic consumption and direct monitoring of mechanical energy. Materials used for experimentations were: corn stalks, wheat straws, and miscanthus. Engine consumed power was determined at different revolutions from 1500 to 3500rpm, forl all the three types of material from experimentations, feeding being done with the help of a conveyer belt [4]. Also, experiments looked to modify screens, from 0.020mm to 4,750mm. So it could be discovered that the consumed power rose curbilinear with 66% from 1.72kW to 1500rpm up to 5.06kW at 3500rpm, the rise of consumption being attributed to te rise of revolution

In the present paper, there were presented the variation of miscanthus and energetic willow chippings depending on two functional parameters. These parameters are the speed of revolution and the type of hammer used. The test were done with a two stage hammer. Revolution speed of hammer mills influences the size of the biomass being processed. Higher revolution speed results into finer milled biomass, but at the price of higher energy consumption. Lower revolution speed results in a lower energy consumption, but a larger particle size for the processed material. In order to find the right revolution speed yielding less energy consumption but ensuring the quality of particle size reduction in grinded material a series of experiments were done in this paper.

MATERIAL AND METHOD

Samples used in the paper were harvested from the experimental field from INMA Bucharest. Both crops were weighted and subjected to shredding with a hammer mill - TCU (fig.1) equipped with an inclined plan (material feeding chamfer), collecting the hash in bags, through a two way evacuation system, hash was directed with the help of a shutter. The hammer mills main characteristics are:

- Electric motor power: 22 kW;
- Electric motor speed: 2.940 rot/min;
- Milling capacity: 900 m^3/h
- Interchangeable grinder sieve with different hole sizes.

Shredding process took place by hitting and shearing the samples between hammers mounted on the hammer disk, and counter knives.

Fig. 1 - Vegetal waste mill (hammer mill) - TCU

For experimental tests a sive with holes of of ø10 mm and a two stage hammer were used. Also the speed of the hammer mill was varied with the help of a frequency converter from 50 Hz (2.940 rpm); 47.5 Hz; 45 Hz; 42.5 Hz and 40 Hz.

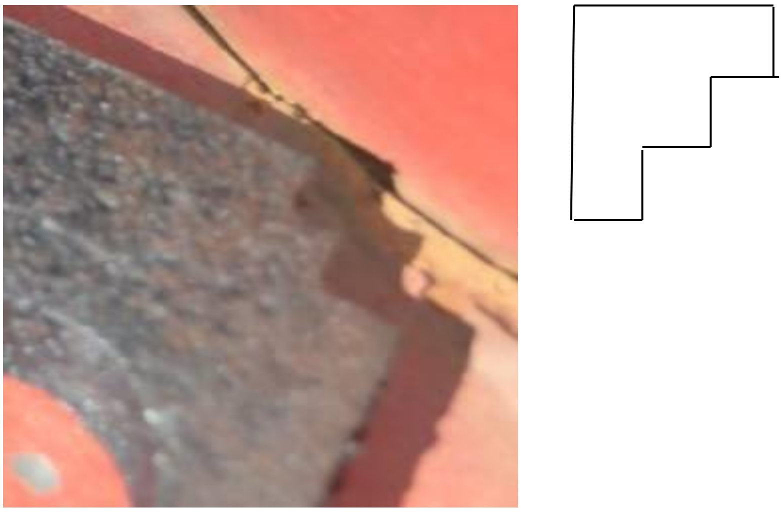

Fig. 2 - Aspects during the experimental tests and the hammer used for testing

In this paper, experimental data was interpreted based on literature which presents similar test done on different biomass types.

RESULTS

The results obtained for miscanthus and energetic willow samples are shown in tables 1 and 2. As it can be seen from these shredded material was divided in three group sizes for miscanthus and four in the case of energetic willow.

Based on the data obtained from experimental tests, were plotted the variation diagrams for each sample analyzed as a function of speed of revolution. Figure 3 represents the correlation between the speed of revolution and the shredded material. As it can be seen the material was divided in three size classes. Each time a polynomial regression analysis function was applied. Also it must be mentioned that as resulted during tests the quantity of smallest and largest particles were given by the speed of revolution of 2850 rpm. The loses of each test were under 5%. The highest correlation coefficient was obtained for size particles above 10 mm.

Table 1

Experimental data obtained after testing for miscanthus samples

Sample no.	Chipped material size/quantity for each dimension			Speed of revolution [rpm]
	< 5 mm [g]	5÷10 mm [g[	>10 mm [g]	
1	1,5177	0,6067	0,6086	3000
2	1,6167	1,099	0,9242	2850
3	0,9336	0,8517	0,9099	2700
4	0,823	0,805	0,655	2550
5	0,654	0,7861	0,5085	2400

Table 2

Experimental data obtained after testing for energetic willow samples

Sample no.	Chipped material size/quantity for each dimension				Speed of revolution [rpm]
	< 4 mm [g]	4÷7 mm [g[	7÷10 mm [g]	>10 mm [g]	
1	1,037	2,2642	1,5695	1,0848	3000
2	0,8058	2,204	1,9272	1,018	2850
3	0,9896	1,9499	1,846	1,169	2700
4	0,939	1,9266	1,8404	1,2465	2550
5	1,0138	2,0705	1,6915	1,1812	2400

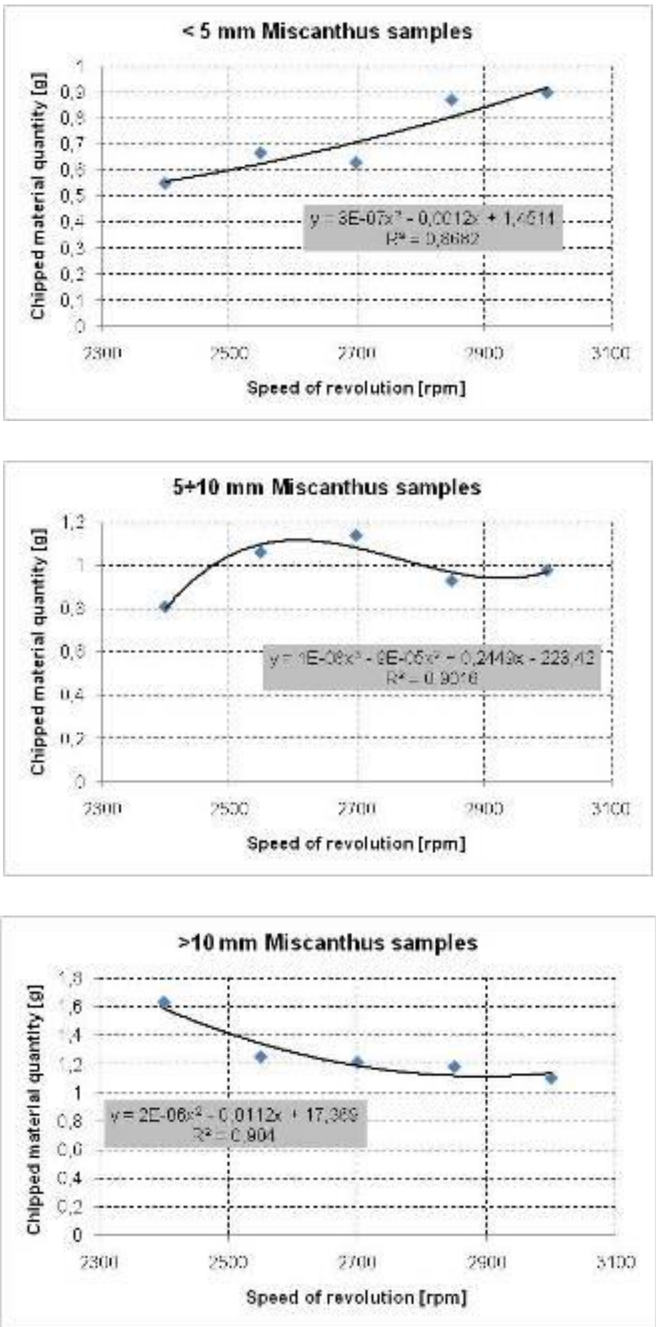

Fig. 3 - Variation between speed of revolution and chipped material quantity for Miscanthus particle size

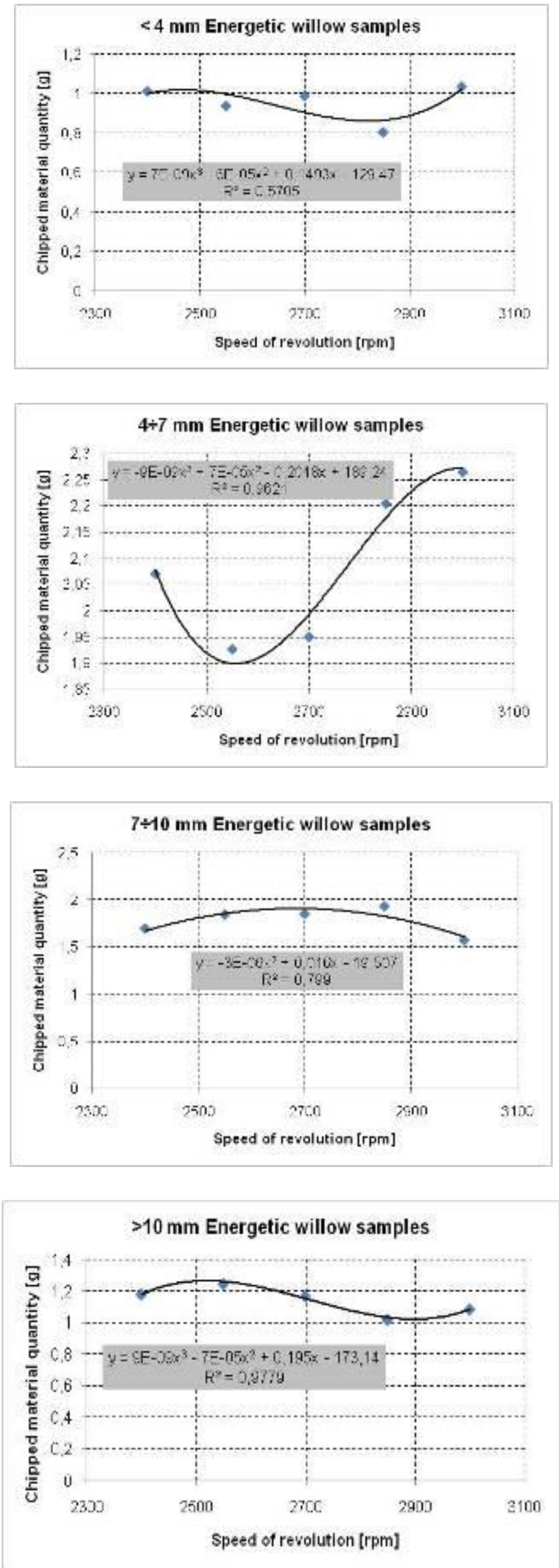

Fig. 4 - Variation between speed of revolution and chipped material quantity for energetic willow particle size

After experimental testing of energetic willow it could be seen that the particles resulted could be divided in four classes of size particles, thus the particles resulted after material shredding were separated in particles under 4 mm, particles between 4 and 7 mm, particles between 7 and 10 mm and particles above 10 mm. Also a polynomial regression analyses was applied. As it can be observed in figure 4 the correlation coefficient was under 0.9 for energetic willow particle sizes under 4 mm and the highest was obtained for size particles above 10 mm (R^2=0.9779).

On all variation curves the polynomial regression function applied was second and third degree.

CONCLUSIONS

The shredding processes is an important part of material handling after harvesting. Thus the equipment need to be adapted to the needs of what it is intended to obtain further. In order to get the desired size particles it is necessary that shredding equipments to furfill a desired design which can be obtained through experimental research. Thus shredding different material and analyzing the resulted material can bring contribution to designing.

Variations of speed of revolution was intended to see if the testing time would be reduced and also if the differences between particles obtained are higher than expected. Staring from this point of view the experiments done on different times of biomass had the same purpose. As in could be seen the sample were on average the same sizes both times. Also the material distribution on sieves happened similar. Each time the regression that best correlated the experimental data was polynomial regression.

Further experimental research has to be done with other sieve size so that in can be concluded that the results on both cases are similar.

ACKNOWLEDGEMENT

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EXPERIMENTAL RESEARCHES ON PLANTING ENERGY WILLOW USING THE EIS TECHNICAL EQUIPMENT
/
CERCETĂRI EXPERIMENTALE PRIVIND PLANTAREA SALCIEI ENERGETICE UTILIZÂND ECHIPAMENTUL TEHNIC EIS

PhD. Eng. Găgeanu P.*, Phd. Eng. Marin. E., PhD. Stud. Eng. Găgeanu I., PhD. Stud. Eng. Gheorghe G.
INMA Bucharest/ Romania
E-mail: paulgageanu@yahoo.com

Keywords: *renewable energy, energy willow, biomass, planting equipment*

ABSTRACT
Energy willow represents species of willow which has proven to be an effective plant cultivated for energy purposes, also having other benefits besides its possible use for obtaining energy. Growing energy willow has some advantages that justify its wide spread in recent years. This paper presents some experimental researches on a technical equipment for establishing energy willow plantations for small entrepreneurs in the field.

REZUMAT
Salcia energetică este o specie de salcie care s-a dovedit a fi o plantă eficientă, cultivată în scopuri energetice, dar pe lângă acest fapt ea prezintă şi alte beneficii. Cultivarea salciei energetice prezintă o serie de avantaje care justifică răspândirea ei pe scară largă în ultimii ani. În acestă lucrare se prezintă cercetările experimentale asupra unui echipament de înfiinţare a plantaţiilor de salcie energetic destinat micilor întreprinzători în domeniu.

INTRODUCTION
The use of fossil fuels raises two main problems: they represent and exhaustible source of energy and their use leads to environment pollution through harmful emissions of carbon dioxide and also sulphur and nitrogen oxides. The answer to the two problems can be given by the use of renewable energy in the form of biomass coming from energy crops, their use leading to a significant reduction of the quantities of harmful emissions in the atmosphere. (*Păun et al., 2015*)

Rapid growth willow (RGW) is an agricultural perennial crop, cultivated for producing wood material used for heating and for generating electrical energy. Energy willow is an alternative energy source. It has an accelerated growing rhythm (during summer it can grow as much as more than 3 cm/day), has a very high energetic value (4900 kcal/kg) and, very importantly, it has low production costs. (*http://greenenergycluster.ro/*)

The big difference between energy willow and coal is represented by the polluting emissions released into the atmosphere. Besides the production of thermal energy, energetic willow can also be used in other various fields (to obtain biodegradable products and other polymers, as riparian buffer, for phytoremediation, snow retention, wastewater management, etc.).

Energy willow is one of the most efficient strategies for replacing fossil fuels and for reducing greenhouse gas emissions.

Energy willow is a rapid growth species (approx. 3-3.5 cm/day), producing 1-3 sprouts in the first year and reaching 2-3 meters in height.

If the majority of forestry plants require 3-5 years before they can be harvested and used in energetic purposes, willow can harvested every two years, having a volume of wood mass of 40-60 tons / hectare / dry material harvest.

The most important characteristic for which energy willow cultivation has gained ground (in Sweden there are more than 50000 ha, in Hungary and Poland over 2000 ha, etc.) is the rapid growth of sprouts, both in length and in volume, but besides this advantage, there are a series of other advantages, making energy willow one of the most important energy crop in the EU, where authorities decided to subvention the cultivation of this plant. (*http://greenenergycluster.ro/*)

This plant can capitalize sloping lands, fixing the soil and improving its quality, can fulfil the role of bioremediation of polluted soils extracting the ions that are found is excess and can also be used for rendering in the productive cycle of some highly degraded lands (waste dumps, saline soils, eroded or sandy lands, etc.). (*Găgeanu I. et al., 2015*)

MATERIAL AND METHOD

Taking into consideration the enlargement of energy willow crops in Romania, within INMA Bucharest was achieved a technical equipment for establishing energy willow plantations, in order to meet the needs of operators in the field.

This is a carried type technical equipment destined to operate in aggregate with agricultural or forestry wheeled tractors with powers between 80 and 150 HP. The equipment is used for planting energy willow cuttings. The machines works on two rows at a 0.75 meter distance between rows, and the free space between a set of two planted rows is of 1.5 meters.

The machine is used for establishing energy willow crops destined to be consumed in energetic purposes. The thickness of the cuttings to be planted is between 8 and 26 cm. Besides energy willow crops, the equipment can also be used for establishing other types of crops that can be planted by cuttings that have the most similar characteristics to energy willow cuttings, the most similar being the energy poplar. This equipment can only be used for planting cuttings and it is not suitable for planting shrubs (shrubs require a specific technical equipment with a planting mechanism destined especially for this type of plants).

RESULTS

The technical equipment for establishing energy willow plantations – EIS (fig. 1) is comprised of the following main subassemblies:

- Main frame;
- Planting station frame;
- Planting mechanism;
- Drive system;
- Assembled ploughshare;
- Seat;
- Track marker support;
- Tray for cuttings;
- Soil compaction assembly;
- Canopied.

