

INTERNATIONAL SCIENTIFIC JOURNAL

MECHANIZATION IN AGRICULTURE & CONSERVING OF THE RESOURCES



Issue 3
2017

Year LXIII, ISSN print 0861-9638, ISSN web 2534-8450

SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING INDUSTRY-4.0
BULGARIAN ASSOCIATION OF MECHANIZATION IN AGRICULTURE

The FEDERATION OF THE SCIENTIFIC ENGINEERING UNIONS (FSEU)

in Bulgaria is a professional, scientific - educational, non-governmental, non-political non-profit association of legal entities - professional organizations registered under the Law on non-profit legal entities, whose members are engineers, economists and other specialists in the field of science, technology, economy and agriculture.

FSEU performed bilateral cooperation with similar organizations from many countries.

FSEU brings together 19 national associations - Scientific and Technical Unions / STU /, 34 territorial associations, which have more than 15 000 professionals across the country.

FSEU is a co-founder and member of the World Federation of Engineering Organizations (WFEO).

FSEU a member of the European Federation of National Engineering Associations (FEANI), and a member of the Standing Conference of engineering organizations from Southeast Europe / CO.PICEE /, Global Compact, European Young Engineers (EYE). The Federation has the exclusive right to give nominations for the European Engineer (EUR ING) title.

Contacts:

108 Rakovsky Str., Sofia 1000, Bulgaria

web: www.fnts.bg

e-mail: info@fnts.bg



PUBLISHERS

SCIENTIFIC-TECHNICAL UNION OF MECHANICAL ENGINEERING "INDUSTRY-4.0"
BUGLARINA ASSOCIATION OF AGRICULTURAL MACHINERY

ISSN (PRINT) 0861-9638, ISSN (WEB) 2534-8450

YEAR LXIII ISSUE 3 / 2017

DITORIAL BOARD

Chief Editor: Prof. Dr. eng Miho Mihov

Responsible secretary: Corresp. Memb. Prof. D.Sc. Hristo Beloev

MEMBERS:

Acad. D.Sc. Jemal Katsitadze – Georgia
Acad. D.Sc. Sayakhat Nukeshev - Kazakhstan
Acad. D.Sc. Volodymyr Bulgakov – Ukraine
Acad. D.Sc. Valeriy Adamchuk – Ukraine
Prof. Abdullah Sessiz - Turkey
Prof. Abdulrahman Al-soqeer - Saudi Arabia
Prof. Alexander Tokarev - Russia
Prof. Alexey Vassilev - Russia
Assoc.Prof. Angel Trifonov - Bulgaria
Prof. Anupam Kumar Nema - India
Prof. Ayrat Valiev - Russia
Prof. Barbro Ulén - Sweden
Prof. Carmen Puia - Romania
Prof. Cheslav Vashkievich - Poland
Prof. Cumhur Aydinalp - Turkey
Prof. Daisuke Higaki - Japan
Prof. Davor Romic - Croatia
Prof. Domenico Pessina - Italy
Dr. Finn Plauborg - Denmark
Assoc.Prof. Ganka Baeva - Bulgaria
Assoc.Prof. Georgi Mitev - Bulgaria
Prof. Georgi Tashev - Bulgaria
Prof. Haiyan Huang - China

MEMBERS:

Prof. Hoang Thai Dai - Vietnam
Prof. Iliya Malinov - Bulgaria
Assoc.Prof. Ivan Ivanov - Bulgaria
Prof. Jan Szczepaniak - Poland
Prof. Komil Muminov - Uzbekistan
Prof. Krassimira Georgieva - Bulgaria
Prof. Maja Manojlović - Serbia
Prof. Mihail Iliev - Bulgaria
Prof. Mohammad Salem Al-Hwaiti - Jordan
Prof. Papamichail Dimitris - Greece
Prof. Pavel Tlustos - Czech Republic
Prof. Plamen Kangalov - Bulgaria
Prof. Ralph Meissner - Germany
Prof. Rossen Ivanov - Bulgaria
Prof. Svetla Rousseva - Bulgaria
Prof. Tadeusz Pawłowski - Poland
Prof. Tamara Persikova - Belarus
Prof. Valentina Kundius - Russia
Prof. Wojciech Tanaś - Poland
Prof. Yerbol Sarkynov - Kazakhstan
Prof. Zdenko Tkach - Slovakia
Prof. Zinta Gaile - Latvia
Prof. Zivko Davchev - Macedonia

The journal "Mechanization in agriculture" is continuer of the journals "Mechanized farming" (1948-1957), "Mechanization and electrification of agriculture" (1959-1980) and "Mechanization of agriculture" (1981-1991)

108, Rakovski Str., 1000 Sofia, Bulgaria
tel. (+359 2) 987 72 90, tel./fax (+359 2) 986 22 40,
office@stumejournals.com
WWW.STUMEJOURNALS.COM

CONTENTS

MECHANIZATION IN AGRICULTURE

OPTIMIZATION OF TRIBOLOGICAL PARAMETERS IN THE DESIGN OF ROTARY TILLER BLADES Ass. Prof. Dr. Eng. Caslli Sh., MSc. Eng. Hasanaj A., Eng. Dimo Dh.	87
THEORETICAL STUDY TO DETERMINE THE STANDARD SIZE RANGE OF AGRICULTURAL TRACTORS Prof. Eng. Bulgakov V., PhD., Prof. Eng. Kyurchev V., PhD., Prof. Eng. Nadykto V., PhD., Corresp. Member Prof. Eng. Beloev H., DHC, Prof. Eng. Kangalov P., PhD, Assos. prof. Eng. Mitev G., PhD	92
EXPERIMENTAL STUDY OF TWIN ROWS DRILLING MACHINE Kr. Bratoev, G.V. Mitev	95
THEORETICAL STUDY OF THE MOTOBLOCK STABILIZING ON A SLOPE WORKS Prof. Doc. Eng. Bulgakov V., PhD., Prof. Doc. Eng. Adamchuk V, PhD., Doc. Eng. Ruzhylo Z., PhD., Doc. Eng. Usenko M. PhD., Prof. Doc. Eng. Beloev H. PhD., Prof. DrSc. Eng. Borisov B. PhD., Doc. Eng. Mitev G. PhD.	98
OPTIONS FOR USING HYDRODYNAMIC CAVITATOR TO SPEED UP SEED GERMINATION Ivanov Yevgeny G., Candidate of Technical Science, Associate Professor	101
METHODS OF CONTROL AND MANAGEMENT OF AGRICULTURAL PROCESSES Prof. Dr. Kr. Georgieva, Prof. PhD. M. Mihov , Assoc. Prof. Kr. Krastev, PhD	106
CURRENT PROBLEMS OF AGRICULTURAL PRODUCTION MECHANIZATION Prof. PhD. M. Mihov, Prof. Kr. Georgieva, Assoc. Prof. N. Ivanova	111

CONSERVING OF THE RESOURCES

STUDYING CORRESPONDENCE OF RAGWEED POLLEN'S AIRBORNE CONCENTRATION AND THE NEW GREENING MEASURES UNDER THE COMMON AGRICULTURE POLICY M.Sc. Surek Gy., M.Sc. Mányoki G., M.Sc. Csonka B., M.Sc. Kajtor-Apatini D., M.Sc. Udvardy O., M.Sc. Nádor G., Prof. M.Sc. Kazinczi G. PhD., M.Sc. Vojnich V.J. PhD., M.Sc. Magyar D. PhD.	115
ON THE ISSUE OF REDUCING THE HARMFUL INFLUENCE OF THE MOBILE AGRICULTURAL SYSTEMS UNITS ON THE SOIL Prof. Doc. Eng. Adamchuk V. PhD., Doc. Eng. Pogoriliy S. PhD., Prof. Doc. Eng. Beloev H. PhD., Prof. Eng. Kangalov P., PhD, Prof. DrSc. Eng. Borisov B. PhD., Assos. prof. Eng. Mitev G. PhD.	119
MACHINES AND IMPLEMENTS FOR NON-CHEMICAL WEED CONTROL IN ORGANIC VEGETABLE GROWING Assoc. Prof. Eng. Angel Trifonov, PhD	122

OPTIMIZATION OF TRIBOLOGICAL PARAMETERS IN THE DESIGN OF ROTARY TILLER BLADES

Ass. Prof. Dr. Eng. Caslli Sh.¹, MSc. Eng. Hasanaj A.¹, Eng. Dimo Dh.²
Polytechnic University of Tirana, Albania¹, Agricultural Machinery Station of Fier, Albania²
E-mail: shcaslli@fim.edu.al, anxhela.hasanaj@hotmail.com, dhimitraqdimoo@yahoo.it

Abstract

The argument of this paper is rotary the tiller blade, which undergoes severe surface wear during tillage of agricultural land. The study was conducted by comparing on H-shaped blades, of two different manufacturers, used in rotary tillers, mainly in the fields of Myzeqe, Lushnje. Our tests included the measurement of the abrasive wearing as weight loss of material of each blade to the end of lifecycle - recorded after every 10 hectares cultivated surface in field conditions. We experimented in laboratory the blade wearing through 'pin on disk' test. Another tribological parameter measured in the laboratory was the hardness in Vickers on cutting edge of the blade, before and after wearing. To make the targeted optimization, we initially computed a stressed situation on the blade cutting edge, and then processed through the SOLIDWORKS software, which generates a map of more stressed areas that lead to significant wear. By simulating with geometric parameters of tiller blades, we have sought the situation of stresses with less impact on wearing of tiller blades. This paper is also includes relevant recommendations.

KEY WORDS: TILLER BLADE, TRIBO-PAIR, SURFACE WEAR, WEIGHT LOSS, PIN ON DISC.

1. Introduction and study purpose

In this paper, we focus on efficiency of agricultural machinery used for breaking the soil and preparing the seedbed for the planting of agricultural crops. The main phenomenon that significantly affects the decline of this effectiveness is the wearing of the working parts of these machines. Our study has taken in account the tribological phenomena that occur between the rotary tiller blades and agricultural land [1]. The tiller blades undergo severe surface wear, which means increased costs for agricultural land preparation and therefore food costs [2].

The study conducted by comparing on H-shaped blades, made from two low alloy steel brands of two different manufacturers, used in rotary tillers, MASCHIO H205, mainly in the fields of Myzeqe, Lushnje [3]. We started from a detailed study of the wear as a tribological phenomenon, with the aim of reducing the power requirement by improving the geometry of tiller blade. Thus, the proper design of the rotary tiller blades is essential for efficient operations; by optimizing their geometry, the power required will

reduce [4]. At the end of this article are also made recommendations for the selection of appropriate materials for tiller blades.

For coming up here, first analyzed the phenomenon that occurs and then we defined tribological parameters, such as the hardness of the blades, loads on cutting edge of blades, speed and distance prescribed by each tiller blade (distance per working hours) throughout its life cycle, the type and content of the agricultural soil and geometrical parameters of the blade.

2. Tillage and tribological phenomenon on Rotary Tiller blades

Tillage is a process performed to obtain a desirable soil structure for a seedbed. This is a granular structure that allows rapid infiltration and good retention of rainfall, will provide adequate air capacity and exchange within the soil and minimizing resistance to root penetration. Rotary tiller is a tillage machine designed for preparing the land by breaking the soil with the help of rotating blades [2].



Fig. 1. MASCHIO H205 rotavator with 10 flanges and 60 blades; 1 - rotor, 2 – right blade, 3 – left blade, 4 – flange (on the left); The tiller blade 1 and 2 in study, from two different manufacturers made from two different steels brands, 'C' shaped & 'H' type [3].

Our rotary tiller, MASCHIO H205 [3], is a specialized mechanical tool used to plough the land by series of blades ('C' shape, 'H' type) which are used to swirl up the earth (fig. 1). This rotavator is available in the size 2.00 m working width, which is suitable for tractors having their power 30 to 60 hp. The work quality by using rotavator not only depends on the machine performance but also on soil conditions, blade geometry and velocity ratio. It often happens to interfere on the backside of the blade and the uncut soil, which may result in severe soil compaction and high power consumption. This is the main reason to cause vibrations, which are a result of the soil upon the tiller blades. The proper design of the rotary tiller blades is essential for efficient operations [5].

Both blades and tillage constitute a tribologic pair. These blades interacting with soil subjected to impact of soil crust / clods / stone and high friction, which develop high stress areas on blade tip or blade critical edges. Tribological phenomenon that is present

throughout tillage and the life span of tiller blade is predicted by wear. Blades are under pulsating loads and subjected to high abrasive wear and fatigue. As this wear, the total cost of agricultural production inflates [6].

Our rotary tiller has 10 flanges with six blades for each flange. Each blade cuts a segment of soil as it removes downward and towards the rear. Because of the high peak torques developed during each cut, it is important to stagger the blades in the different courses, with equal angular displacement between them, so no two blades strike the soil at the same time (Fig.2).

We think that an appropriate geometric shape of the tiller blade will provide easy soil cutting by reducing the maximal loads (their high stress), consequently reducing blade wear. Let us have a look at the experiments and measurements that we have done for determining the blade wear on the field and laboratory, as well as some of the other tribological parameters associated with this phenomenon.