Fig. 1 – Technical equipment for establishing energy willow plantations - EIS [9,6]

The working process of the technical equipment implies conducting four operations, respectively:
- Opening the channel by the ploughshare;
- Planting the energy willow cutting by the planting mechanism;
- Covering the cutting with soil and lightly pressing it by the drive system wheels;
- Additional soil compaction around the cuttings.

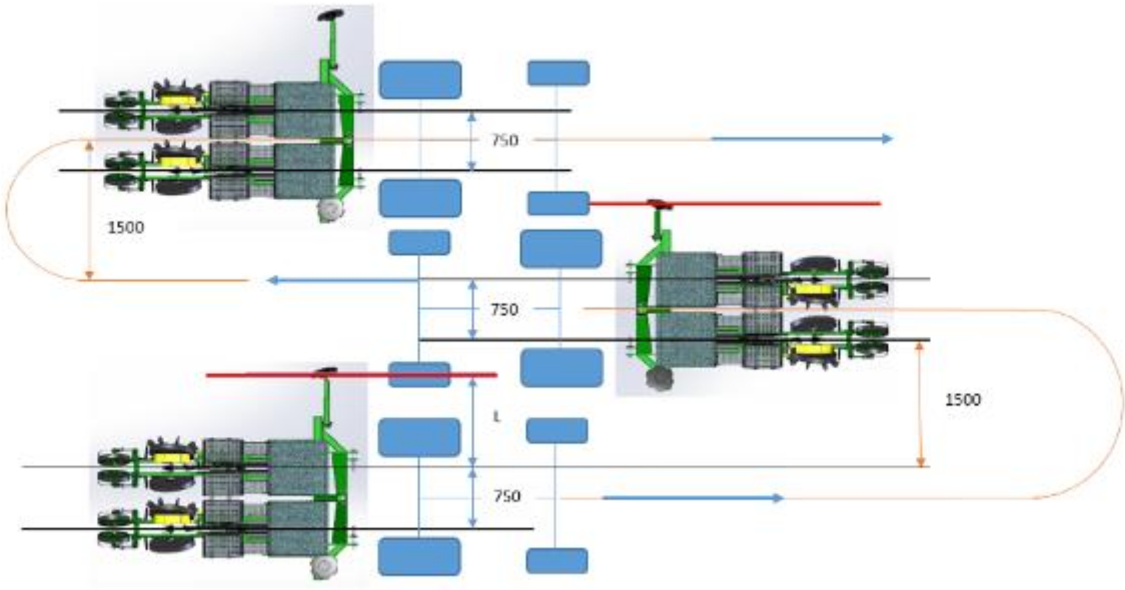

Fig. 2 – Energy willow planting scheme [9,6]

Channel opening implies cutting the soil on a vertical plane on a depth "a" and a width "b", deforming and displacing the soil cut in horizontal plane, in order to achieve the channel.

Planting is performed by the planting mechanism on two rows at 750 mm distance between them, followed by a 1500 mm free space and again another two rows with 750 mm distance between them (fig. 2).

In order to achieve the planting operation at high qualitative indices, the terrain needs to be adequately processed, especially in terms of processing depth and soil grinding degree.

During operation, the distinctive sign made by the track marker is followed by the front wheels of the tractor (alternatively by the right wheel, respectively the left wheel).

In order to achieve the experiments, the equipment was linked (on the three point linkage) to a 80 HP T80 New Holland tractor. The sizes of cutting used for planting were the following ones: diameter between 12 and 26 mm and length between 180 and 200 mm. The cuttings used were obtained from willow sprouts that were planted in the spring of 2013. The results obtained in terms of distance between plants on the row are shown in table 1.

Table 1

Results obtained after planting the willow cuttings

No.	Measurement	Distance between plants on the row										
		Measurement number										
		1	2	3	4	5	6	7	8	9	10	Average
1	m1	1048	1051	1067	1055	1053	1049	1052	1056	1062	1055	1054.8
2	m2	1051	1048	1052	1053	1047	1052	1055	1060	1057	1049	1052.4
3	m3	1049	1052	1056	1062	1055	1057	1051	1048	1053	1066	1054.9
4	m4	1052	1053	1051	1063	1051	1054	1055	1047	1049	1056	1053.1
5	m5	1055	1066	1057	1052	1049	1051	1056	1058	1052	1047	1054.3
6	m6	1061	1054	1049	1056	1057	1048	1062	1051	1055	1058	1055.1

By analyzing the data in table 1, the following aspects are found:
- The distance between rows is complied to, with small fluctuations due to high soil moisture;
- The distance between plants on row shows small differences, caused by the sliding of the drive wheel;

- The space between rows in adequate.

In order to obtain an optimal operating regime with the equipment for planting energy willow (*Salix viminalis*), in accordance with agro-technical requirements, the following adjustment possibilities were provided:

- The possibility to adjust the distance between rows by positioning the two stations at a 750 mm distance;
- The possibility to adjust the distance between plants on row, by using a number of planting arms depending on the distance desired: 3 arms for approximately 1000 mm between cuttings, 5 arms for 785 mm between cuttings, 5 arms for 630 mm between cuttings and 6 arms for approximately 500 mm between cuttings;
- The possibility to adjust the pressing force of the compaction disks by tensioning or relieving the coil springs on each station;
- The possibility to adjust the falling angle of the cuttings by adjusting the cam actuating the tweezers and releasing the cuttings as close to the vertical plane as possible.

CONCLUSIONS

After conducting experiments using the equipment for planting energy willow, the following aspects were found:

- The distance between cuttings on row was not constant, due to the fact that soil structure varied, and compaction was also different in several areas of the parcel.
- High soil moisture led to the occurrence of the skidding phenomenon both for the equipment drive wheels and also for the tractor wheels;
- Soil compaction around cuttings was not achieved evenly, due to the skidding of the equipment and also to the varied soil moisture.

The technical equipment for establishing energy willow plantations represents an opportunity for small operators in the field, making it possible to capitalize degraded lands that are not suitable for agriculture, to have energetic autonomy, to produce and use clean, renewable energy.

ACKNOLEDGEMENT

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MANAGEMENT OF AGRO-ZOOTECHNICAL BIOMASS IN SMALL FARMS. ROMANIAN CASE STUDY

MANAGEMENTUL BIOMASEI AGRO-ZOOTEHNICE ÎN FERMELE MICI. STUDIU DE CAZ: ROMÂNIA

Lecturer Ph.D. Eng. Deac T.A.*[1], Ph.D. Stud. Eng. Nagy E. M.[2], PhD. Eng. Cota C[2]., Ph.D. Eng. Cioica N.[2], Eng. Gyorgy Z.[2]
[1] Technical University of Cluj-Napoca, Faculty of Mechanics / Romania; [2]INMA Cluj-Napoca
E-mail: teodora.deac@autoutcluj.ro

Keywords: *biomass, management, small farms, alternative energy*

ABSTRACT

According to European statistics, Romania is one of the countries owning the greatest number of agricultural holdings in Europe. Among them, 92.9% have less than 5 ha surface and approx. 20% have a mixed structure (vegetal production and livestock) having a biomass potential that can be used with reduced costs for generating the energy necessary to farm. Therefore, this paper achieves an analysis of biomass current state use in small farms from Romania, as well as of national and European policies that are supporting and promoting the increment of energetic capitalization of allowable biomass.

REZUMAT

Conform statisticilor europene România este una dintre ţările cu cel mai mare număr de exploataţii agricole din Europa. Dintre acestea 92,9% au suprafaţa mai mică de 5 ha şi aprox. 20% au structură mixtă (producţie vegetală şi zootehnie) dispunând de un potenţial de biomasă, care poate fi utilizată cu costuri reduse pentru generarea de energie necesară în fermă. Astfel, în lucrarea de faţă se realizează o analiză a: situaţiei actuale a utilizării biomasei în exploataţiile agricole mici din România, precum şi a politicilor europene şi naţionale care susţin şi promovează creşterea gradului de valorificare energetică a biomasei disponibile.

INTRODUCTION

Energy is one of the main conditions of ensuring a fair standard of and of sustainable living and of sustainable development of a certain community. Ensuring the energy necessary solves also other important aspects related to daily life, coverage of basis needs: water, food, environment protection, thus ensuring a fair living standard, respectively the development of rural households, etc. Nowadays, at world, European and national level, the main sources of primary energy are the fossil fuels. Nevertheless, due to their finite character (estimations have shown that in 2030 the world energy total demand will be greater by 50% than in 2003, and for oil by 46% bigger; under these conditions, the current world oil stock being able to support a current level of consumption up to year 2040, [14]), increasing the utilization degree of energy alternative sources, respectively developing relevant conversion technologies that becomes one of the main challenges of current century. At European level, the EU Directives establish a few goals that support and promote the increasing of renewable energy utilization degree, so that for 2020 it is proposed that the share of energy coming from a renewable energy source-SRE reach 20% out of final raw consumption. For Romania, the national target was fixed at 24% [14].

Romania's rural zone represents about 87.1% out of country's total surface [20], being preponderantly agrarian. Therefore, the rural field owns a real potential of renewable energy sources, respectively vegetal biomass and animal dejections {6}. At the present moment, the capitalization degree of these resources is very low, only 1.7% out of total production of renewable energy coming from agricultural sector, comparatively with 10.6% in UE27 (year of reference 2010), while in 2010 Romania had 31.2% from the whole of agricultural holdings in UE27 [11]. The low degree of capitalization of agricultural mass in Romanian farms is due to their low level of economic development. According to EU statistics, 73% of Romanian farms are under 2000 Euro as standard production/farm, while at European level, they represent approx. 44.7% out of the total [11]. At the same time, the agricultural holdings size (92.9% out of the entire Romanian holdings have under 5 ha surface, the average surface being of 2.5 ha) negatively influences the economic development degree of biomass as energetic source.

Another important aspect that imposes a high valorisation degree of renewable energy sources in Romania's rural area is that of lack or incomplete infrastructure, on one hand and, on the other hand of energy cost, which has a negative impact on economic development of the country and life standard. This assertion is supported by national statistics [20] which show that heating of individual national housing (urban and rural) is performed predominantly on the base of firewood (60.75%) and methane (36.45%) situation due to the lack or deficiency of natural gas transport infrastructure and the high cost of other energy sources (Liquefied Petroleum Gas-GPL or liquid fuels).

The data presented for rural environment shows that 90.63% of the total individual households are heated using firewood (including biomass), followed at a considerable distance by natural gas – 8.11%. From the point of view of heating systems, heating stoves and cooking ovens represents approximately 83.4% of the total heating systems based on firewood and biomass [14], demonstrating a low efficiency in producing thermal energy in individual households.

Thus, in the current context, due to economic and social development of the Romanian rural environment and increase the efficiency of small farms in our country, in line with European and national policies of increasing the use of renewable energy by 2020, is necessary the development and implementation of management strategies for vegetable biomass and manure toward their energy capitalization, specific farms with an area less than 5 ha (mainly in Romania), to ensure the basic needs of the farm (food, heating, lighting) .

Considering the type of farms in our country and socio-economic context described above, the present work has as main objective an analysis of the current state of biomass in small farms in Romania and the European and national policies that support and promote the degree of increased biomass energy valorization.

MATERIAL AND METHOD

Typology Analysis of agricultural holdings in Romania.

According to INSSE [19], the total number of holdings in Romania were in 2010 of 4.484.893, out of which 4.462.221 (99,4%) were without legal personality (constituted in privately owned in individually farms established, individually authorized or in family businesses, and a number of 22.672 agricultural holdings were legal personality units (companies / agricultural associations, commercial companies government units and cooperative units and other types). The total area occupied by farms without legal personality represents approximately 53.5% of total utilized agricultural area.

Farms with legal personality with an average size of 100 ha / holding, covered 46.5% from SAU. A number of holdings of 3,399,906 (75.80%) have a mixed structure (with farmland and livestock), while a number of holdings of 899 455 (20.05%) had only agricultural land and holdings 185 532 (4.13%) had only livestock. Among individual farms, mainly in Romanian agriculture, 76.11% had mixed structure of agricultural land and livestock, while only 19.74% holdings have only agricultural areas and only 4.14% have livestock farms (Figure 1 b). So it can be concluded that Romanian farms were mainly of mixed structure (crop and animal) which implied a high biomass available zoological-technical consists of vegetable residues and manure.

Biomass structure assessment, available in Romanian farms

Available biomass in Romanian farms which is main composed of vegetable waste and animal dejections is influenced by used surfaces category in property and existent animal species.

In accordance to statistical dates [19] the main usage categories of agricultural surfaces are (fig.2, 3): cereals for grains (55,86% of the total farms, respective 78,30% of usage agricultural surface-UAS), leguminous plants for grains (2,97% of total farms respective 0,69% of UAS), industrial plants 5,36% of total farms, respective 13,75% of UAS), potatoes (14,58% of total farms, respective 2,44% of UAS, sugar beet (1,12% of total farms, respective 0,38% of UAS), fodder roots (0,9% of total farms, respective 0,1% of UAS), fruit tree (3,92% of total farms, respective 1,82% of UAS), chestnuts, walnuts, hazelnuts, other related species (0,03% of total farms, respective 0.02% of UAS), other fruit trees (0,01% of total farms, respective 0,01% of UAS), grapes (15,25% of total farms respectively 2.46% of UAS).

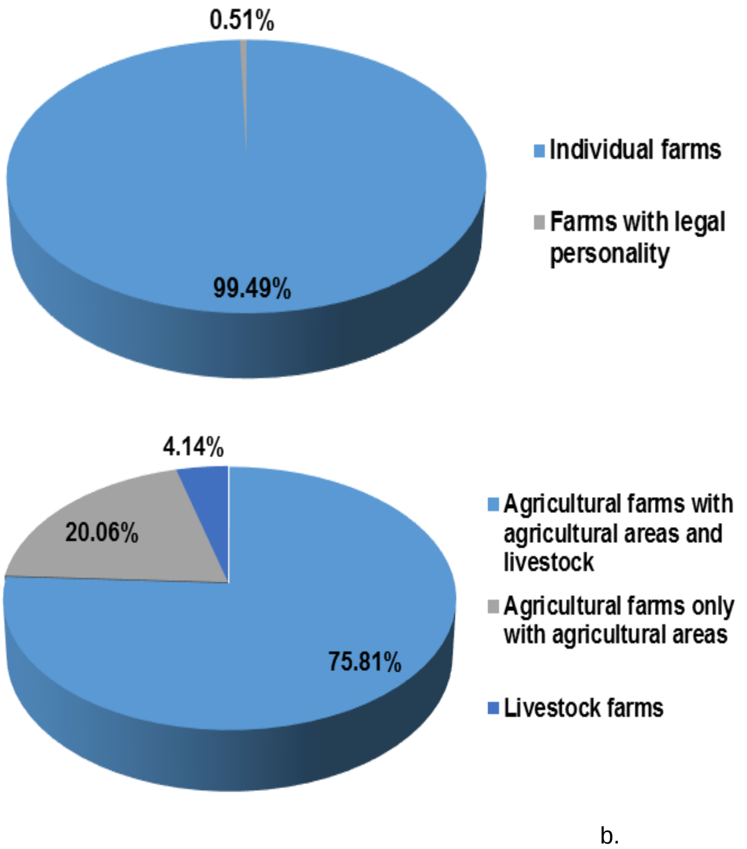

Fig.1 – Farms situation: a. according to legal form; b. according to structure [19]

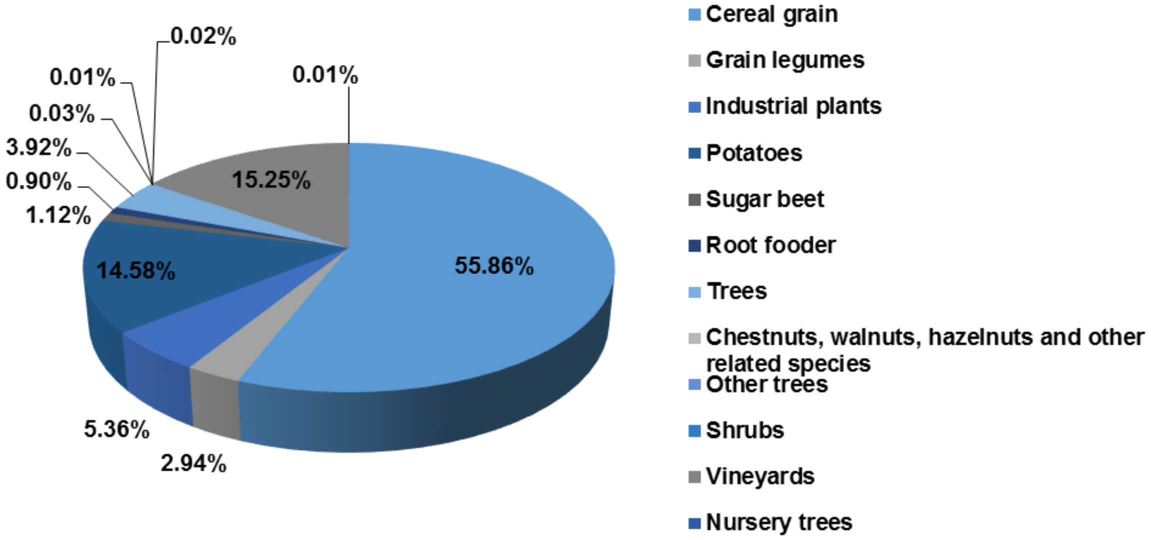

Fig.2 – Farms situation according to usage category of agricultural area [19]

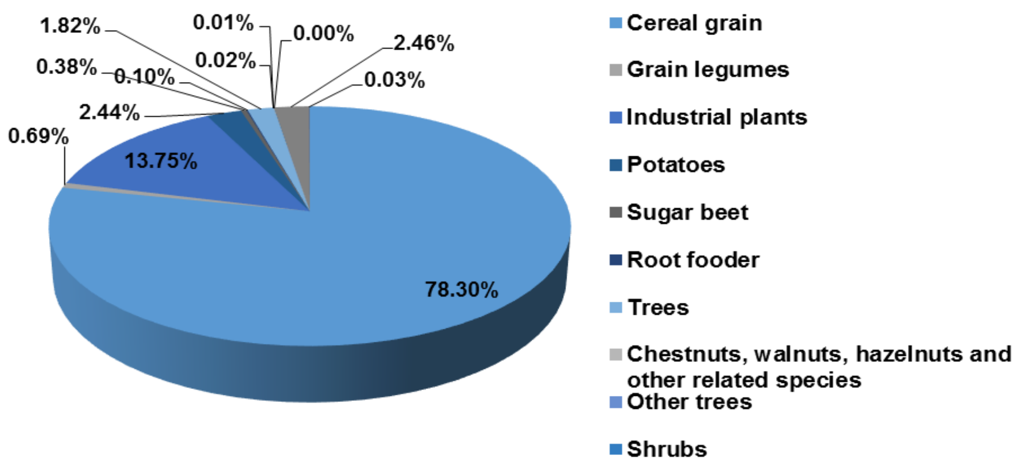

Fig.3 – Farms situation according to usage category of agricultural and cultivated surface [19]

Analyzing the number of farms show that the main source of vegetable biomass in farms in Romania are cereals for grain, potato and industrial plants. It should be noted the high percentage of agricultural holdings and holding areas under vines (15.25% of agricultural holdings). Given the types of farms in Romania, biomass available to be used for energy purposes consist of vegetable mass derived from basic cereals and cleaning of the vineyard surfaces and manure from cattle, pigs, poultry, horses and sheep. Table 1 shows the available biomass in farms in Romania, according to their typology [22, 23].