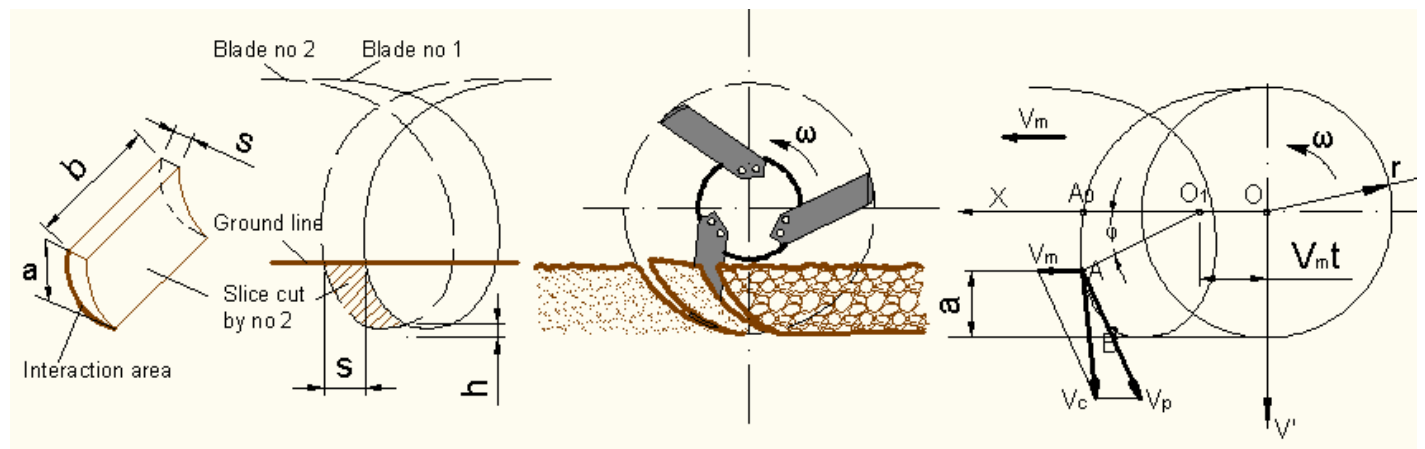


Fig. 2. Parameters of the rotary tiller blade movement and forming of the slice cut [11]

3. Testing on ground and Laboratory

3.1. Field test procedure

Based on the available data and feedback from users, it has been found that the blade is worn out after certain hours (100 – 300 hours) field usages depending on the soil conditions. Two are the factors that we have considered: the tillage or digging strikes of blade in soil and the linear distance described by tiller blade throughout their live span. Digging and strikes of tiller blades on soil will cause excessive loads and high stresses that are related with fatigue wear. The second factor related with high friction due to stones, gravel and sand in soil during the tillage and consequently the abrasive wear is also present. The blades undergoing severe surface wear of the tip and cutting edges.

Number of strikes by cutting edge of tiller blade is 8000 strikes / ha [1]. Our field test was measured after tillage of 45 ha; so, there are 360000 strikes of a tiller blade.

The linear distance described from a point of cutting edge of tiller blade when interacts with soil (fig. 2, bold contour), for a slice cut is 20 cm, for 15 cm tillage depth (diameter of rotor is 20 cm and diameter of tip of blade is 50 cm), will be 1600 m/ha and 72000 m per 45 ha.

Let us calculate the wear rate, w , for each of tiller blades, 1 and 2 [7], when their loss weight is respectively 95 gr and 158 gr:

$$w = \frac{\text{Volume of material removed from contact surface (m}^3\text{)}}{\text{Distance slid (m)}} = \frac{V}{L} \text{ (m}^2\text{)} \quad (1)$$

$V_{\text{Blade 1}} = m/\rho = 1.2 \times 10^{-5} \text{ m}^3$ and $V_{\text{Blade 2}} = 2 \times 10^{-5} \text{ m}^3$, where specific weight, $\rho = 7900 \text{ kg/m}^3$.



Fig. 3. Wear tiller blades 1 and 2, after tillage of 45 hectares (on the left) and blade 2 (on the right) as new product that weight 720gr, under it the same blade with full wear at the end of its lifecycle.

Our tests included the measurement of the wearing as weight loss of material of each blades recorded after every 10 hectares cultivate

surface in field conditions after tillage of 45 hectares.

Table 1. Wearing of blades that is defined with loss weight

Hectares / Blades product	10	10	10	10	5
Blade 1 (gr)	21	22.3	20.2	19.5	12
Blade 2 (gr)	40,6	36,5	35,7	33,1	12.1

It is observed a severe wear at the beginning of the life cycle of new blades. The wearing of blade 1 is far less than 2 ones.

3.2. Wear Testing with Pin-on-disk apparatus (G-99)

This test method describes a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus [8]. Materials were tested in pairs imitating real conditions of tiller blade work mainly in clay soil or heavy loam. Pin is a prismatic specimen with a flat surface on the tip such that it will support the load over its entire cross-section, is positioned perpendicular to the other, usually a flat circular disk. The specimen of pin is taken from tiller blade and disc is an abrasive stone with corundum particles. The pin specimen is pressed against the disk at a specified load usually realized by means of an arm or lever and attached weights [9].

The pin was held against the counter face of a rotating disc with wear track diameter of 60 mm. The pin was loaded against the disc through a dead weight loading system. The wear test for all specimens was conducted under the normal loads of 20N, 40N and a sliding velocity of 2 and 4 m/s.

Wear tests were carried out for a total sliding distance of approximately 3000 m under similar conditions as discussed above. The pin specimens were 43 mm in length and 72 mm² and 78 mm² in the across section, respectively made from blades 1 and 2 materials.

The wear rate was calculated from the weight loss technique and expressed in terms of wear volume loss per unit sliding distance. The specific wear rates of the materials were obtained by [10]:

$$W = \frac{\Delta w}{L \rho F} \quad (2)$$

Where W denotes specific wear rates in mm³/N, Δw is the weight loss measured in grams, L is the sliding distance in meters, ρ , density of the worn material in g/mm³ and F is the applied load in N.

Table 2. Weight loss of the steel specimens in grams

		Weight loss of steel sample of pin					
N o	Specimen name	Sliding speed, 2 m/s			Sliding speed, 4m/s		
		Initial weight (gr)	Final weight (gr)	Weight loss (gr)	Initial weight (gr)	Final weight (gr)	Weight loss (gr)
1	Blade 1	35.046	34.242	0.804	34.242	32.425	1.817
2	Blade 2	36.173	34.041	2.132	34.041	30.004	4.037

Results of laboratory tests attest measurements of wear of tiller blades during tillage in field.

3.3. Chemical composition and microstructure observation

It is clear that the severe surface wear is present on rotary tiller blades. We have already defined the types of wear and its wear mechanisms. The occurrence of different types of wear mechanisms may depend upon the chemistry, microstructure and hardness of material. To access which wear mechanism dominates between our two steel grades, let us do the analysis of chemical composition,

microscopy and hardness test.

The chemical composition of rotary tiller blades made from low alloy steel given in Table 3, offers a good combination of mechanical properties, which are required to exhibit excellent resistance to fatigue loading and severe wear from high friction, as necessitated by tiller blades during field operation [6].

Table 3. Chemical composition (wt. %) of our tiller blades

	C%	Si%	Mn%	P%	S%	Cr%	Ni%	Mo%
1: 72MnCrB5-2	0.221	0.252	1.4	0.023	0.0076	0.385	0.173	0.068
2: 33MnCrB5-2	0.302	0.222	1.39	0.024	0.012	0.424	0.202	0.078
	Al%	Cu%	Co%	Ti%	B%	V%	W%	Pb%
1: 72MnCrB5-2	0.016	0.265	0.015	0.042	0.0017	0.0075	<0.007	.0012
2: 33MnCrB5-2	0.017	0.227	0.01	46	0.0018	0.0063	<0.007	<.001

Now we know that the properties of engineering components depend on the structure of material. Microstructures views show clear crystallographic compounds.