Table 1

Vegetable biomass potential/dejections in Romanian farms, structured on main vegetable cultures and animal species

		Vegetable biomass [23]				
		Corn	Grain	Sun-flower	Barley	Oat
Biomass production [d s t/ha]		4÷6	1,2÷2.5	1,7÷4	3	1÷1,6
Harvesting humidity [%]		40÷65	10÷14	14÷20	11÷14	9÷14
Low calorific power, [MJ/kg$_{dm}$]		13,8÷17,6	17,5÷19,5	15,2÷17,9	17,5÷19,5	17,5÷19,5
		Dejections [22]				
		Cattle	Pigs	Poultry	Horses	Sheep
Dry substance contain [%]	liquid dejections	6÷11	2.5÷9.7	10÷29	-	-
	solid dejections	11÷25	20÷25	32÷32.5	28	25÷30
Organic substance [% dry substance]	liquid dejections	68÷85	60÷85	75÷77	-	-
	solid dejections	65÷85	75÷90	70÷80	75	80
Biogas yield [m^3/organic substance]	liquid dejections	200÷260	260÷450	200÷400	-	-
	solid dejections	200÷300	450	400	200÷400	240÷500

RESULTS

Agro-zootechnical biomass management in small farms in Romania

Given the types of farms in Romania having the surface bellow 5 ha and the use of land mode, harvesting conditions (mechanization degree, harvesting moisture, moisture) as well as dejections collecting mode (in livestock or mixed farms) in the main available biomass category is composed of agricultural waste (respective vegetable mass at cereals harvesting) and semi-liquid manure [6]. These are main used (in 98,3 % out of total agricultural exploitations) as animal food and fertilizer (figure 4). Less than 0.9% of Romanian holdings with an area bellow 5 ha [11] biomass resulting from their core business is energy capitalized.

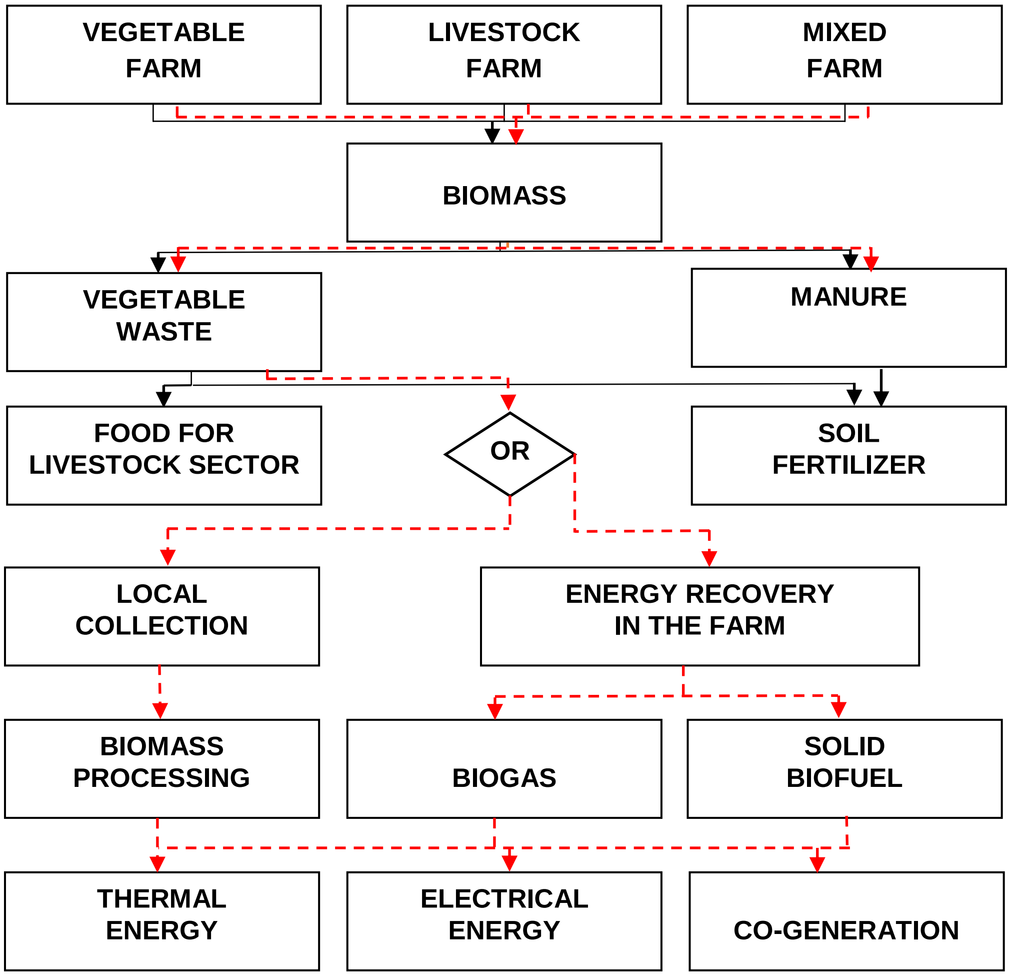

Fig.4 – Biomass management in farms bellow 5 ha surface:
--------------- current state; --------------- energy capitalization possibilities**.**

Energy capitalization possibilities are limited primarily to surface that the number of animals existing in small farms (most of them can be classified as subsistence farms). However, energy can be harnessed in order to provide thermal energy needs of farms or residential space heating for and animals. Another possibility for energy capitalization of vegetable biomass is setting up of storing centres at Community level, namely its processing and use for commercial purposes or to generate heat or electricity in a centralized system [8, 9] (figure 4).

Barriers and opportunities in harnessing biomass energy

The main existent barriers in available energy biomass in small farms in our country are mainly of socio-economic development nature.

Low level of economic development of these (73% of farms are below than 2,000 Euros Romanian standard production / farm) implies lack of funds for the acquisition and processing technologies converting energy stored in biomass to heat and electricity.

On the other hand small agricultural farms area involving a small amount of agricultural residues, thus to achieve efficient energy recovery is necessary to collect them at Community level in order to decrease the costs involved. The achievement of such storage centres would be beneficial not only to harness the energy of the biomass but also for sustainable development of rural areas by attracting investors and creating new jobs, thereby decreasing the effect of the migration of young people to urban or increased standard of living and the shift from subsistence farms to the intensive and economically efficient.

Development and implementation of biogas plants and vegetable biomass processing technologies, involve a number of investments for Romanian farms and these are major obstacles. Associated costs associated of such investments consist of initial investment or capital costs involved in the studies needed for analysis of biomass potential, identify the necessary heat energy of the farm, the development of technical systems and their implementation at farm level as well as the purchase and installation of equipment necessary and operation and maintenance costs [10].

Technical literature analyze and the experience of other countries in the development and implementation of such projects [10] show costs for the development of such systems. For example European initial investment required for the development of a biogas low capacity 100-200 kW can reach up to 1.5 million Euros. Thus, given the economic development of farms in Romania, exploitation of available biomass farms will not only be possible by accessing funds in this respect, namely the achievement of a government policy to promote and support the increasing exploitation of biomass energy at Community (local) or at farm level.

Existing opportunities for increasing energy recovery from biomass in small farms consist mainly of European and national policies promotion of energy from renewable sources-RES and also by accessing funds currently available through European programs and national funding grants.

EU Policy of renewable energy promotion

In this respect has to mention a series of European policies for supporting of using renewable energy sources, at national and local level. Important decisions in this respect have been taken at European level since 2001, in the same time with elaboration of European 2001/77/EC Directive [7] which promote the concept of renewable energy sources producing, followed by „Roadmap for renewable energy" – Renewable energy in XXI century: building a more sustainable future (COM(2006)0848) [2], which establish a renewable energy sources at European level strategy on long term until 2020, materialized by 2009/28/EC directive. This establishes a comprehensive policy for the production and promotion of energy from renewable sources in EU [18]. To the same legislative category belong COM (2010)11 595 EC Report [3], COM(2012) 595 [4], SWD (2014)259 regarding to sustainable requirements for used solid and gaseous biomass for electricity, heating and cooling producing, (State of play on the sustainability of solid and biomass used for electricity, heating and cooling in the UE) and 3.D59.1-Mid-term evaluation of the Renewable Energy Directive [21].

Regarding financial support accorded in November 2013, European Commission provided supplementary orientations regarding to supporting systems for energy coming from renewable sources and cooperation mechanisms for objectives fulfilling regarding to renewable energy sources at as low costs as possible (COM(2013)7243) [21]. The commission announced complete subsidies, which member states are authorized to offer the renewable energy sources sector. Orientations regarding to state aid for environment protection and energy, 2014-2020 (2014/C200/01) contribute to new frame modelling regarding to support systems for renewable energy sources [5]. In communication entitled „Energetic perspective 2050" (COM(2011)0885) [12] EC, says that "renewable sources energy play a key role in Commission strategy" so, their financing mechanisms will be achieved in this sense, too.

National policies of promoting renewable energy sources

Romania was among the first European countries which adopted the policies to promote the use of renewable energy sources. Thus, the first legislative initiatives in this respect, in the negotiations for EU membership, was "Energy Roadmap" approved by GD 890/2003 [1] which stipulates that the use of RES will be promoted and encouraged.

This was followed by the adoption of the GD 1535/2003 regarding to approving the Strategy for renewable energy use [1] followed in 2007 by GD 1069/2007 regarding to approving the Romanian Energy Strategy for 2007-2020 [1] and GD 1661/2008 regarding to approving the "National Program for energy efficiency and use of renewable energy in the public sector for the years 2009 -2010" [1].

In order to promote energy production from RES in 2008 is adopted the law 220/2008, which aims at establishing the system for promoting energy from RES, republished in Official Gazette 577/2010 and subsequently amended by Ordinance 29/2010, Law 139 / 2010, GEO 88/2011, Law 134/2012, OUG57 / 2013 79/2013, Law 23/2014, version in force at the moment being Law no.122 / 2015 [15].

Regarding to state aid schemes and supporting the use of renewable energy, have been approved by a series of acts, of which the most important are: GD 750/2008 approving the scheme of capitalization Regional state renewable energy resources, GD 495/2014, GD 620/2014, HG823 / 2016 1015/2015 GD, GD 113/2016 [1].

In order to promote the using of biomass as alternative energy source in Romanian farms has to be mentioned the objectives assumed in the development strategy of rural environment and disadvantaged areas [12].

Romania's rural development strategy for the period 2014 - 2020 "[13] provides adoption of more efficient practices on energy production, specifying the priority need of promoting actions to address these issues, including the adoption and use of renewable energies. In terms of biomass, within mentioned strategy is mentioned the high potential but still insufficiently explored, both in production processes and increasing the standard of living.

Increasing the use of available biomass at farms level, become thus a priority for 2014-2020 at this level. Under the measure "Investments in fixed assets" states that at farm level will be able to produce and use the RE for their own consumption and also will be eligible for funding and economic agents, other than farmers who want to process biomass. Investment in biomass for energy recovery will be supported and financed by the measure "Development of the farms and businesses (sub-measure investment in the creation and development of non-agricultural activities" which is supported by the production of biomass fuels [17].

CONCLUSIONS

Following the analysis carried out, the following conclusions can be drown: Romania is among the EU countries with the highest number of farms. Analysis of the structure by land usage and respective the average size and the degree of their economic development, indicate that 97.3% of them fall into the category of small farms under 5 ha of agricultural land and more than 20% have a of mixed structure, crop and animal production. Available biomass in small farms is composed primarily of crop residues and manure, according to their structure. Management of biomass currently provides in particular activities aimed at using biomass as animal feed (vegetable biomass) or fertilizer (animal manure) and less for energy capitalization.

Availability of biomass from small farms can be used to obtain thermal energy on the farm or in the case of vegetable biomass could be made activities of collecting, processing and capitalizing at the community level. The use of biomass available in small farms, as a source of energy on the farm for 2014-2020 is supported both by European policies and national policies, this goal is considered as a target for the European and national strategies, to encourage the use of RES or the development of rural areas. In this context there are a series of grants in the programs sponsored by the Ministry of Agriculture and Rural Development.

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STUDY ON IRRIGATION SYSTEMS IN AREAS THREATENED BY DESERTIFICATION-REVIEW
/
STUDIU PRIVIND SISTEMELE DE IRIGAŢII ÎN ZONELE AMENINŢATE DE DEŞERTIFICARE - REVIEW

PhD. Eng. Manea D.*[1)], Ph.D. Stud. Eng. Dumitraşcu A.[1)], PhD. Eng. Marin E.[1)], PhD. Eng. Mateescu M.[1)], Ph.D. Stud. Eng. Gheorghe G.[1)], Eng. Dumitru I.[2)]
[1)]INMA Bucharest / Romania; [2)]Power Group International SRL / Romania
Tel: 0724350567; E-mail: manea_dragos_05@yahoo.com

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ABSTRACT

Global climate change increases the areas subject to desertification, the greatest scourge that threatens Earth. One third of the globe is subject of aridity, affecting more than one billion people in 110 countries, including five countries in the European Union, including Romania. In this paper there are presented some modern methods of irrigation, applicable effective in areas threatened by desertification, namely: drip irrigation, with variants wetting the surface and water underground, irrigation by condensation of water vapor existing in the pores of the soil or the atmosphere and the complementary systems for irrigation by condensation, such as systems to optimize the temperature in the root zone of the plants.

REZUMAT

Modificările climatice globale determină creşterea suprafeţelor supuse deşertificării, cel mai mare flagel care ameninţă Terra. O treime din suprafaţa globului este supusă aridizării, afectând peste un miliard de oameni, din 110 ţări, inclusiv 5 ţări din cadrul Uniunii Europene, printre care şi România. In aceasta lucrare sunt prezentate cateva procedee moderne de irigare, cu aplicabilitate eficientă în zonele ameninţate de deşertificare si anume: irigarea prin picurare, cu variantele udare la suprafaţă si udare subterană, irigarea prin condensare a vaporilor de apă existenţi în porii solului sau în atmosferă, precum si sisteme complementare pentru irigarea prin condensare, cum sunt sistemele de optimizare a temperaturii în zona rădăcinilor plantelor.

INTRODUCTION

According to the United Nations Convention to Combat Desertification (*http://www2.unccd.int),* desertification is the degradation of land in arid, semi-arid and sub-humid areas, resulting from various causes, including climate and human activities.

The Fifth Report of the Intergovernmental Panel on Climate Change (*IPCC, 2013*) mentions that global average air temperature has increased by about 0,85ºC in the last 100 years (1850-2012), the period 2001-2013 is one of the warmest in the data stream recorded after 1850. Also, the number of hot days increased frequency of heat waves registering a growth trend evident in most of Europe, Asia and Australia. Over 90% of extreme events produced in Europe in the last 30 years are the dangerous hydro-meteorological phenomena (floods, storms) and climate (heat waves, droughts, forest fires) (*EEA, 2010*).

In this context, climate change is a major challenge for agriculture, water resources and ensuring stability crops being key priorities in policy of prevention and mitigation of extreme events.

Globalization demographic, economic and climatic factors exert great pressure in the agricultural sector to increase food production and reduce water consumption. Part of this pressure linked to the global need for water due to the livestock sector. Statistically, it is known that meat production requires 8-10 times more water than grain production. 70% of global water consumption goes on agriculture for irrigation. Irrigated agriculture accounts for 20% of total cultivated land (global average), but bring 40% of food (*WWDR, 2016*).

MATERIAL AND METHOD

In Romania, changes in the climate falls in the global context, but with specific geographic region in which our country is situated. Agricultural areas of Romania are affected by drought frequency (approx. 7 million ha), temporary excess of water (approx. 4 mil ha), water erosion and landslides (approx. 6.4 million ha), compaction (approx. 2.8 million ha), etc. It noted that drought is the limiting factor that manifests the largest agricultural area. In this context, the data indicate that most agricultural areas vulnerable to water scarcity in the soil are the Dobrogea, southern Romanian Plain, south-eastern and eastern Moldova and western Tisa Plain. These areas are mainly used in agriculture (approx. 80% of the total, of which approx. 60% is arable land) and forestry (approx. 8%), especially the Danube Meadow (*National Strategy on reducing the effects of drought prevention and combating land degradation and desertification, short, medium and long - MARD, 2008*).

Farmers apply two methods: dryfarming and agriculture through irrigation. Technology "dryfarming" is profitable for crop production without irrigation in areas receiving less than 500 mm rainfall annually or less. In areas with heavy rain, strong winds, uneven distribution of rainfall, the term "dryfarming" it is also recommended under irrigated crop in terms of annual rainfall between 601-700 l/sqm. The basic problems of the system "dryfarming" are so accumulation in soil of a small amount of annual rainfall, keeping moisture in the soil until it is used by plants, preventing evapotranspiration direct soil moisture during the growing season, adjust the quantity the plant extracts water from the soil, choice of crops suitable for arid, applying appropriate treatments to crops and evaluate products based on superior composition of plants that require small amounts of water (*ANM, 2014*).

In this paper there are presented some modern procedures of introducing water into the soil, applicable effective in areas threatened by desertification, namely: drip irrigation, consisting of watering through tubes or strips, the water being dispensed drop by drop, into the root zone, with variations in surface and water underground watering; irrigation by condensation of the water vapor existing in the soil pores (underground) or the atmosphere (air); complementary systems for irrigation by condensation (temperature optimization systems in the plant roots).

RESULTS

Drip irrigation systems

A drip irrigation systemis is based on distribution of water slowly and evenly, drop by drop, in an amount and with a frequency tailored to the needs of the plant, with offsetting strict evapotranspiration, with close supervision rules watering (*Payero et al, 2008*). Drip irrigation involves the distribution of water directly to plant roots, reducing water consumption by 70%, while achieving higher yields by up to 90%. Drip irrigation method introduced the concept of fertigation, irrigation, fertilization while using irrigation water as support (*Phuntsho et al, 2012*). They are using nutrients and stimulating total water soluble. They are managed in strict rules, without being scattered in the areas between the rows that does not require fertilization.

The surface drip irrigation presents a number of advantages over conventional systems (eg. sprinkler irrigation), namely: the ability to irrigate land irregularly shaped; soil moisture is maintained at field capacity, strictly in the root zone; it is reduced weeds, between rows of plants because the soil is dry; between rows is facilitated access to culture for mechanized or manual work; reduces soil erosion; plant leaves stay dry and thus reduce the risk of diseases and burns; pressures are much lower than in conventional systems, reducing pumping costs (energy saving).

A schematic diagram of a surface drip irrigation system is presented in fig. 1 *(Bloomer et al., 2013*).

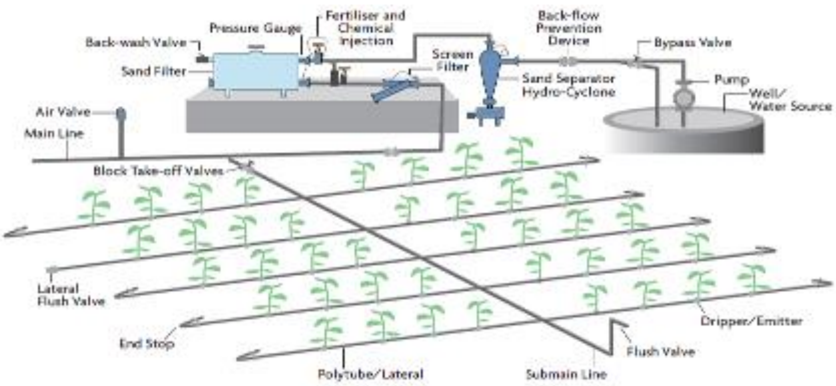

Fig.1 – Components and layout of a drip irrigation system *(Bloomer et al., 2013*)

Subsurface drip irrigation

Compared to surface drip irrigation, the subsurface enables the execution of all agricultural mechanized (*Gil et al, 2008*). This system is especially advantageous as the soil surface remains dry, which leads to the decrease in the degree of weed. Also, the volume of wet soil in the root zone is larger compared with surface drip irrigation (fig. 2). The subsurface drip irrigation can be operated continuously or intermittently at a pressure of about 1 (one) atmosphere, at a dispensing flow rate between 0.4 and 10 l/h (*http://www.eurodripusa.com*).

Fig. 2 - The distribution of water in the roots area (*http://www.eurodripusa.com*)

Irrigation By Condensation Systems

Concept description

Condensation is the process by which water is transformed from gaseous into liquid. Condensation is important for water cycle because it forms clouds. They produce precipitation, which is the main way to return water to Earth (*https://ro.wikipedia.org*).

Water entering the first ground hygroscopic and capillary saturate all its particles and the pores of the capillary of a particular layer. The water which is under the force of gravity gradually penetrates in depth, continuously wetting the soil to a depth that ensures its saturation water absorbent, film and capillary. Soil water movement occurs in three forms: vapor movement, capillary movement, the gravity movement. The movement of the vapor occurs as a result of differences in vapor pressure of water in the different layers of the soil. The movement takes place from the higher layers by the vapor pressure of the lower pressure layers (*Kleps, 2002*). Lebedeff (*Lebedeff, 1927*), studying the movement of water vapor in the soil, determined that, in a year, about 72 mm of water condensed from the vapor in the atmosphere in a soil type mold. Water condensation in the atmosphere increases as the difference between absolute humidity and water vapor pressure is higher. In Romania, Botzan (*Botzan 1966*) found the process in research on water balance in soils irrigated Dobrogea on the Black Sea coast and on the terrace of the Danube at Braila. Studies in this area are of practical importance, both in terms of the water balance in the soil and in the study of crop resistance to drought conditions unfavorable intervals during the growing season.

State of the art

Irrigation by condensation is an inexhaustible resource of water for irrigation, the combination of high relative humidity, the air temperature and the low temperature of water circulating through a closed loop system. Irrigation by condensation are designed primarily to arid and semi-arid areas, where groundwater is deep and fresh water sources are rare.

Worldwide, studies on irrigation by condensation were made over time by several researchers (*Widegren, 1986; Nordel, 1987; Ruess and Federer, 1990; Gustafsson and Lindblom, 2001).*

Absorption of water by plants is very effective in moderating the distribution of daily water, as demonstrated in the plant irrigation condensation built in 1993 by Swiss Company Ingenieurbüro (*Hausherr, 1993*), the condensation stream of moist air in underground pipes of halved consumption of water at tomato crop. The temperature into the soil has been decreased by increasing the distance between the pipe or decreasing the burial depth, although in both cases the condensation rate increased.

Other theoretical and experimental studies of the irrigation by condensation system were carried out in Adana, Turkey (*Gustafsson et al., 1999*), resulting in the possibility of irrigation 4.6 mm/day with an energy consumption of 1.6 kWh/m^3.

In 1987, *Nordell* built a small-scale plant in a greenhouse cucumbers in Övertorneå, Northern Sweden. The air conditioning system was intended to reduce the temperature difference between night and day. During the day, moist air was circulated through underground pipes for heating and cooling ambient soil.

When designing an irrigation by condensation system, underground piping configuration such that the critical temperature is reached by the pipe walls and not in the soil between two parallel pipelines. In this way, the roots will grow freely in the space between the pipes. Pipes diameter, depth of burial and pipe spacing is chosen depending on water availability and temperature distribution in the soil (fig. 3) *(Lindblom, 2006).*

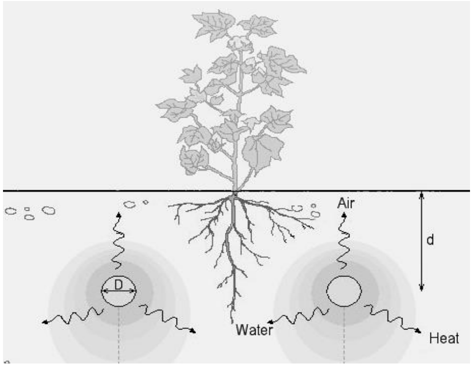

Fig. 3 - Section through pipes buried into the soil *(Lindblom, 2006)*

The length of the pipes affect the efficiency of the dehumidification of air, since the rate of condensation decreases along the pipe. Small depths of burial of the pipeline can increase the rate of condensation resulting in a superficial layer of the water distribution in the soil, water that accumulates on top of the pipe. If one takes into account sunlight, shallow burial depth leads to a lower production of water at a rate of greater evaporation surface due to additional heating of the soil surface. The power consumption of the fan necessary to drive the flow of air through a perforated pipe was 0.4 kWh per 1 m^3 of the condensed water *(Lindblom and Nordell, 2006)*.

Constructive solutions

The document *US 4459177 (O'Hare, 1984)* relates to a system for the transfer of moisture in the soil horizontally (fig. 4), which can be used in the production of drinking water or irrigation in arid zones. The system uses solar energy for extracting moisture from the soil by heating soil water evaporation and subsequent condensation of water vapor.

Convection column *1* is a black box type solar collector rectangular form, vertically arranged. In its interior, the heated air flows from the entrance to the exit located at the bottom of the upper part, the lower part forming the circulation. This edition pulls warm air from the solar evaporation pipe *2* by *4* in the condensation pipe *3*. The pipe *4* has small holes through which soil moisture enters through capillarity and soaking. The water is evaporated by hot air stream in line *4* and transferred to the pipe *3* is cooled by the soil around, which condenses. The water formed by condensation in the pipe *3* can be extracted using a pump or by removing the cap *5* from the outlet pipe *7*. The outlet pipe in place of the porous material can be used for drainage into the soil. In this way the water is transferred from a wet to a dry area.

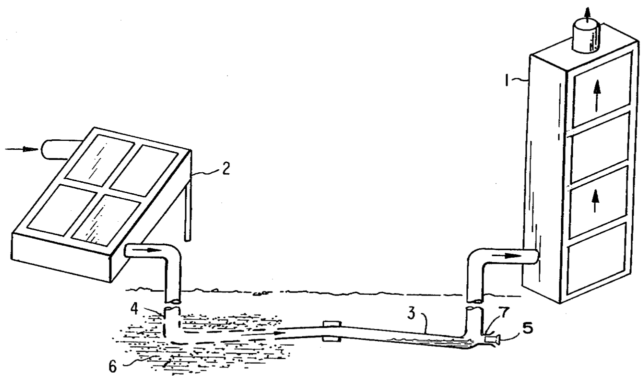

Fig. 4 - System for the transfer of moisture into the soil, horizontally *(O'Hare, 1984)*:
1 - convection column*; 2 - solar colector; 3* - condensation pipe*; 4* - evaporation pipe*; 5* - cap*; 6 - moist soil; 7 - exit pipe*

National Institute for Research in Rural Engineering, Water and Forestry (INRGREF) of Tunisia built in 2004 a pilot plant for underground irrigation by condensation and air irrigation (fig. 5 and fig. 6), in a region characterized by climate variable and minimal rainfall (*Lindblom and Nordell, 2006*). The pilot plant includes the following main parts:

- a hot water storage tank heated by solar energy, which takes place humidifiers;

- a network of underground pipes with a length of 13 m and a diameter of 63 mm, placed at different depths (0.25 m and 0.4 m);
- an air irrigation system (dew induced irrigation) with vertical pipes;
- a monitoring system of parameters: current air and soil temperature, moisture etc.

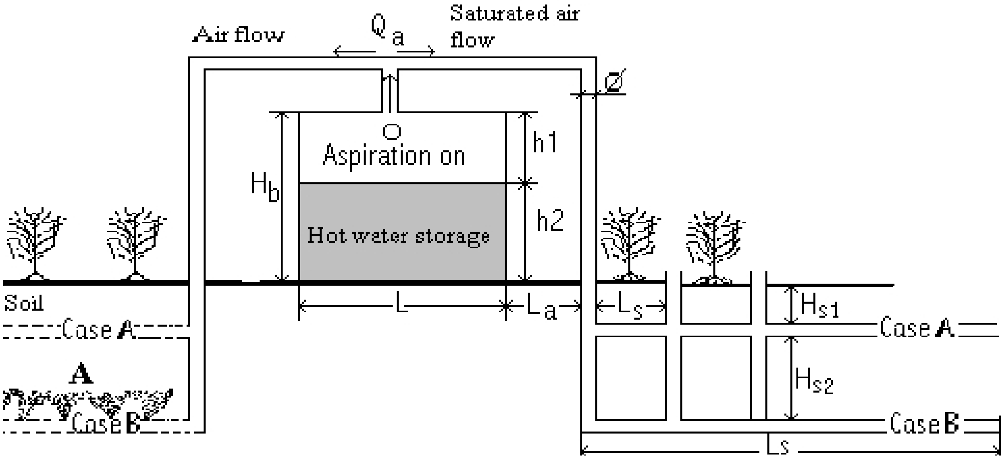

Fig. 5 - Sketch of pilot plant *(Lindblom and Nordell, 2006)***:**
irrigation by condensation (right side); air irrigation (left side); H_{s1}=0.25 m; H_{s2}=0.4 m

Fig. 6 - The pilot plant located in the experimental field *(Lindblom and Nordell, 2006)*

According to experimental research carried out in the pilot plant, underground irrigation by condensation provides a quantity of water that ensures more than 50% of the water needs of vegetable crops in arid areas of Tunisia (Table 1) (*Chaibi, 2013*). This amount of water can be doubled by the 20% increase of the water temperature in the storage tank.

Table 1

Coverage degree (production/demand) for the irrigation by humid air condensation *(Chaibi, 2013)*

Daily water production (mm/day)	Rate of satisfaction in water needs (%)				
	Green beans	Peas	Tomato	Potatoes	Onion
2.8	51-56	69-71	57-64	61-68	74-81

Dew induced irrigation

The dew induced irrigation system is an alternative of the irrigation by condensation and was first introduced in 2003, at the International Conference ICEE in Brack, Libya. Dew induced irrigation is obtained by placing the horizontal lines of vertical pipes buried with the top end above the soil surface, which allows the evacuation of the air flow in hot and humid atmosphere. Because of the difference in temperature between the flow of air from the underground pipe and the ambient air, the vapors form a cloud of condensed water droplets falling to the ground in the form of dew. This system can also be used to protect crops from frost, because the latent heat released by steam condensed prevent sudden drop in temperature during the night (fig. 7) *(Lindblom, 2003*).

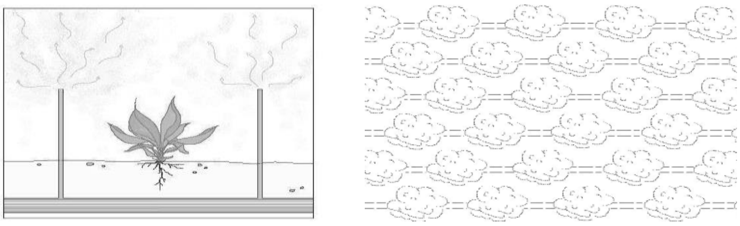

Fig. 7 - The principle of the dew induced irrigation system *(Lindblom, 2003)*

Since the amount of water extracted from the atmosphere increases with increasing temperature difference between ambient air and the air in the pipes, the best performance can be achieved when the hot water tank is stored during the day and at night used for irrigation.

The irrigation device Airdrop (fig. 8) (*Dolasia, 2011; Kaja, 2012*) uses the process of condensation to collect moisture from the air. Through the air intake system of the turbine, the air is channeled into the underground through a copper coil and the temperature is brought quickly to the ground. This process creates an environment with a humidity of 100%, from which the water is then collected and stored in an underground tank to be pumped into the underground irrigation system.