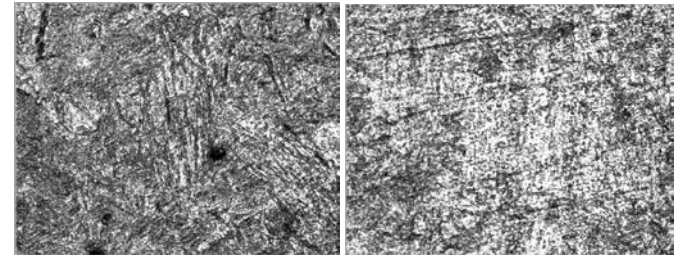


Fig. 4. Microstructural views of new tiller blades 1 (on the left) and 2 (on the right); Samples are taken in cutting edges areas of each blade and corroded with 4% nital, 500 x. Tiller blade 1 has needle and bainitic structure while the blade 2 has fine granulated structure with chrome carburets.

These materials have high resistance against abrasion and are used for tools that work in high friction. Such is our case study of tiller blades.

3.4. Hardness Testing

Hardness is the most important tribological parameter. In a tribosystem is the soft material that undergoes a severe wear. In our tribo-pair, tiller blade made from low alloy steel and soil, can be thought that blades are many time stronger than soft soil. Nevertheless, it is not so, because there are too many stones, gravel and sand into the soil, which are harder than the steel of blades. Therefore, the blades that undergo a severe wear that often end with breaking, fracture or failure. Here there are shown the results of Vickers Micro-Hardness test, for new (unwearing) and wearing tiller blades. The test load is 10 N or 1 kg.

Table 4. Results in Vickers (HV) measured before and after wearing

Distance from cutting edge	0.5 mm	1.5-2 mm	7-8 mm	15 mm
Blade 1: Before	368.5	493.6	565	547
After	540	534	533	539
Blade 2: Before	533.6	593.3	564.6	530.6
After	567	600	577	575

These results show a reinforcement of surface in cutting edge blade due to its plastic deformation in the cold, during tillage operation when the blade shocked with the solid material in the soil. Reinforcement is quite obvious on the blade 1, while highest values of hardness encountered on blade 2 (600HV).

4. Design of rotary tiller blades

The design of rotary tiller blades depends on type and number of blades and the working conditions of rotary tiller. In this design, the 'H' type blades are considered for the rotary tiller according to the working conditions presented. The total power of machine, N_C , is distributed between the blades: $N_C=40hp$. Our rotary tiller was designed with the working width of 200 cm and having $i=10$ flanges on the rotor shaft with six blades on each flange. The agricultural land in Myzeqe, Lushnje is between clay soil and heavy loam, non-rocky soil.

4.1. Calculation of forces on the blade

Two major forces are known to act on rotating blade used for tilling or digging operations. Tangential force, P_o , acts at the tip of the blade as shown in Fig. 5, through tangent of blade cutting edge [11]. Soil force, R_T , acts perpendicular to cutting edge of the blade. Soil force for analysis is considered as uniformly distributed load acting along the cutting edge.

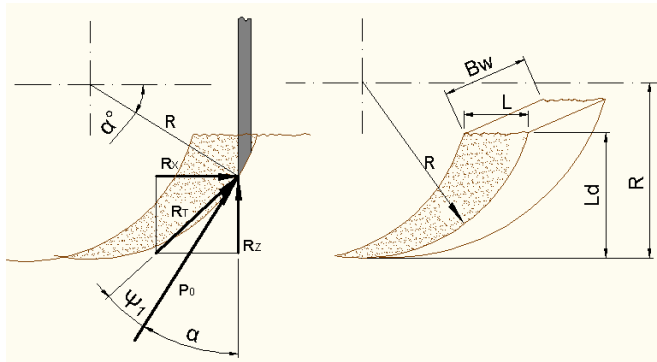


Fig. 5. Major forces acting on a rotavator blade and dimensions of sliced soil [11]

The maximum tangential force that occurs at the minimum of blades tangential speed is calculated by following relation (Bernacki et al.):

$$P_o = C_s \frac{75N_c \eta_c \eta_z}{U_{min}} \quad (3)$$

Where C_s , is the reliability factor; $C_s=1.5$, for non-rocky soils; $N_C=40hp$; η_c is traction efficiency; $\eta_c=0.9$, because the directions of tractor forward speed and the rotational speed of rotor shaft are the same. η_z is coefficient of reservation of power taken 0.7-0.8, $\eta_z=0.75$; u_{min} is minimum peripheral velocity: $u_{min}=v\lambda$, $\lambda=u/v$; u , tangential speed of blades (m/s). v , forward speed (m/s). Forward speed is dependent to the tangential speed of blades (that is function of rotational speed of rotor, n) and the length of sliced soil, L .

In our calculations [1, 11, 12], $v=0.6$ m/s, $\lambda=2.13$, $L=36.85$ cm, $R=25$ cm, conventional rotor radius, $Z=3$, number of blades on each side of the rotor flanges; $\lambda_{min}=1.42$ and $u_{min}=0.85$ m/s.

$$P_o = C_s \frac{75N_c \eta_c \eta_z}{U_{min}} = 1.5 \frac{75 \times 40 \times 0.9 \times 0.75}{0.85} = 2382kg$$

The soil force acting on the sharpened edge of each blade, R_T , is calculated:

$$R_T = \frac{P_o \times C_p}{iZ_e n_e} = \frac{2382 \times 1.5}{10 \times 6 \times 6 / 60} = 595.5 kg \quad (4)$$

Number, n_e is obtained through division of the number of blades which action jointly on the soil into the total number of blades; $C_p=1.5$, coefficient of tangential force;

The main forces on blade are the maximum tangential force,

$P_o = 2382kg = 23360N$ and the soil force, $R_T = 595.5kg = 5840N$.

4.2. Optimal design of blades by simulating with SolidWorks

Proper design of tiller blades is necessary in order to increase their working lifetime and reduce the farming costs. High rate of wear is the phenomenon, which will reduce the service life. Seeing under this prism, the blade geometry shape is directly related to the phenomenon but also to the quality of tillage. Often the farmers complain for bad quality of land preparation. That is true. Therefore, we think that an appropriate geometric shape of the tiller blade will provide easy soil cutting by reducing the maximal loads (their high stress), consequently reducing blade wear. Initially we simulated the maximum tangential force, P_o and soil force, R_T on the blade (fig.7). This figure shows comparison of results with FEM: stresses and deformations/displacements caused from complex loading [13].

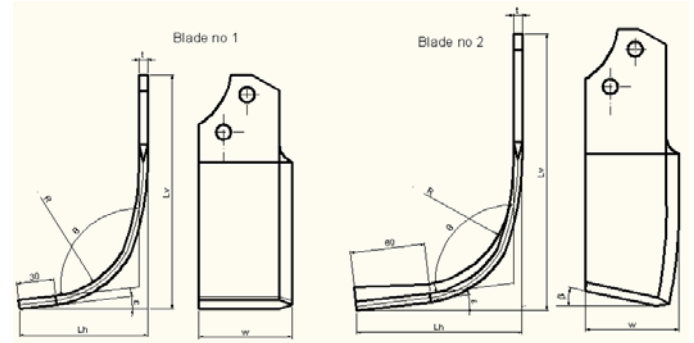


Fig. 6. Blade schematic with designed parameters (values in Tab.5)

Table 5. Parameters of different blades designed for the study

Parameters	Notations	Values	
		Blade 1	Blade 2
w	Blade span, mm	75	75
L_v	Effective vertical length, mm	188	222
L_h	Blade cutting width, mm	103	133
R	Curvature between $L_v - L_h$, mm	85	80
θ	Blade angle, degree	96°	97°
β	Clearance angle, degree	3°	12°
t	Blade thickness, mm	7	7
ϵ	Bending angle, degree	6°	7°

To do an optimizing of the blade design have to consider that blade parameters are functions of operating parameters, soil parameters and tool parameters. Two are geometric parameters, thickness t and curvature R that optimized tiller blades on plane 6, where software found the situation of stresses with less impact on wearing of tiller blades.

Table 5. Tribological parameters after optimizing of t and R .

Tribological parameters	Blades	Original	Optimal	Plane 6
Blade thickness (mm)	1	7	5.6	8.5
	2	7	6.2	8
Curvature R, (mm)	1	85	75	85
	2	80	70	90
Von Misses stresses (N/m ²)	1	11.13e+009	12.33e+009	10.81e+009
	2	6.887e+009	7.204e+009	6.573e+009
Displacements (mm)	1	27.67	32.45	18.08
	2	21.7171	24.55	19.5

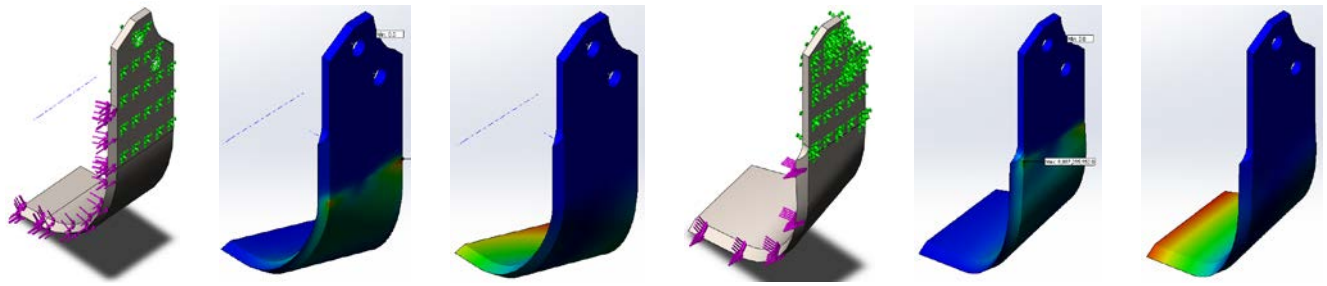


Fig. 7. Comparison of result between blade 1 (on the left) and 2 (on the right): loading, stresses and displacements

5. Results and Recommendations

- The results of testing on ground and laboratory show that tillage is a process that is realized with the help of rotary blades, which undergo a very large wear of its cutting edge. There are two forms of wear in tiller blades, abrasive and fatigue; dominate abrasive wear. This wear reaches approximately 1/4 of the initial weight up to the end of life. The results of wearing was determined by means of method of material weight loss.
- Chemical analysis determined the grades of steel: 72MnCrB5-2 and 33MnCrB5-2. While the microstructure observation shows respectively its needle and bejnitic structure for blade 1 and fine granulated structure with chrome carbures for blade 2. These materials have high resistance against abrasion and are used for tools that work in high friction. Presence of boron, B gives a significant increase in tempering/hardening of low alloy steels, providing a better behavior against wear. Relatively low carbon content (less than 0.35%) of these steels after quenching causes them not to reach too high hardness (less brittleness), but provides a combination of moderately high reinforcement with good tenacity and high resistance to abrasive wear.
- Results of hardness testing show that this property increases after a working period. It is a reinforcement of surface in cutting edge blade due to its plastic deformation in the cold, during tillage operation when the blade is shocked with the solid material in the soil. The reinforcement is obvious on the blade 1 and 2, while highest values of hardness are encountered on blade 2 (600HV). Experience confirms that blades with very strong surface are brittleness and come out of use very quickly or accidentally, as is the case of the blade 2.
- Our recommendation in this case related to the preparation of tiller blades is that they should be strong on the surface but plastic inside so they will face better the shocking with solid materials into the soil without failure.
- Our calculation of forces in blades show a complex stresses situations caused from tangential force acting at the tip of the blade ($P_o=2382kg$) and soil force acting perpendicular to the cutting edge of blade ($R_T=595.5kg$). Results generated from SolidWorks show a less stresses situation and deformations on blade 2 than on blade 1.

Conclusions

CAD method is an effective tool for the development of blade as this the main critical parts of a rotavator. It always exist the tribologic phenomenon, which often happens in these parts that encourages us to look for ways to reduce its impact on the tiller blade. CAD

combined with finite elements method in SolidWorks are useful tools for analyzing stresses and deformations in design of complex geometries. Less wear of blades means less power of tractor and higher effectivity of preparation this agricultural land. The power required can be lowered by optimizing the blade and minimizing stresses. Above analysis reveals, that blade 1 undergoes high surface stresses, which reinforce their surface and make it more resistant against wear. Field study & hardness test confirmed these results.

6. References

- [1] A. Hasanaj, "The Study of experimental and laboratory results on wearing of rotary tiller blades" - Scientific work – Diploma on Material Engineering Master Level, Mechanical Engineering Faculty, PUT, 2016, pp. 5-78;
- [2] S. K. Mandal, B. Bhattacharya, S. Mukherjee, "Optimization of Design Parameters for Rotary tiller's Blade", Proceedings of the 1st International and 16th National Conference on Machines and Mechanisms", Roorkee, India, 2013, pp. 533-539;
- [3] MASCHIO H205 – 'Maschio Gaspardo' S. p. A., Manual
- [4] M. Gavali, S. Kurkarni, "Development of Rotary weeder blades by Finite Element Method", International Journal of Scientific Research Engineering & Technology, Vol. 3, Issue 6, 2014, pp. 941-945;
- [5] J. S. Mahal, G. S. Manes, A. Prakash, M. Singh, A. Dixit, "Study in Blade Characteristic of Commercially Available Rotavators in Punjab", Agricultural Engineering Today, Vol. 36 (3), 2012, pp. 8-11;
- [6] A. S. Kang, G. S. Cheema, Sh. Singla, "Wear behavior of hardfacing on rotary tiller blades", The 12th Global Congress on Manufacturing and Management, GCMM 2014, Procedia Engineering 97 (2014), pp. 1442-1451;
- [7] Michael Ashby, Hugh Shercliff and David Cebon, "Materials Engineering Science Processing and Design", Chapter 11, Butterworth Heinemann, GB 2007, pp. 227-243;
- [8] Standard Test method, G-99, Wear Testing with Pin-on-disc apparatus;
- [9] Gwidon W. Stachowiak, Andrew W. Batchelor: "Engineering Tribology", Elsevier Butterworth Heinemann, ISBN 0 444 89235 4, Australia 2002, pp. 574-580;
- [10] 'Wear Testing Measurement' Chapter 6, pp. 84-93;
- [11] Y. Shurdha, "Agricultural Mechanic" – Textbook, 1996, pp.235-268;
- [12] S. K. Mandal, B. Bhattacharya, S. Mukherjee, "Design of Rotary Tiller's Blade Using Specific Work Method (SWM)" Journal of Applied Mechanical Engineering, Vol. 4, Issue 3, 2015, pp. 01-06;
- [13] SolidWorks 2012, software;