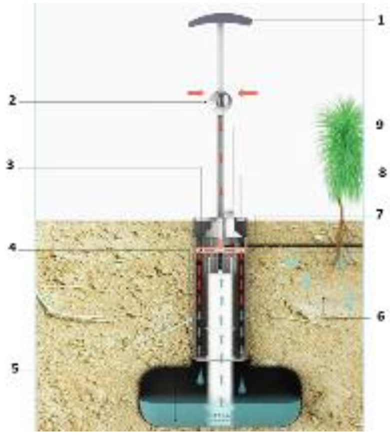

Fig. 8 - The irrigation device Airdrop (*Dolasia, 2011*)

1 - photovoltaic panel with spherical surface; 2 - turbine; 3 - the direction of air flow; 4 - condensation process; 5 - tank; 6 - water distribution in the soil; 7 - semipermeable pipe; 8 - battery ; 9 - air out

Air flow regime inside the copper coil can be laminar or turbulent (fig. 9) (*http://bustler.net/news*). In the case of laminar flow, air passes directly through the tube and condensate is formed only on the inner wall of the tube, which is only cold area with warm air comes into contact. Turbulent flow of air was carried out by placing a spiral coil of copper, to increase the contact surface between the air and the pipe and when the air temperature falls to the ground temperature. Copper coil acts as a resistance to the air and creates the effect of turbulent flow.

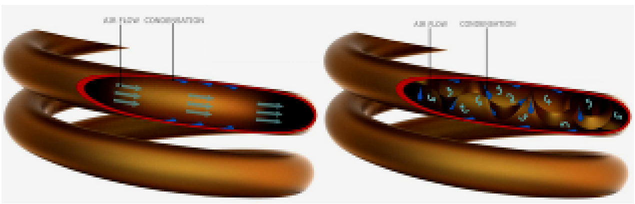

Fig. 9 - Flow regimes through the copper coil *(http://bustler.net/news)*:
laminar (left); turbulent (right)

Temperature Optimisation Systems in the Roots Area

Concept description

The principle underlying the temperature optimizing system in the plants roots area is that the temperature gradient betweeen the soil surface and a certain depth is maintaining approximately constant throughout the year. In other words, the temperature of the soil to a certain depth is greater than the temperature of the surface of the soil during the cold season and less than that in the hot season. Within the context of current climate change, this temperature difference became significant, reaching and even exceeding 10ºC (*http://rootssat.com*).

Due to the cooling effect of the root area during the summer, is maintained soil moisture and evaporation rate is reduced. System energy requirements are minimal and are assured of unconventional energy sources, such as solar. It is a simple and reliable system that requires a low initial investment and low maintenance costs (fig. 10).

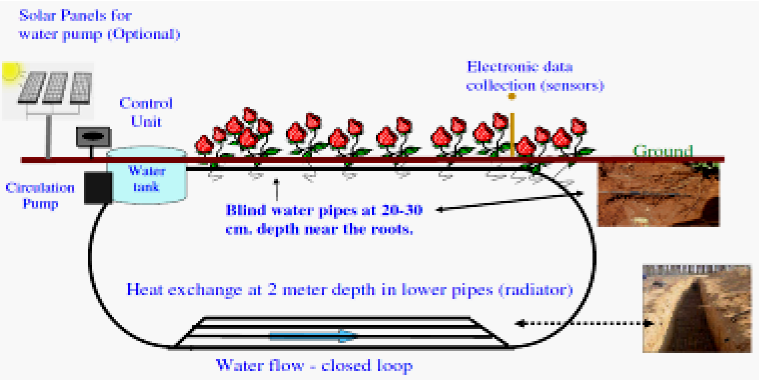

Fig. 10 - The scheme of temperature optimization system in the area of plant roots *(http://rootssat.com)*

Constructive solutions

In US 6148559 patent document *(Monte, 2000)* are presented a system and a method for preventing the formation of premature buds of fruit trees during the transition period between seasons, when take place sudden temperature increases. The method consists of maintaining the temperature in the plant roots area to a value lower than the temperature at which the buds are formed under normal circumstances. Through a network of underground pipes circulates a cooling agent which, under normal conditions of pressure and temperature, is in gaseous state (eg. hydrocarbons, CO_2, noble gases, anhydrous ammonia); in the pipework there is an area of high pressure (10 - 17 bar) in which the cooling agent is in liquid state and an area of low pressure (2 - 2.7 bar in which the cooling agent is in gaseous state. Root area temperature control system is shown in fig. 11.

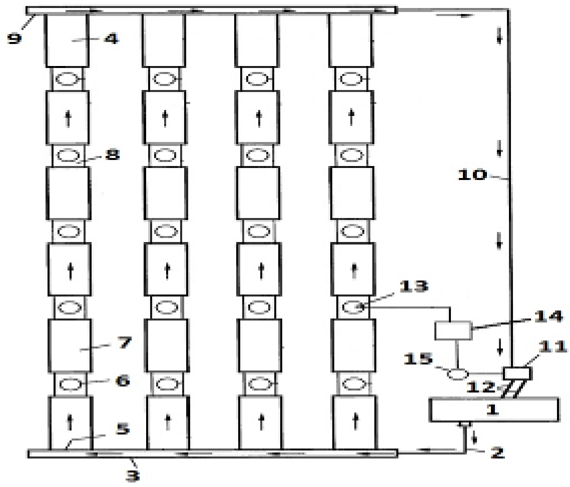

Fig. 11 - The scheme of the temperature control system in the area of plant roots *(Monte, 2000)*

1 - reservoir; 2 – transfer pipe; 3 – high pressure collector; 4 - distribution lines; 5 - regulator; 6 – roots area; 7 – isolated area; 8 - area without insulation; 9 - low pressure collector; 10 - return pipe; 11 - compressor; 12 - heat exchanger; 13 - sap flow sensor; 14 - microprocessor; 15 – solenoid valve

The high pressure area comprises tank 1 in which the cooling agent is in liquid state, the pipe 2 for transfering of the cooling agent to the high pressure collector 3, to which are connected the distribution lines 4, each line having a regulator 5, which allows the adiabatic expansion by Joule-Thomson effect. In general, the plant roots configuration includes a central spherical zone. Distribution lines of the cooling agent are located in the immediate vicinity of this zone, so that the cooling affect about one-third of the zone. To maximize cooling efficiency and to avoid its propagation in areas where there are no roots, distribution lines are provided at equal intervals with fiberglass insulations. The cooling agent in gaseous state is taken away from the low pressure collector 9 and sent to the compressor 11, passing again in liquid state and goes into the storage tank after previously passing through the heat exchanger 12 on freon basis. To monitor the sap flow departing from the plant roots to buds it is used a special sensor that sends an electrical signal to a microprocessor. The microprocessor drives a solenoid valve which controls the compressor so that when the sap begins to rise, the compressor is turned on and the root zone is cooled to stop the sap flow.

For a total length of the distribution lines of about 75 m and a diameter of 1/2 inch, buried at a depth of 13 cm, the flow rate of the cooling medium is 267 g/min, at a pressure of 2.3 bar. In these conditions, when the ambient temperature is between 10 ... 44 °C, the temperature of the soil at a distance of 20 cm from the distribution line is maintained in the range of 3 ... 6 °C. At a distance of 10 cm from the distribution line, the ground temperature is between -5 ... -1 °C. It is recommended that the depth of burial of the distribution lines is between 13 ... 20 cm. The flow rate of the cooling agent is between 84 ... 300 g/min. In the US 4577435 patent document (Springer, 1984) is shown a device for both heating/cooling of the plant root system and for heating/cooling the air surrounding the plants (fig. 12). The power supply system is both from unconventional sources (solar, geothermal) and from conventional sources (boilers, chillers, wood or coal burners). The temperature control device is adaptable to a wide range of applications and operating conditions, it is easy to install and maintain and has improved efficiency in operation. The device is designed mainly to heat the root system of the plants in the pots, but can be used in germination beds, the heat transfer tubes being buried in the ground. The input/output collectors are located on the same side of the array of tubes which form U-shaped loops. This location mode enables the temperature gradient between the inlet collector and U loop have the opposite direction of the temperature gradient between the U loop and the output collector. In other words, adjacent tubes have temperature gradients with opposite directions, which leads to uniform temperature in the root zone.

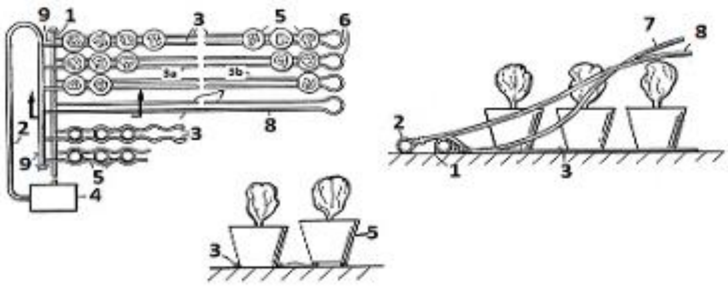

Fig. 12 - Device for heating/cooling of the plant root system *(Springer, 1984)*

1,2 – inlet/outlet collector; 3 – heat transfer pipes; 4 - liquid pumping station; 5 – plant pots; 6 – terminal loop; 7 - portion of the pipe to the outside; 8 - the top portion of the tube; 9 - ventilation valves

The heat transfer tubes have circular section and are made of flexible plastic material (polypropylene, elastomeric polymers of ethylene, diene monomer - EPDM), capable of sustaining the weight of the pots with plants and to support temperatures from -45 °C to 150 °C. For a length of the transfer pipes of 30 m, water temperature in the inlet collector is 40 °C, and those of the output collector reaches 32 °C. The optimal distance between the tubes is between 2.5 … 7.6 cm.

When it’s necessary heating the air around the plants during the cold season or coolling it down in hot season, transfer pipes can be removed and placed above the plant height. The loop can be supported in this position by some special supports. In this way, the system is not only used in the root area temperature control, but also to control the ambient air temperature.

The experiments described below were made by the company Netafim *(http://www.netafim.com)* and placed in three different climate zones in Israel (South - arid, Central and North).

- ***Pilot installation for heating/cooling the melons (Arava melons) culture root area*** (fig. 13), located on an area of 1000 m^2 in the South.

Fig. 13 - Pilot installation for growing melons *(http://www.netafim.com)*

- ***Pilot installation for growing cucumbers in a greenhouse*** (fig. 14) *(http://www.netafim.com)*, located in the North. Planting took place in December, and harvesting was carried out from February to May. It has been observed an increase in production of up to 240% with the optimization system of root zone temperature.

Fig. 14 – Pilot installation for growing cucumbers in greenhouses: comparison between control culture and culture created with optimization system root zone temperature *(http://www.netafim.com)*

- ***Pilot installation for growing strawberries in greenhouses in suspended layers*** (fig. 15) (http://rootssat.com, http://www.netafim.com), the greenhouse being located in the central area. The experiment was carried out in winter, the temperature difference between the unheated soil of the control culture and the heated soil of the experimental culture was 10.8 °C at an ambient air temperature of 1.2 °C. It has been observed an increase in production between 20 ... 25% and an early maturity of the fruit compared to the control culture, when using the temperature optimizing system in the root zone.

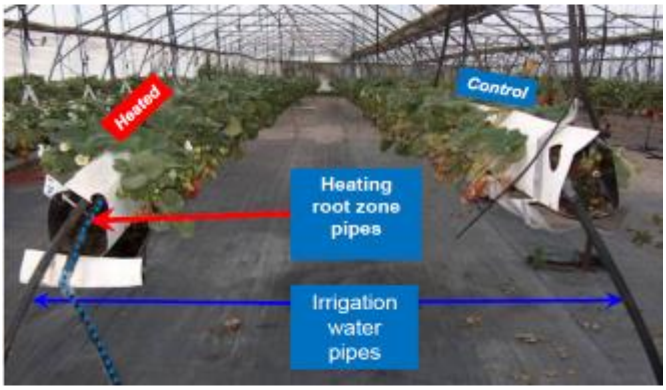

Fig. 15 - Pilot installation for growing strawberries in greenhouses *(http://rootssat.com, http://www.netafim.com)*

CONCLUSIONS

If until recently drought was considered an accident climatic, weather conditions in the last 20 years shows that due to the global climate changes, drought tends to be a state of fact.

To prevent this, *irrigation systems are needed in all areas with danger of desertification*. It is also necessary to educate farmers in applying technologies appropriate to this crisis, which preserve water in the soil. Relative effectiveness of different methods of irrigation, traditional or new, must be reported also to soil characteristics, climate, hydrology, which can radically alter the terms of comparing a method to another.

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OBTAINING BIOMASS FROM ENERGY WILLOW, A SOURCE OF THERMAL ENERGY FOR RURAL AREAS
/
OBŢINEREA BIOMASEI DIN SALCIE ENERGETICĂ, SURSĂ DE ENERGIE TERMICĂ PENTRU ZONELE RURALE

PhD.Eng. Găgeanu P.*, PhD. Stud. Eng. Găgeanu I, Eng. Milea D., Eng. Bogdanov G.
INMA Bucharest / Romania
E-mail: paulgageanu@yahoo.com

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ABSTRACT

Biomass plays an important part in the National Action Plan for Renewable Energy, which is developed within the frame established by the Directive for Renewable Energy. The main biomass use is for heating buildings (houses, schools, dispensaries, kindergartens, etc.) in small communities, which will use approximately 80% of the total production, the remaining 20% of biomass can be used for producing biofuels (12%) and electric energy (8%). The paper presents the harvesting and chopping manner for energy willow plants (Salix viminalis) in the purpose of obtaining the necessary wood chips for feeding thermal plants in rural areas.

REZUMAT

Biomasa joaca un rol important în Planul National de Actiune pentru Energie Regenerabila, care este dezvoltat în cadrul stabilit de Directiva privind Energia Regenerabila. Principala utilizare a biomasei va fi dată de încălzirea clădirilor (locuinţelor, şcolilor, dispensarelor, grădiniţelor etc.) din comune, care vor consuma cca. 80% din totalul producţiei, în care 20% din biomasă poate fi utilizată pentru producţia de biocarburanţi (12%) şi energie electrică (8%). În lucrare este prezentat modul de recoltare şi tocare a plantelor de salcie energetic, Salix viminalis în scopul obţinerii tocăturii necesare alimentarii centralelor termice din zonele rurale.

INTRODUCTION

Energy willow crops for biomass determine the increase of habitat diversity, being situated in agricultural areas, and not in forestry exploited surfaces. These crops can capitalize sloping terrains, fixing the soil and improving its quality, can fulfil a soil bioremediation role, extracting excess ions and can be used to give back the productive cycle of heavily degraded lands (waste dumps, saline, eroded, sandy soils, etc.) (*Ion V.I., 2006*).

Willow can be transformed in a variety of non-polluting and sustainable resources including (*Arion et al., 2008*):

- ❖ Heat and electricity through direct combustion, combustion together with coal and gasification;
- ❖ Biodegradable plastic and other polymers;
- ❖ Biofuels.

Energy crops for biomass can be harvested repeatedly 10-15 times before being necessary to replant them. The cost of maintenance works for willow is reduced, compared to classic agricultural species, using reduced quantities of pesticides. The production of biomass from willow reduces the need for fossil fuels and petrol products (*Găgeanu I. et al, 2015*).

Harvesting is performed beginning with year 2 or 3, in winter, when the dry substance has maximum value and the quantity of water in stems is reduced. Costs for establishing a hectare of willow for biomass varies depending on the type of planting material used, the terrain on which the crop is situated, the level of mechanization and the technology adopted (*Păun A. et al., 2015*).

Dry matter production from willow can vary depending on the species, soil type and growth cycle. In the first 3 years from planting, production varies between 15-45 t/ha, in the next 3 years between 22-70 t/ha. Salix viminalis grown in a loamy soil with fertilization treatment shows the same yield in both cycles (45-70 t/ha) (*Găgeanu P. et al., 2014).* Average stem diameter in the second cycle varies between 24-39 mm and stem height between 2.2 and 5.4 m. The number of stems per plant is 6-11 with an average of 8 stems per plant in a favourable environment. The variation of stem diameter is between 20-80 mm and many plants have a lot of smaller stems. The recommended cutting height is between 100-150 mm from the ground in order to avoid trunk destruction. After this period, stem and leaf density becomes very big, reducing light towards the lower part and reducing growth potential.

The thermal energy that can be obtained from this source ensures heating for 145.000 conventional apartments annually. By extending energy willow plantations, besides representing a source of renewable energy, energy willow reuses terrains that were left unused, avoids (or reduces considerably) deforestation generated by the increasing need for cheap fuel [11].

Energy willow harvesting can be achieved manually or mechanized. Manual harvesting is very little used and only on small surfaces.

Mechanized harvesting is used in the case of larger surfaces, with special equipment that are chosen depending on the size of surfaces that need to be harvested: from simple (and cheaper) equipment that can harvest approximately 50 ha / season, to more complex and robust equipment (but also more expensive) that can harvest 300-350 ha / season or even combines with a device adapted for willow, which are only profitable on large surfaces (800-1000 ha / season).

Depending on the manner of harvesting stems, they can be harvested as long stems, as wood chips of different sizes and as bales.

Equipment for harvesting energy willow in the form of wood chips can be self propelled or towed. Through their construction, they can achieve willow harvesting on simple or double rows. The characteristic for this type of equipment consists in the fact that after cutting the stems, they are chopped into 2-10 mm fragments, and the wood chips obtained are loaded directly into technological trailers. Energy willow stem harvesting in the form of wood chips is the method most commonly used in Europe, especially for producing energy through gasification and combustion. For this, moisture has to be reduced to less than 30% in order to produce energy. Chopped wood can also be used for the paper industry or for pressed wood, without requiring other treatments.

MATERIAL AND METHOD

Harvesting and chopping energy willow plants is performed using specialized technical equipment for cutting, feeding, chopping and throwing energy willow. The thickness of plants that can be harvested and chopped is between 10 and 70 mm. Besides energy willow crops, the same equipment can be used for harvesting other crops whose plants can be used as biomass, complying to the conditions imposed for the maximum thickness of plants that can be harvested.

Towed or carried during transportation and operation type of technical equipment for harvesting and chopping energy willow (fig. 1) are destined to work in aggregate with agricultural or forestry tractors on wheels with a power of approximately 150 HP, being driven from the tractor's PTO. This type of equipment is used for harvesting and chopping energy willow stems. The machines operate on two rows at a distance of 0.75 m between them and the free space between two planted rows is of 1.5 m. There are also some technical equipment adapted for coupling to combines destined for harvesting cereals and technical plants. By using the same combines in winter, the downtimes during winter are removed, because energy willow is only harvested in winter.

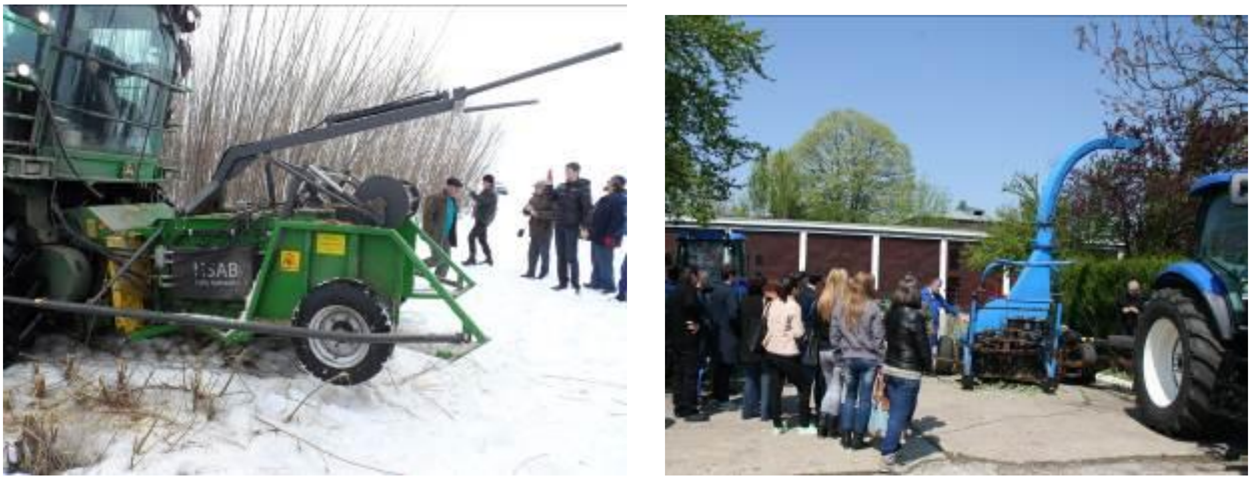


Fig. 1 Types of technical equipment for harvesting energy willow [10, 12]

a) Towed harvesting and chopping technical equipment b) Carried harvesting and chopping technical equipment

An equipment for harvesting energy willow is mainly built of the following subassemblies: cutting-feeding station, chopper-thrower with conveying system, hitch, plant bender, cardan shaft and coupling pieces. In the case of carried equipment, the rolling system, hitch, cardan shaft and coupling pieces are missing.

Stem cutting is achieved by two saw blades made from hard metal that can cut stems up to 1000 mm in diameter. A hydraulic or mechanically driven arm pretensions stems, bending them forward. Thin stems protruding from the main stems are directed towards the cutting discs. After being cut, stems are taken by two drums fitted with pulling fingers or with serrated blades, directing them towards the feeding device of the chopping device.

Specific for all energy willow harvesting equipment is the fact that the two saw discs for cutting stems overlap on a certain portion and the pulling drums are provided with fingers or pallets that improve the process of pulling in the cut stems (fig. 2 a, c).

There are also equipment with a single drum and a cutting blade, which has a diameter of up to 2000 mm. The cutting disc is divided in multiple sectors, which in care of deterioration can be easily replaced. (fig. 2 b).

Fig. 2 – Types of drums with cutting and pulling disk [13]
a) with serrated pallets and fingers ; b) with single segmented cutting blade c) with serrated pallets

Plant chopping is performed using *chopping devices* or *choppers*, which have the role of taking willow stems transported by the feeding system, of chopping (fragmenting) them to the desired length and throwing them due to the peripheral speed towards the equipment's evacuation system.

The chopping devices used need to fulfil the following technological requirements:

- To ensure that the material is chopped on the prescribed length (usually between 3 and 100 mm, depending on the technology employed);
- To achieve an adequate evenness of the wood chips length.

From a constructive view, the devices for chopping willow are of the type with blades fitted rigidly on the driving element. They can be: with tangential blades or with radial blades.

Chopping devices with blades fitted rigidly on the driving element show high safety during exploitation, ensure high uniformity for the chopping length and allow a precise adjustment of the chopping length.

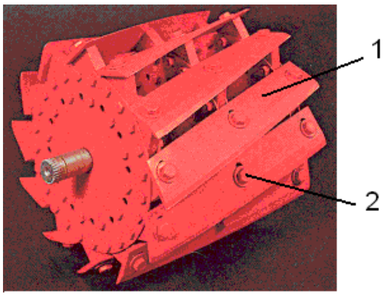
These devices are characterized by the fact that they have active elements (the blades) fixed rigidly through the means of screws on the support elements, which, depending on the shape, can be:

- Chopping devices with blades fitted on a drum;
- Chopping devices with blades fitted on disc.

The chopping devices with blades fitted on drum (called *cylindrical drums*) are composed of the following main parts: drum with blades, the housing (case) of the drum and the counter blade. In case the drum also performs the throwing of the chopped material, the blades are executed in the shape of spiral pallets or throwing pallets are fitted on the supports of the blades.

The counter blade in fixed on the housing of the chopping device and is set parallel to the axle of the drum, and the space between the blade and the counter blade is 0.3…1 mm. Experimentally, was established that the distance between the elements of the cutting pair (blade and counter blade) has an energetic influence on the cutting process. The specific energy consumption increases along with increasing the distance between the blade and the counter blade, due to the fact that setting of the plants on the counter blade is done at a certain distance from the cutting section and therefore, the bending of the rods occurs.

The space between the blade and the counter blade has a smaller influence in the case of well sharpened blades and of thick plants. Another important factor in decreasing energetic consumption is constituted by the thickness of the blade's edge and its maintenance for a period as large as possible. Edge thickness is recommended to be maintained within the interval of 15…150 μm, a fact for which the combines are fitted with special devices for sharpening the blades, placed directly on the drum. Sharpening is performed by rotating the chopping drum in the opposite direction and approaching the abrasive stone to the blade device.



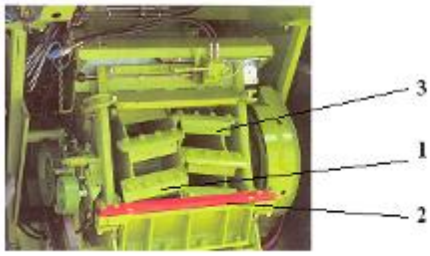



Fig. 3 – Types of cutting drums

a) Chopping drum with spiral blades (New Holland 770)
1 – spiral blade;
2 – fixing screws

b) Chopping drum with cascade blades (John Deere 3760)

c) Drum with two rows of V placed blades(CLAAS)
1- blade;
2-counter blade
3-pallet

The diameter of the chopping drum at the periphery of the blades is of 250…800 mm, and the peripheral speed is of 19…35 m/s for drums with tangential blades that only perform the chopping and up to 38 m/s for drums that both chop and throw the chopped material. The blades are placed inclined to the drum generator, at an angle of 6…12^o in order to achieve a progressive cutting, and the edge is sharpened to an angle of 16…37^o. In case the chopping drum also throws the chopped material, the blades are built in the shape of spiral pallets or throwing pallets are fitted on the blade support.

The chopping devices with blades fitted on disc are composed of: blades for chopping the material, feeding inlet, discs, pallets for throwing the chopped material and housing.

Blades can have straight or curved edge and can be placed inclined to the rotation plane of the blade. Blades with a straight edge are more common, are easily manufactured and sharpened being placed inclined to the radial direction. Feeding the chopping device with material is done on the axial direction where the feeding inlet is found. The length of the feeding inlet is $L = (0.7…0.8)R_d$ (R_d being the maximum radius of the disc, at the edge of blades). The number of blades fitted on the disc is 2…12, and the disc's speed of revolution in 500-1000 rot/min.

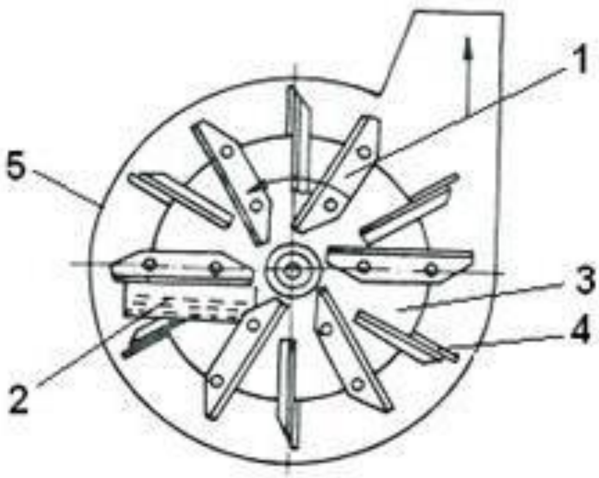


Fig. 4 – Chopping device with blades mounted on disk [12, 13]

left – constructive diagram; right- version built by Ceahlăul Piatra Neamţ company

1 – blades for chopping the material; 2 – feeding inlet, 3 – disc for attaching the blades,

4 – pallets for throwing the chopped material; 5 - housing.

Chopping devices with blades fitted on the disc are used for attachable harvesting equipment (towed or carried).

RESULTS

Experiments were performed using a technical equipment for cutting and chopping energy willow with chopping device having the blades fitted on disc. The equipment is so designed as to operate in aggregate with a 150 HP agricultural tractor, being attached to its PTO according to the technological diagram show in figure 5.

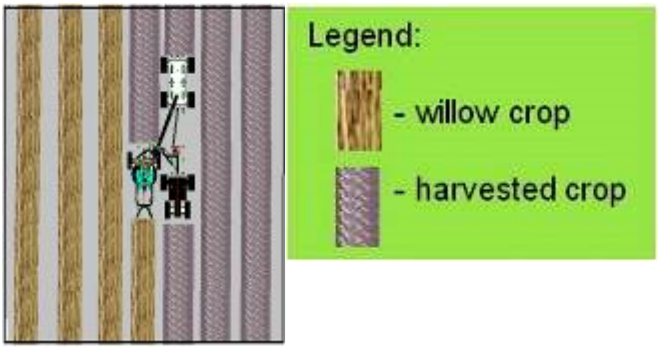


Fig.5 – Technological diagram for the equipment for harvesting and chopping energy willow

The rotation movement from the tractor's PTO is transmitted through the means of two cardan transmissions, one being of the type with safety coupling and a transmission with trapezoidal belts to the axle of the chopper, from where, by the means of a transmission with trapezoidal belts will transmit the movement to the auger of a redactor that is engaged with two auger wheels obtaining their rotation in opposite directions, directions that need to be transmitted to the cutting discs and to the feeding rollers for introducing the chopped material in the chopper.

From the two auger wheels, the movement is transmitted to the feeding rollers and the speed of revolution that is transmitted to the cutting discs is of 1063 min^{-1}, obtained through a multiplication with the help of two pairs of gears fitted on the reducer.

When the tractor is set into motion, it pulls the equipment which enters the willow crop according to the technological diagram and the operation of bending the plants forward by the plant bender starts, the plants being maintained in this position until they are cut by the cutting discs and directed forward by the two pairs of pulling rollers which grab the cut plants transporting them to the feeding inlet of the chopping device.

Once the plants reach the inlet of the chopper, they are cut by the blades fitted on the chopper's disc. The fragmented material passes behind the disc through the windows created for each blade and is taken by the pallets fitted behind the disc, pallets representing the chopper's ventilator.

Once they reach the pallets, the fragments are taken and thrown through the chamfer for directing the wood chips towards a means of transportation situated behind the equipment.

Measurements were taken for the traction force and for the torque at the PTO on a concrete track and on uneven ground for different speeds of transportation, the results being shown in the diagrams obtained from specific transducers and tensometric sensors fitted on a special bar on which the technical equipment for cutting, feeding and chopping was fitted on. The diagrams obtained are shown in the graphical representations shown in figure 6 and 7.

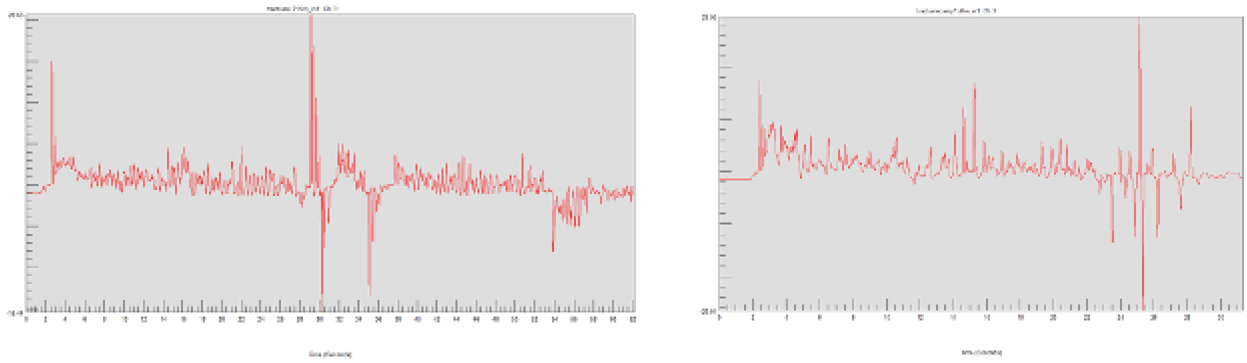


Fig. 6 – Average traction force

a) On concrete track at an average speed of 21 km/h b) On uneven ground at an average speed of 15 km/h

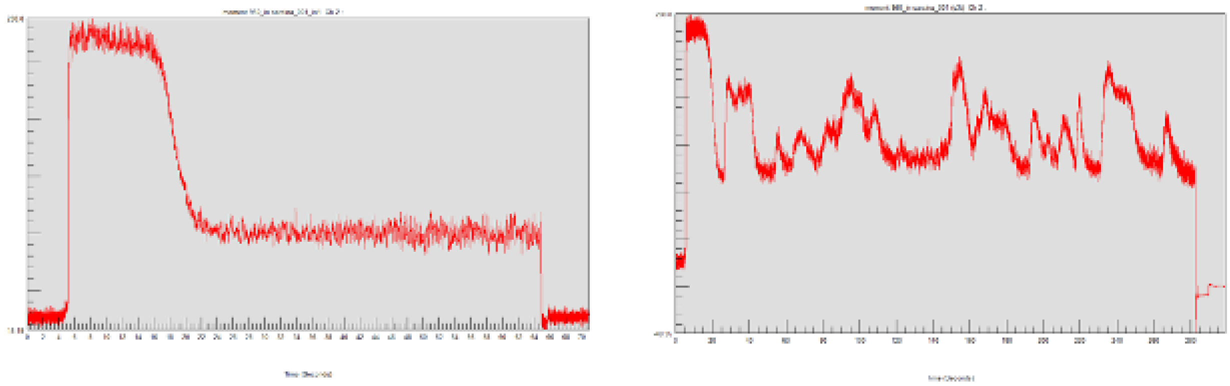


Fig. 7 – Average torque at PTO

a) at 950 rot/ min without load b) at 950 rot/min with the TE mounted

Material chopping was ensured in good conditions, the wood chips resulted fitted in the required sizes. The shape and size of wood chips is shown in figure 8.

Fig. 8 - Wood chips

The size of wood chips was determined using the Retsch AS 200 BASIC sieving system (fig. 9).

a ***b*** ***c*** ***d***

e ***f*** ***g*** ***h***

Fig. 9 - Separating the chopped willow on fractions

a - Retsch device AS 200 BASIC; b) wood chips>10 mm; c) wood chips >8<10 mm; d - wood chips >6.3mm<8mm; e) wood chips >5<6.3mm; f - wood chips >4<5 mm; g) wood chips >3.15<4 mm; wood chips <3.15 mm wood chips >3.15<4 mm; h) wood chips <3.15 mm

Sample weighing was achieved using the Mettler PM 6000 non automated weighing device, as shown in figure 10.