THEORETICAL STUDY TO DETERMINE THE STANDARD SIZE RANGE OF AGRICULTURAL TRACTORS

Prof. Eng. Bulgakov V.¹ PhD., Prof. Eng. Kyurchev V.² PhD., Prof. Eng. Nadykto V.² PhD.,
Corresp. Member Prof. Eng. Beloev H.³, DHC, Prof. Eng. Kangalov P.³, PhD, Assos. prof. Eng. Mitev G.³, PhD

¹National University of Life and Environmental Sciences of Ukraine, 15, Heroyiv Oborony Str., Kyiv, 03041, Ukraine;

²Tavria State Agrotechnological University, 18, Khmelnytskoho pr., Melitopol, 72312, Zaporozhye region, Ukraine;

³"Angel Kanchev" University of Rousse, 8, Studentska Str., 7017 Ruse, Bulgaria

Abstract: Since the tractor is the main energy source in agriculture, the state with highly developed agrarian production, tractor and agricultural machine building should have a fairly clear and consistent policy in the field of organizing the production and supply to agricultural producers of a wide range of tractors for various purposes. Such a policy is based on the type of mobile energy resources, i.e. tractors, based on a deep analysis and study of the volume of agricultural production, the needs for mechanized technologies, the theory of the operation of agricultural machines, the overall assessment of the development of high-tech agriculture. The purpose of this study is to develop theoretical bases for calculating the type of agricultural tractors based on an optimization of technical and economic analysis, taking into account the need for a qualitative and timely implementation of the entire closed set of works in agricultural production. During the research methods of machine use in agriculture, higher mathematics, economics, compilation of programs and numerical calculations on PC were used. The results of the study showed that the classification of tractors should be carried out not according to traction power (as is done in most countries of the world), but by the nominal traction force developed by them. It has been established that this gives a more accurate representation of the operational properties of an energy tool, which in turn allows for the very accurate and correct selection of complexes of appropriate agricultural machinery and implements for its effective operation. The presented theoretical approaches allow to determine with a high degree of accuracy the type of agricultural tractors for any country.

KEY WORDS: AGRICULTURAL PRODUCTION, TRACTOR, TYPE, TRACTIVE POWER, OPERATION, TRACTIVE EFFORT.

1. Introduction

The main energy source in the agricultural production of any country was and in the near future will remain a tractor. Therefore, Ukraine, where agriculture is regarded as the locomotive of the entire economy, must necessarily have a clear tractor policy, the organizational basis of which should be a type of mobile energy.

2. Results and discussion

The type of tractors is usually called the aggregate of all their models (including modifications), compiled on the basis of optimization of technical and economic calculations, taking into account the need for high-quality and timely performance of a set of works in the national economy of the country.

A promising fleet of tractors, based on their standard size range, is the main reference material in selecting design parameters and creating a new model of the power facility. All prospects for the use of agricultural tractors as a mobile energy source, the appearance of energy resources of non-traditional layout schemes, etc., require constant specification of their type

In the past, we adopted the type of agricultural tractors according to their destination and the traction class. According to the first classification – it's tractors of general purpose, universal-tilled, specialized and small-sized.

Tractors of general use are used for soil cultivation, fertilization, sowing and harvesting of agricultural crops. Cultures and the like.

Universal-tilled tractors are mainly intended for cultivating tilled crops. Can be used on transport and other robots.

Specialized tractors are designed to perform work on growing and harvesting individual crops: beets, grapes, rice, vegetables, etc. In practice, these tractors, as a rule, are modifications of the basic models of general and universal-tilled power equipment.

Small tractors can be used on all types of agricultural work.

Accordingly, the former GOST 27021-86 or ST SEV 628-85 standard agricultural tractor series included 10 traction classes. As can be seen from Table 1, it was an increasing sequence of dimensionless numbers (0.2...8.0), each of which expressed the value of the nominal tractor pulling force (P_{db}) in the tones, since the formation of the type originated as early as the old system of measuring physical values.

Table 1 – Ratio between traction classes and categories of tractors

№	Traction class	Nominal pulling force (P_{db} , kN)	Basic model		Power category and traction power ($N_{db,max}$, kWt) (ISO 730/1 and 730/3-82)
			Model	Engine power (N_e , kWt)	
			GOST 27021-86 (ST SEV 628-85)		
1	0.2	1.8...5.4			I – 25
2	0.6	5.4...8.1	T-25	18.4	
3	0.9	8.1...12.6	T-40	36.8	II – 30...70
4	1.4	12.6...18	MTZ-80	55.3	
5	2	18...27	T-70S	51.5	
6	3	27...36	T-150K	121.5	III – 70...135
7	4	36...45	T-4	80.9	
8	5	45...54	K-700	161.8	IV – 135...300
9	6	54...72	T-130	116.2	
10	8	72...108	K-710	220.5	

According to the plan, the values of P_{db} (in kN) should represent such a geometric progression, the denominator of which (q) would be determined from the following relationship [9]:

$$q = n - 1 \sqrt[n]{\frac{P_{db,max}}{P_{db,min}}}, \quad (1)$$

where: $P_{db,max}$, $P_{db,min}$ – the upper and lower limit of the entire operating range of traction forces of tractors; n is the number of terms in the series (traction classes).

It is assumed that with a rationally designed standard size range, the intervals between the traction ranges of adjacent tractor classes should be absent, the ranges themselves are identical, and the denominator of the progression q is equal to the ratio (r) of the maximum (P_{max}) and minimum (P_{min}) traction forces of the same Traction rang, i.e.

$$q = r = P_{max}/P_{min}. \quad (2)$$

In international practice, in accordance with ISO 730/1 and 730 / 3–82, the classification of tractors according to the maximum tractive power $N_{db,max}$ obtained when testing the power facility on a smooth horizontal and dry concrete surface, or a surface covered with beveled / uncut grass, is used. Tractors are divided into four categories, each corresponding to the classification of energy

resources in accordance with the international standard GOST 27021-86 (ST SEV 628-85, see Table 1).

The long-term practice of recent years shows that the classification according to GOST 27021-86 (ST SEV 628-85) gives a more accurate representation of the tractor's operational properties. And this, in turn, allows you to correctly pick up a complex of agricultural machines and tools. For example, at one time the Minsk and Vladimir Tractor Plants produced tractor class 2 tractors (MTZ-142 and LTZ-145, respectively) with a maximum traction power of about 95 kW. If only the ISO classification is used (Table 1), then it is possible to conclude incorrectly that MTZ-142 and LTZ-145 could work with a train of machines intended for tractors of traction classes 3 and 4.

At the same time, the tractor of traction class 6 (T-130) according to traction power belonged to group III of ISO-730/1 standard. It turns out that it could effectively be aggregated with tools to the energy facilities of significantly lower traction classes 3 and 4 (see Table 1).

One more example. In 1998, 650 tractors "John Deer-8940" were purchased for the needs of Ukraine's agriculture [10]. Based on the power of their engines (200 kW) and the ISO classification (see Table 1), it was assumed that they would be used with tools intended for class 5 tractors (K-700, K-701). In practice, this was not possible, because the traction and coupling properties of the "John Deer-8940" occupy an intermediate position between the energy facilities of traction classes 3 and 4.

Another thing is that the real type of tractors, which formally acts on the localities of the CIS countries, is now created, as the researchers have repeatedly emphasized [3, 4, 7], with significant deviations from the above requirements (2). In the direction of its improvement, first of all, it would be necessary to clarify the methods of determination:

- the operational weight of the tractor;
- nominal tractive effort and tolerance to its fluctuations;
- the width of the traction effort range of the tractor;
- the rate of slipping of the power source when determining its nominal;
- tractive effort.

Moreover, an effective standard-sized line of tractors should be created taking into account the technical and economic performance of machine-tractor units based on them [1, 2, 5]. Due to the implementation of one of the attempts of this approach, it was found that for tractors of seven traction classes, for our country's economy, taking into account their specialization, zonal features and the structure of cultivated areas, it is enough: 0.2; 0.6; 1.4; 2; 3; 5 and 6 [11]. It is interesting that a similar conclusion was reached by those scientists who considered the question of specifying the type of tractors both for the conditions of the USSR [4] and for the current conditions in Russia [8]. In the first case, the size range of power tools should have the following form: 0.4; 1.1; 1.8; 2.5; 4; 5.5; 7, and in the second – 0.4; 0.7; 1.1; 1.8; 3; 5 and 7.

In comparison with [11], these types, although new, but they, in our opinion, are not devoid of shortcomings [because of inconsistency with condition (2), for example].

As for the type proposed in [11], we can say the following about him. First, tractors of traction class 6 are designed for road construction, meliorative, plantation and excavation works. The determination of their quantity can be carried out by a separately developed method. Nevertheless, as a basic model of tractors of this traction class, it is possible to adopt the caterpillar energy facility TS-10, which is currently produced by JSC "KhTZ".

Secondly, JSC "KhTZ" Tractor Works has mastered the production of tractors of the KhTZ-160 series, which, being power tools of traction class 3, can be used quite efficiently with a set of machines and implements intended for cultivating tilled crops by tractors of traction class 2 [6].

Therefore, if we do not aim to develop an entirely new type of tractors, then for Ukraine it could include power supplies of 6 traction classes: 0.2; 0.6; 1.4; 3; 5; 6.

Producers of this product are Kharkov (KhTZ) and Dnepropetrovsk (YuMZ) tractor plants (Table 2). As a compromise

option, we can consider the production of new tractors of traction class 1.4 (KIY-14102) limited liability company LLC Ukravtozapchastina (Kiev).

Table 2 – Basic models of tractor type of Ukraine

Tractor class	Basic model	Productivity
0.2	KhTZ-1211	JSC "KhTZ"
0.6	KhTZ-3510/3522	JSC "KhTZ"
1.4	YuMZ-8040/8240 KIY-14102	YuMZ (Dnepropetrovsk) LTD "Ukravtozapchastina"
3.0	KhTZ-16131, KhTZ-17221, T-150-05-09	JSC "KhTZ"
5.0	KhTZ-181	JSC "KhTZ"
6.0	TS-10	JSC "KhTZ"

It is known that the type of domestic tractors, presented in Table 1, is not without the disadvantages mentioned above. Moreover, the energy facilities presented in it are characterized by a rigid parametric relationship between their service weight (G_T) and engine power (N_e):

$$E_T = N_e / G_T = \text{const}, \quad (3)$$

where: E_T – energy of the tractor, kW / t.

Every type of energy means needs to develop an appropriate system of aggregation, which would ensure:

- Increase of productivity of work;
- reduction of energy costs and materials;
- Reduction of harmful impact on the environment;
- high versatility and employment throughout the year;
- the necessary reliability and level of unification.

At the present stage of the development of the society, it is impossible to satisfy these requirements within the old traction concept of building energy resources. The fact is that the development of tractors in accordance with the traction concept (3) was and in many cases is now due to the need to realize engine power only through tractive effort. After all, if N_e exceeds the corresponding value of G_T , then it (N_e) will not be used for traction operations. If the engine power deviates in the opposite direction, the tractor will operate at reduced working speeds and the tractor unit based on it will not develop the expected performance.

The modern development of mobile energy resources all over the world occurs within the framework of the new traction-energy concept. The essence of this is that the power of the tractor engine and its operating weight are not related by a rigid (as before) parametric dependence. Those:

$$E_T = N_e / G_T = \text{var}. \quad (4)$$

At the same time, the value of N_e increases according to current technological requirements, the value of G_T increases only for the sake of ensuring the appropriate strength and safety of the tractor construction. As a result, the energy saturation increases and in many cases already significantly exceeds 20 kW/t. This makes it possible to effectively use such tractors as part of traction-drive units, in the implementation of no-till systems, the creation of perspective modular power devices of variable traction class (MES), and so on.

It should be noted that the work on the creation of MES went beyond research, and the results confirmed the hypothesis of technical feasibility and economic feasibility of their development and implementation in Ukraine [6]. MES can be fully considered as components of a new domestic type of tractors

Determination of the required number of tractors can be carried out taking into account the peculiarities of the natural and climatic zones of our country, the size of the acreage of agricultural crops, the specialization of farms, the new technologies used, and so on. For each of the zones, the number of tractors of a traction class (N_i) can be determined from the expression:

$$N_i = K_i \cdot S_i \cdot (1000)^{-1}, \quad (5)$$

where: K_i – specification of the need for tractors of the corresponding traction class per 1000 hectares of arable land or the area of sowing of a particular crop; S_i – total area of crops or arable land.

The complexity of the calculations is precisely in determining the specifications of the need for tractors of one or another traction class for each of the natural and climatic zones of the country. Existing nowadays similar specifications need a significant refinement, since they are designed for tractors of the old traction concept.

Centrally, such work can be performed by scientific research institutions of the National Academy of Sciences. But it can be done only when the type of tractors is finally adopted (determined) in Ukraine.

In conclusion, we should say the following. Adoption of the tractor type will allow to create in the country the corresponding System of Machines, which is now unordered. The reason for this state of things is as follows.

Abroad many firms together with tractors let out also the complex of agricultural machines and tools adapted to them. In this case, it is not very important to what tractive class energy means are, because their traction-energy indicators meet the requirements of the technological part of the AIT with which they are being aggregated.