Fig. 10 – Weighing the chippings using Mettler PM 6000 device

Results from the sieving operation are presented in table 1.

Table 1

Chopped willow size distribution

Sample no.	**Chippings size**						
	φ<3.15	3.15<φ<4	4<φ<5	5<φ<6.3	6.3<φ<8	8<φ<10	φ>10
Sample 1 (g)	73.7	26.6	26.9	24.8	21.7	12.3	64
Sample 2 (g)	50.7	21.2	19.3	14.5	11.7	6.2	126.4
Sample 3 (g)	53.1	25.8	28.2	27.8	27	14.2	73.9
Sample 4 (g)	62.8	34.3	32.7	27.9	23.1	11.5	57.7
Average (g)	60.075	26.975	26.775	23.75	20.875	11.05	80.5

The graphical representation of results is given in the chart shown in figure 11.

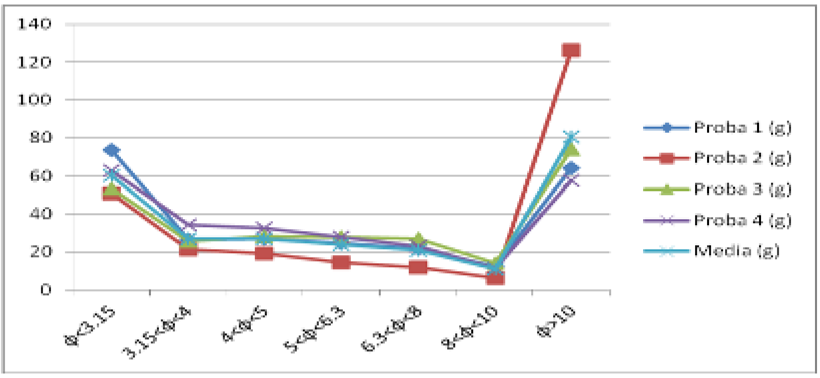


Fig. 11 – fraction distribution of the chopped biomass after saparation

Plant cutting and the cutting height (remaining stub) is shown in figure 12.

Fig. 12 – Cutting height and remaining stub after harvesting energy willow

CONCLUSIONS

After performing the tests on the equipment for cutting, feeding and chopping energy willow, the following resulted:

- The equipment for cutting, feeding and chopping works in aggregate with the 150 HP tractor. Wood chips evacuation can be made in a trailer that can be coupled to the equipment and towed simultaneously with it, or it can be towed by another tractor that moves parallel to the first tractor.
- The drum type chopping device with cascade blades performs a good plant chopping simultaneously achieving a good evacuation of the chopped mass.
- Total material losses are not big, they do not exceed 3% in normal exploitation conditions;
- By analyzing the quality of the chopped material, it is found that the particles with a length up to 3.15 mm represent 24.03 % of the chopped mass, 32.98% is represented by particles with the length between 3.15 and 10 mm, and 32.2 % of the wood chips are larger than 10 mm, this in the conditions of a theoretical chopping length of < 50 mm, provided in the execution documentation. By accident, there are also fragments larger than 50 mm, but insignificant compared to the mass of wood chips.

ACKNOWLEDGEMENT

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TENDENCIES IN ACHIEVING COMPOSITE MATERIALS FOR REDUCING THE IMPACT ON THE ENVIRONMENT
/
TENDINŢE ÎN REALIZAREA MATERIALELOR COMPOZITE ÎN SCOPUL REDUCERII IMPACTULUI ASUPRA MEDIULUI

Eng. Gyorgy Z.[1)], Ph.D. Stud. Eng. Nagy E. M.*[1)], Eng. Cota C.[1)]., Ph.D. Eng. Cioica N.[1)]
[1)] INMA Bucharest Branch of Cluj Napoca / Romania
E-mail: nagy_m2002@yahoo.co.uk

Keywords: *material, composite, synthetic, biodegradable, environment*

ABSTRACT

Along with the development of technology, the need has risen for new materials that fulfil current demands. Such materials are composite materials, which offer many advantages from the point of view of their performances and characteristics, but beside these qualities, they also create problems related to environment pollution. Synthetic composite materials, due to the demands related to their resistance, do not degrade naturally, leading to the accumulation of waste quantities, respectively by being products of petrol origin, they also contribute to the depletion of these resources. Due to this reason, was required to replace synthetic composite materials with biodegradable ones, even if certain compromises must be made, related to their mechanical and thermal properties. By using renewable raw materials from agriculture for manufacturing composite materials, they also contribute to maintaining petrol resources and to reducing the quantity of waste produced by humans.

REZUMAT

Odata cu dezvoltarea tehnologiei a apărut nevoia de materiale noi care sa îndeplinesca cerinţele actuale.Acestea sunt materialele compozite, care oferă multe avantaje din punct de vedere al performatelor si caracteristicilor, dar pe lângă aceste calitati creaza si probleme legate de poluarea mediului. Materialele compozite sintetice din cauza cerinţelor legate de rezistenţa lor, nu se degradează natural, ceea ce duce la acumularea unor cantinăţi de deşeuri, respectiv fiind produse de origine petroliera, contribuie si la epuizarea acestor resurse. Din acest motiv sa impus înlocuirea materialelor compozite sintetice cu cele biodegradabile, chiar dacă trebuie facute unele compromisuri legate de proprietăţile lor mecanice şi termice. Utilizand la realizarea compozitelor biodegradabile materii prime regenerabile din agricultură, acestea contribuie si la păstrarea resurselor petroliere şi la reducerea cantităţii de deşeuri produsă de om.

INTRODUCTION

Technology is part of our everyday life, and on the market emerge daily new products that are either novelties, innovations or replace products that are old, used or only surpassed by modern technology. In the last 50 years, rapid product development has requested the use of new technologies, but also the use of new materials. The more sophisticated the products have become, the more the need to use special materials that meet new requirements has increased.

The use of synthetic composite materials allows to create components with certain mechanical, physical, chemical properties, imposed from the design stage, making it possible to reduce material consumption, respectively to reduce the quantity of waste resulting from the manufacturing procedures.

Besides the advantages offered by composite materials, another problem appeared in the last 50 years. Synthetic composites, due to their physical and chemical properties, are very resilient to natural degradation, some are not naturally degraded even after hundreds of years. This constitutes a problem related to the impact of composite materials on the environment. The recycling of waste from composite materials poses multiple difficulties, most often concerning the high costs of recycling. Due to these reasons is imposed to develop and use biodegradable composite materials, which, besides complying with technological requirements, also need to fulfil the demands for efficient and non-polluting manufacturing technologies, respectively controlled decomposition after the term of use has expired.

MATERIAL AND METHOD

The development of manufacturing processes implies using new (high-tech) materials. A few years ago, the industry of composite materials was exclusively dedicated for the military and aero-spatial sectors, but lately, the use of composite materials covers a large range in various fields of activity, both due to the specific properties, but also to the possibilities to adapt these properties to the condition of exploitation, even if the costs of these materials are higher. (fig. 1).

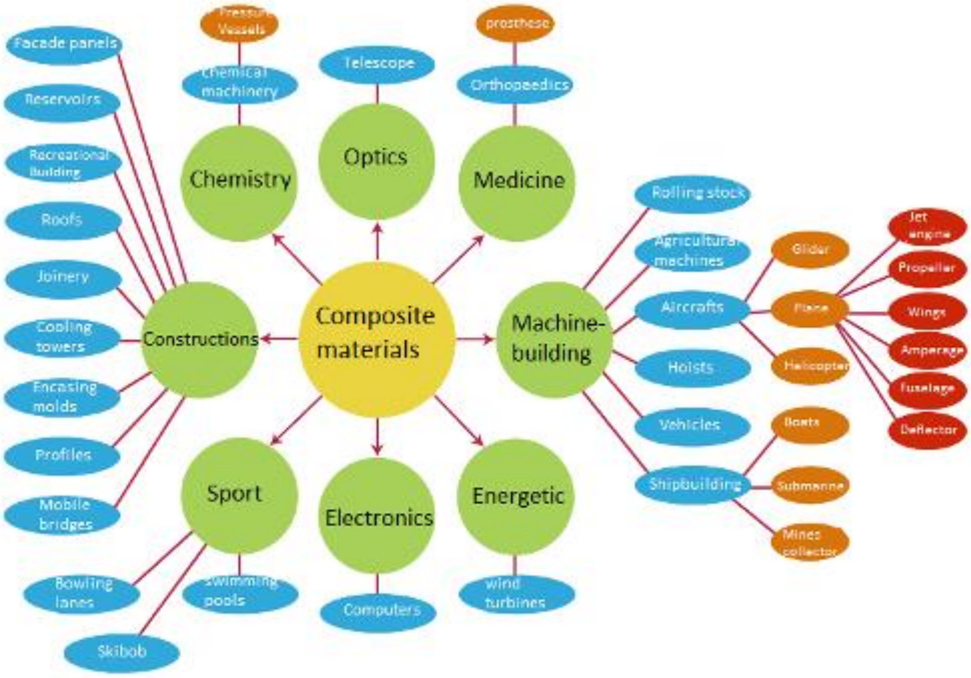

Fig. 1. Fields of using composite materials [6]

In the specialty literature are found multiple definitions for the term of composite material (*Geier M, Duedal D, 1985; 11, 12, Carcea I., 2008*). In general, composite materials are combined from two or more materials, different from a chemical point of view, which maintain their separate identity at a macroscopic level, and by combining them, are obtained properties and characteristics that are different from those of each component material, thus, the new material sums the benefits, behaves unitary, the stresses and tensions are transmitted simultaneously throughout the entire mass of material.

For manufacturing composite materials, at least two components are used, the matrix, or the continuous phase and the reinforcement, or the discontinuous phase. The matrix has the role to surround the reinforcement and to transmit efforts uniformly in the entire mass of material, and the reinforcement has the role to intake the efforts. In the structure of a composite material, the matrix represents the "weak" element, and the reinforcement is the "strong" element. The efforts taken by the reinforcement are directed by the matrix on specific senses and directions. [16].

Compared to traditional materials, composite materials have many advantages such as reduced weight, smaller volume mass in relation to metals, high mechanical strength. Composite materials have a strength-resistance ratio superior to metals.

Depending on their structure, composite materials can contain fibers, particles, can be stratified, this offering a possibility to orient the armature so that it increased strength is obtained. For example, Kevlar composite has a double resistance to traction on the longitudinal direction of fibers compared to glass.

Composite materials are resistant to temperature variations, to corrosive environments and to the action of chemical agents. Another advantage consists in their formability – composite materials can be used in complicated shapes and elements, thus obtaining material gain without losing any mechanical strength, respectively an aesthetic shape and a pleasant design (*Nicolae O., 2013*).

Besides the advantages offered, composite materials also have a series of disadvantages, among which the first one is the high cost, these materials being more expensive than traditional materials. When breaking, composite materials have a linear-elastic behaviour, which does not show ductility. Another disadvantage is the impossibility to use these materials at high temperatures, due to the fact that composite materials have a transition temperature above which, the resistance and elasticity module decrease, giving way to plastic deformations. All organic materials used in the structure of composite materials are combustible, they burn and the smoke emitted can be toxic, thus having a negative impact on the environment. There is a possibility to introduce combustion delayers in the composition, but they also affect the mechanical characteristics. (*Nicolae O., 2013*).

RESULTS

In order to determine the impact on the environment, all stages should be taken into consideration by assessing the product's life cycle. This is a modelling system that allows to quantify and validate these influences taking into consideration both the economic and environment factors and also the social factors. The "from cradle-to gate" methodology assesses the impacts associated with the extraction of petrol, minerals and biomass as raw materials for manufacturing composite materials, their transport and packaging until the actual manufacturing process. Because the use of the product after it leaves the factory gates has a significant impact on the environment, a more complete approach is known as "from cradle-to grave", which analyses a product from manufacturing, use and until the completion of life cycle and elimination.

The impact of composite materials on the environment. The most frequently used composite materials are those obtained based on components originating from petrol (especially those with polymeric matrix and/or synthetic reinforcement fibers), leading to the acceleration of petrol products depletion.

Due to the use of composite materials with polymeric matrix in a large range of activity fields increases polymer production and a big problem is represented by their recycling or the destruction of these materials after the life cycle of the product made from composite materials ends (for example at the end of the life cycle of carbon fiber composite, it can be recycled through thermal degradation without oxygen by depolymerisation, obtaining carbon fibers that can be reused in other applications). The production of plastic materials after the 50s is presented by the diagram in figure 2.

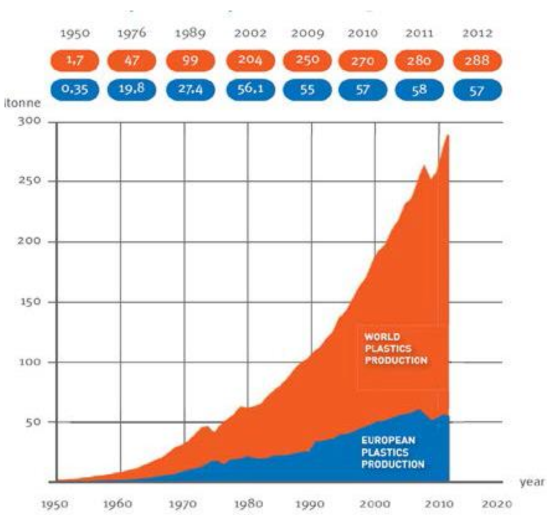

Fig. 2. Global production of plastic materials 1950-2012 [14]

Due to the reasons states above related to environment pollution, the use of composite materials with biodegradable matrix and reinforcement from natural fibers is a tendency of fundamental importance.

An example of composite natural biodegradable composite material is wood, where the matrix is represented by lignin and the reinforcement by the cellulose fibers.

Currently, there are two solutions for biodegradable polymers that can replace synthetic polymers used as matrix, polycaprolactone (PCL) and polylactic acid (PLA), but the use of these materials is not justified due to their high costs.

As tendency to replace synthetic polymers with a biodegradable material, without too high costs, would be to use polymers based on thermoplastic starch, starch being found available at low prices, even if the applicability is limited by the weak mechanical properties and the low resistance to humidity [9].

In order to improve mechanical properties of thermoplastic starch, it can be mixed with natural fibers, and from the researches in the field it was found that due to transformations and multiple chemical reactions, the production of biodegradable composite material is much more complicated than in the case of using synthetic polymers. [10]

The impact of processes of manufacturing synthetic composite materials on the environment. In general, technologies of processing composite materials involve equipment and processes for obtaining the polymeric matrix, preparing reinforcement components, impregnating or treating the fibers, cutting the fibers, making the reinforcement (it can be made in various shapes: network, weaving, braiding, etc.), making the actual composites through injection, extrusion, pressing-moulding, or other procedures. Basically, for each type of polymeric composite material and for each mark is necessary to have a different technology with specific operations and equipment.

From the point of view of manufacturing technologies, polymeric composites can be classified in two categories: thermorigid and thermoplastic.

Thermorigid composited have the property that after heating they suffer an irreversible transformation, while thermoplastic composites regain their initial structure when cooling down after being heated to the melting point.

For the material of matrixes, most of the time are used materials such as nylon, polyethylene, vinyl, acryl, polypropylene. These materials have petrol origin, which besides the fact that the production processes require a large consumption of energy and produce a large quantity of waste, they also contribute to the depletion of petrol resources. Another problem is the time of total material decomposition, which is extremely long. The polymers reminded above have very good mechanical properties, are resilient to corrosion, chemical agents and water. These properties make the natural decomposition of composite materials having these materials in their composition to last tens or even hundreds of years; there also exist plastic materials used as matrix, which will last for more than 1000 years before fully decomposing [15].

The recycling of thermoplastic composite materials requires a high consumption of energy, and the recycling of thermorigid materials poses even more difficulties. Due to the fact that these polymers can withstand chemical agents, chemical decomposing cannot be achieved, or can be achieved with great difficulties and at very high costs. When destroying these materials through incineration, toxic gases are released, which affect the entire environment (land, water, plants, animals and humans). In the case of natural decomposition, these plastic materials of fossil origin release dangerous chemical substances that penetrate the soil, reach the groundwater and affect all species that require water.

In synthetic composite materials, the most used components for reinforcement are: fiberglass, carbon fibers, asbestos, silicon, boron, graphite. It is estimated that fiberglass is used for the reinforcement of around 95% of the total composite materials (*Witten et al., 2014*).

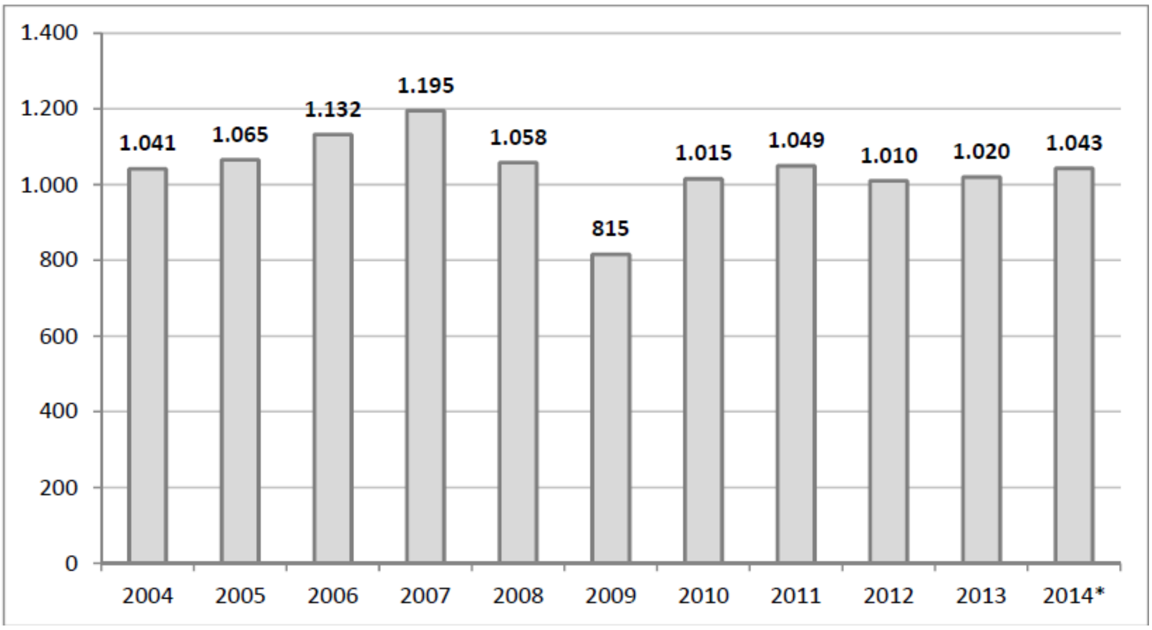

Fig. 3. The production of fiberglass reinforced plastic in Europe, thousands of tons [8]

Fiberglass is produced in two phases, obtaining the glass and spinning the glass fibers. Fiberglass has the advantage that the raw materials for obtaining the glass are easily found, the usual raw materials being only quartz sand, limestone, soda and Glauber salt. The problem consists in the manufacturing process, these substances have to be mixed and then heated up to 1200-1600º C, translating into a high energetic consumption, which indirectly affects the environment in a negative way. Additionally, besides the spinning processes for manufacturing fiberglass, chemical substances with adhesive role are used. [16]

In order to obtain silicon fibers by removing impurities from fiberglass, various thermal treatments are necessary, which require a lot of energy and have high costs.

Quartz fibers are obtained by melting quartz crystals, at very high temperatures, that is why the cost price of these reinforcement materials is too high, even if they yield efficient materials, their use is only justified in special cases.

Currently, the material most used for reinforcing the composition of composite materials is carbon fiber, which is obtained through controlled pyrolysis (1000-1700º C) of organic fibers in an inert atmosphere, as polyacrylonitrile. Graphite fibers are obtained from natural graphite through oxidation. [15]

Another disadvantage of using these synthetic composite materials consists in the risk posed to the health of operators involved in manual processing. When cut or polished, the fibers shatter, and these material particles penetrate the human body, endangering its health. For example, when processing composite materials processed with fiberglass, macroscopic pieces of glass float in the air, the operator inhales them, they reach the lungs from where they can also reach the other internal organs and many times lead to the emergence of malignant tummours. [17]

The impact of biodegradable composite materials on the environment. Due to problems related to environment pollution by manufacturing synthetic composite materials, replacing these materials with biodegradable materials and reinforcing them with natural fibers has a fundamental importance.

The impact of biopolymers on the environment depends on the raw material used. From a study ordered by Natureworks, in which was studied the impact of thermo-formed packaging for food products on the environment, was found that PLA is better than PET, PS and PP (*Detzel A., Krueger. M., 2006*). Due to the rigidity of PLA, it was possible to obtain lighter parts and the options when ending the lifecycle of PLA are better than for PET. Nevertheless, it was found that PLA recycling is a better option compared to its composting. The environmental indicator with the largest relative contribution for the PLA production was aquatic eutrophication, caused by the chemical consumption of oxygen (COD), a measure of the organic compounds released by the PLA production system and the nitrate emissions from the corn growing process.

In a critical review on the assessment of the lifecycle of biodegradable polymers conducted by the Cambridge University (*Yates M., Barlow C., 2013*), was attempted to determine the impact of polyacrylic acid – PLA, polyhydroxyalkanoates – PHA and starch based polymers on the environment, compared to petrochemical polymers, taking into consideration the agricultural practices in question, which can severely affect the environment. It was found that many studies concentrated on energy and the potential for global warming were in the favour of polymers, but studies that take into consideration other categories affecting the environment were not that favourable.

Life cycle assessment conducted as part of the Multibio European project found that for multilayer packaging foils made from biopolymers based on modified starch and PLA, the impact on the environment was half compared to conventional foil based on PP and AP6 (*Garrain D. et al., 2007*). From the point of view of the impact on global warming, biopolymer foil had the best result and also had a small impact regarding the depletion of fossil fuels compared to conventional foils. Concerning the eutrophication, bio foil has a higher impact but, nevertheless, it was found that this category of biopolymer foils has the smallest global impact on the environment, compared to conventional foils.

Also, each stage of the manufacturing process has a certain impact on the environment, contributing to the total impact that characterizes the product obtained. The analysis of these impacts allows to emphasize the processes contributing the most to the total impact and emphasises the interdependence of the stages of the manufacturing processes from the point of view of the impact on the environment – choosing a certain process can influence the amplitude of the impact of other processes. This interdependence is obvious when choosing the manufacturing process, the matrix and the reinforcement fibers. For example, if fibers with low impact on the environment are chosen, it is possible not to have the possibility to also choose a matrix with very low impact. These choices also influence the quantity of material used for manufacturing, which influences the global impact.

CONCLUSIONS

As conclusions, we can say that replacing synthetic composite materials with biodegradable ones would be a good solution for protecting the environment.

The advantages offered consist in using raw materials that can be continuously produced without resource depletion, in eliminating problems related to manufacturing processes that pollute the environment, respectively problems related to waste accumulation. Thus, is considered that natural fibers have a more reduced impact on the environment compared to fiberglass, due to the reduction of CO_2 emissions and of the energy consumption in the production stage. In the case of composite materials, the matrix has a higher impact than reinforcement fibers, thus a special attention needs to be given to the development of biodegradable materials forming the matrix of bio-composites.

After completing their lifecycles, bio-composite materials can be recycled, biodegraded, or can be incinerated to recover energy.

When choosing the right material products, a compromise needs to be reached between the mechanical capacities of materials, respectively the trace left by these materials in the environment.

The use of biodegradable bio-composite materials is a process in full development, researches in the field targeting in the first place the improvement of physical-chemical properties for these materials.

Acknowledgment

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Three types of manuscripts may be submitted:

1. **Regular articles:** These should describe new and carefully confirmed findings, and experimental procedures should be given in sufficient detail for others to verify the work. The length of a full paper should be the minimum required to describe and interpret the work clearly (max.10 pages, even number);
2. **Short Communications:** A Short Communication is suitable for recording the results of complete small investigations or giving details of new models or hypotheses, innovative methods, techniques or apparatus. The style of main sections has not necessarily to be in accordance with that of full-length papers (max. 6 pages, even number);
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Manuscripts should be written in English (American or British usage is accepted, but not a mixture of these) and submitted **electronically** at the following e-mail addresses: ***inmatehjournal@gmail.com***
Please be sure to include your full affiliation and e-mail address (see Sample manuscript)
The authors are responsible for the accuracy of the whole paper and references.
There are allowed 2 papers by each first author.
The text layout should be in single-column format. To avoid unnecessary errors it is strongly advised to use the "spell-check" and "grammar check" functions of your word processor.

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All manuscripts are reviewed by 2 members of the Scientifically Review Office. Decisions will be made as rapidly as possible and the journal strives to return reviewers' comments to authors in approx.3 weeks.
The editorial board will re-review manuscripts that are accepted pending revision.

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- Title will be ***Arial 12 pt***. and explicit figures will be ***Arial 9 pt***.
- Text will be written in English.
- Chapters' titles are written by ***Arial 10 pt, Bold, Uppercase*** (e.g INTRODUCTION, MATERIAL AND METHODS), between chapters is left a space for 10 pt. At the beginning of each paragraph, leave a tab of 1 cm.
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TITLE ***Arial 12 pt., Uppercase, Bold, Center*** *(in English language)* and ***Bold Italic*** *(in native language)*.
Should be a brief phrase describing the contents of the paper. Avoid long titles; a running title of no more than 100 characters is encouraged (without spaces).

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Under the paper's title, after a space (enter) 9 pt., write ***authors' names*** and ***affiliations (Arial 8 pt.-Regular)***
When the paper has more than one author, their name will be followed by a mark (Arabic numeral) as superscript if their affiliation is different.
Corresponding author's name (next row), ***(Arial 8 pt.)***. Should be added also: phone, fax and e-mail information, for the paper corresponding author (***font: 8 pt., Italic***).

KEYWORDS ***(In English)*** about 4 to 7 words that will provide indexing references should be listed (title: ***Arial 10pt, bold italic***, text ***Arial 10 pt., italic***).

A list of non-standard *Abbreviations* should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelled out and introduced in parentheses the first time it is used in the text. Standard abbreviations (such as ATP and DNA) need not to be defined.

ABSTRACT ***(in English and Native language, Arial 10 pt.)***, the title *bold*; the text of abstract: *italic*) should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The Abstract should be max.250 words. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited.

INTRODUCTION ***(Arial 10 pt.)*** should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific subjects. We should refer to the current stage of researches performed in the field of the paper to be published, by quoting up-to-date specialty studies, preferably published after 2006, excepting certain referential specialty books/studies, especially papers issued in magazines/journals/conferences/ISI quoted symposia or in other international data bases, which are well known and available.

MATERIALS AND METHODS (***Arial 10 pt.***) should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Methods in general use need not be described in detail.

RESULTS (***Arial 10 pt.***) should be clarity presented. The results should be written in the past tense when describing findings in the authors' experiments. Results should be explained, but largely, without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the Results, but should be put into the Conclusions section.

CONCLUSIONS (***Arial 10 pt.***) The main conclusions drawn from results should be presented in a short Conclusions section. Do not include citations in this section.

Formulae, symbols and abbreviations: Formulae will be typeset in Italics (preferable with the Equation Editor of Microsoft Office 2003) and should be written or marked as such in the manuscript, unless they require a different styling. They should be referred to in the text as Equation (4) or e.g. (4). The formulae should be numbered on the right side, between brackets (***Arial 10 pt.***):

$$P = F \cdot v \tag{1}$$

Terms of the equation and the unit measure should be explained, e.g.

P is the power, [W];
F – force, [N];
v – speed, [m/s]

SI units must be used throughout.

Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented both in table and graph form or repeated in the text.

Table's title will be typed ***Arial 9 pt, Bold, Centered***

In the table, each row will be written Arial 9 pt, single-spaced throughout, including headings and footnotes.

The table should be numbered on the right side, between brackets (***Arial 10 pt***):

Figure (Arial 9 pt., Bold, Center) should be typed in numerical order (Arabic numerals). Graphics should be high resolution (e.g.JPEG). Figure number is followed by what represent the figure or graph e.g.:

Fig.1 – Test stand

Legend: ***Arial 8 pt, Italic, Center,*** e.g.

1 - plansifter compartments; 2- break rolls; 3 – semolina machines; 4 – reduction rolls; 5 – flour

ACKNOWLEDGMENTS (***Arial 10 pt.***) of people, grants, funds etc should be brief (*if necessarily*).

REFERENCES (***Arial 10 pt.***)

(In alphabetical order, in English and in the original publication language).

Minimum 10 references, last 10 years, minimum 3 references from the last 2 years

It can be used "References" tool from the Word Editor.

References should be cited in the text in brackets as in the following examples:

(Babiciu P., Scripnic V., 2000)

All references must be provided in English with a specification of original language in round brackets.

Authors are fully responsible for the accuracy of the references.

References should be alphabetically, with complete details, as follows:

Examples:

Books: Names and initials of authors, year (between brackets), title of the book (Italic), volume number, publisher, place, pages number or chapter, ISSN/ISBN:

[1] Vlădut V., (2009), *Study of threshing process in axial flow apparatus (Studiul procesului de treier la aparatele cu flux axial),* vol.1, ISSN/ISBN …………, "Terra Nostra" Publishing House, Iaşi/Romania;

Journal Article: Names and initials of authors, year (between brackets), full title of the paper, full name of the journal (Italic), volume number, publisher, place, ISSN, page numbers:

[1] Lizhi Wu, Yan Di., (2005), Demonstrational study on the land consolidation and rehabilitation (LCR) project of saline-alkali soil in arid areas: a case study of Lubotan LCR project in Pucheng County, Shaanxi Province (干旱区盐碱化土地整理工程实证研究-以陕西蒲城县卤泊滩土地整理项目为例), *Transactions of the Chinese Society of Agricultural Engineering*, vol.21, no.1, ISSN ………, pp.179-182, Madison/Wisconsin;

[2] Leonov I.P., (1973), Basic machine theory for tobacco stringing. Post-harvest care of tobacco and rustic tobacco (Основы теории машин для закрепления табака на шнуры. Послеуборочная обработка табака и махорки), *Collection of scientific articles (сборник научно-исследовательских работ)*, pp.37-45;

Conference or Symposium: Names and initials of authors, year (between brackets), full title of the paper (Regular), full name of the conference/symposium (Italic), volume number, publisher, place, ISSN, page numbers

[1] Bungescu S., Stahli W., Biriş S., Vlăduţ V., Imbrea F., Petroman C., (2009), Cosmos program used for the strength calculus of the nozzles from the sprayers (Program Cosmos folosit pentru calculul de rezistenţă la zgomot al aparatelor de distribuţie), *Proceedings of the 35 International Symposium on Agricultural Engineering "Actual Tasks on Agricultural Engineering"*, pp.177-184, Opatija / Croatia;

Dissertation / Thesis: Names and initials of authors, year (between brackets), full name of the thesis (Italic), specification (PhD Thesis, MSc Thesis), institution, place;

[1] Popa L., (2004), *Research on the influence of structural and functional parameters of the braking system on the braking performance of agricultural trailers (Cercetări privind influenţa caracteristicilor constructive şi funcţionale ale sistemelor de frânare asupra performanţelor de frânare ale remorcilor agricole)*, PhD dissertation, Transylvania University of Braşov, Braşov / Romania.

Patents: Names and initials of authors, year (between brackets), patent title (Italic), patent number, country:

[1] Grant P., (1989), *Device for Elementary Analyses*. Patent, No.123456, USA.

Legal regulations and laws, organizations: Abbreviated name, year (between brackets), full name of the referred text, document title/type (Italic), author, place:

[1] *** EC Directive, (2000), Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000, on the incineration of waste, Annex V, *Official Journal of the European Communities*, L332/91, 28.12.2000, Brussels.

Web references: The full URL should be given in text as a citation, if no other data are known. If the authors, year, and title of the documents are known and the reference is taken from a website, the URL address has to be mentioned after these data:

The title of the book, journal and conference must be written in Italic, the title of the article, chapter of the book, must be written Regular.

Citation in text

Please ensure that every reference cited in the text is also present in the reference list (and vice versa). Do not cite references in the abstract and conclusions. Unpublished results, personal communications as well as URL addresses are not recommended in the references list.

Making personal quotations (one, at most) should not be allowed, unless the paper proposed to be published is a sequel of the cited paper. Articles in preparation or articles submitted for publication, unpublished, personal communications etc. should not be included in the references list.

Citations style

***Text**:* All citations in the text may be made directly (or parenthetically) and should refer to:

- ***single author***: the author's name (without initials, unless there is ambiguity) and the year of publication:
  "as previously demonstrated *(Brown, 2010)*".
- ***two authors***: both authors' names and the year of publication: *(Adam and Brown, 2008; Smith and Hansel, 2006; Stern and Lars, 2009)*
- ***three or more authors***: first author's name followed by "et al." and the year of publication: "As has recently been shown *(Werner et al., 2005; Kramer et al., 2000)* have recently shown ...."

Citations of groups of references should be listed first alphabetically, then chronologically.

Units, Abbreviations, Acronyms

- Units should be metric, generally SI, and expressed in standard abbreviated form.
- Acronyms may be acceptable, but must be defined at first usage.

2. SHORT COMMUNICATIONS

Short Communications are limited to a maximum of two figures and one table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 100 words; (2) instead of a separate Materials and Methods section, experimental procedures may be incorporated into Figure Legends and Table footnotes; (3) Results and Conclusions should be combined into a single section.

3. REVIEWS

Summaries, reviews and perspectives covering topics of current interest in the field, are encouraged and accepted for publication. Reviews should be concise (max. 8 pages). All the other conditions are similar with regular articles.

Edited by: INMA Bucharest
6 Ion Ionescu de la Brad Blvd., sect. 1, Bucharest
Tel: +4021.269.32.60; Fax: +4021.269.32.73
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