In Ukraine, however, tractors are produced by one firm, and agricultural tools and machinery by others. If both the first and the second are not within the limits of the relevant constraints (requirements) in the design of their products, in principle, one can get a situation where a good tractor and a good agricultural machine / tool together can give an insufficiently good machine and tractor unit.

3. Conclusions

The first step in the implementation of the country's own traction program is the adoption of a mobile energy type.

Classification of tractors in Ukraine should be carried out not by traction capacity (as it is done abroad), but by nominal tractive effort. The practice of recent years shows that this gives a more precise concept of the operational properties of the energy facility and, in turn, allows the correct selection of a set of appropriate agricultural machinery and tools.

The basis of the domestic type of tractors should be represented by mobile energy resources of the traction-energy concept. The necessary material and technical basis for their development and implementation in Ukraine is 1912/5000.

4. Literature

1. Kambulov S.I. Obosnovaniye struktury MES sel'skokhozyaystvennogo naznacheniya / S.I. Kambulov // Traktory i sel'skokhozyaystvennyye mashiny. – 2008. – №3.
2. Ksenevich I.P. Ob ekonomicheskikh aspektakh obosnovaniya tipazha s.-kh. traktorov / I.P. Ksenevich // Traktory i sel'skokhozyaystvennyye mashiny. – 1985. – №5.
3. Ksenevich I.P. O sovershenstvovanii klassifikatsii sel'skokhozyaystvennykh traktorov / I.P. Ksenevich, V.I. Mininzon, A.P. Parfenov // Traktory i sel'skokhozyaystvennyye mashiny. – 1989. – №10.
4. Ratsional'nyy tiporazmernyy ryad perspektivnykh sel'skokhozyaystvennykh traktorov / I.P. Ksenevich, M.I. Lyasko, V.I. Mininzon, A.P. Parfenov // Traktory i sel'skokhozyaystvennyye mashiny. – 1990. – №11.

5. Kut'kov G.M. Perspektivnyy tipazh sel'skokhozyaystvennykh traktorov dolzhen byt' optimal'nym / G.M. Kut'kov, V.I. Mininzon // Mekhanizatsiya i elektrifikatsiya sotsialisticheskogo sel'skogo khozyaystva. – 1967. – №1.
6. Noviy mobil'ni yenergetichni zasobi Ukraïni. Teoretichni osnovi vikoristannya v zemlerobstvi: navch. posibnik / V.T. Nadykto, M.L. Krizhachkivskiy, V.M. Kyurchev, S.L. Abdula. – Melitopol': MMD. – 2006. – 337 s.
7. Pozhidaev S.P. Do udoskonalennya metodiki vidnesennya traktoriv do tyagovikh klasiv / S.P. Pozhidaev // Mizhvidomchiy tematichniy naukovo-tekhničniy zbirnik. – K., 1994. – Vip. 79.
8. Surayev N.G. Optimal'nyy tipazh sel'skokhozyaystvennykh traktorov na osnove virtual'nogo tiporazmernogo ryada / N.G. Surayev // Traktory i sel'skokhozyaystvennyye mashiny. – 2000. – №11.
9. Trepnenkov I.I. Ekspluatatsionnyye pokazateli sel'skokhozyaystvennykh traktorov / I.I. Trepnenkov. – M.: Gosudarstvennoye nauchno-tekhnicheskoye izdatel'stvo mashinostroitel'noy literatury, 1963. – 272 s.
10. Frosevich L. Kak kota v meshke kupila Ukraina shestikolesnyy traktor / L. Frosevich // Kiyevskiy Vedomosti. – 1999. – 22 yanv.
11. Yushin O. Perspektivi rozvitku traktornoï yenergetiki / O. Yushin // Mekhanizatsiya sil'skogo gospodarstva. – 1979. – №7.

Bibliography:

1. Kambulov S.I. Substantiation of the structure of agricultural MES / S.I. Kambulov // Tractors and agricultural machinery. – 2008. – №3.
2. Ksenevich I.P. On the economic aspects of the justification of the type of farming. Tractors / I.P. Ksenevich // Tractors and agricultural machinery. – 1985. – №5.
3. Ksenevich I.P. On the improvement of the classification of agricultural tractors / I.P. Ksenevich, V.I. Mininzon, A.P. Parfenov // Tractors and agricultural machinery. – 1989. – №10.
4. Rational series of a number of promising agricultural tractors / I.P. Ksenevich, M.I. Lyasko, V.I. Mininzon, A.P. Parfenov // Tractors and agricultural machinery. – 1990. – №11.
5. Kutkov G.M. Prospective type of agricultural tractors should be optimal / G.M. Kutkov, V.I. Mininzon // Mechanization and electrification of socialist agriculture. – 1967. – №1.
6. New mobile power means in Ukraine. Theoretical foundations in the field of earthquakes: Handbook / V.T. Nadykto, M.L. Krizhachivsky, V.M. Kurchev, S.L. Abdula. – Melitopol: MMD. – 2006. – 337 p.
7. Pozhidaev S.P. Up to the up-to-date methodology of the uptake of tractors to tractors of classes / S.P. Pozhidaev // Interdepartmental thematic scientific and technical collection. – K., 1994. – Vol. 79.
8. Suraev N.G. Optimum type of agricultural tractors on the basis of a virtual type-size series / N.G. Suraev // Tractors and agricultural machinery. – 2000. – №11.
9. Trepnenkov I.I. Operational indicators of agricultural tractors / I.I. Trepnenko. – M.: State Scientific and Technical Publishing House of Machine-Building Literature, 1963. – 272 p.
10. Frosiewicz L. As a cat in a sack bought Ukraine six-wheeled tractor / L. Frosevich // Kievskie Vedomosti. – 1999. – 22 Jan.
11. Yushin O. Perspective of the development of the tractor power industry / O. Yushin // Mekhanizatsiya syl'skogo gosartarstva. – 1979. – №7.

EXPERIMENTAL STUDY OF TWIN ROWS DRILLING MACHINE

Kr. Bratov, G.V. Mitev

ЕСПЕРИМЕНТАЛНО ИЗСЛЕДВАНЕ НА СЕЯЛКА ЗА ТОЧНА СЕИТБА, РАБОТЕЩА В СДВОЕНИ РЕДОВЕ

Кр. Братоев, Г.В.Митев

Abstract: The tried-and-tested seed drill is a modified version of a factory-made seed drill for punched wide-row sowing in paired rows. Failure to observe basic prerequisites, such as agro-technical time, proper soil preparation, compliance with sowing norms, depth of sowing, etc., leads to irreversible losses in the production of a given crop. The seed drill under investigation is part of a machine system used to implement an innovative technology that does not involve traditional soil cultivation machines. This requires that a cultivator section be included in its device to prepare the soil at the same time as sowing. Turning the seed drill into a combined machine requires it to check its performance. The inspection was carried out by examining the degree of crushing of the layer, the alignment of the profile of the treated strip and the deviation from the set depth of sowing. Each of these metrics is considered as an optimization parameter (x).

Keywords: soil productivity, seed drilling, twin rows planting machine

Introduction

One of the directions for obtaining sustainable yields is to reduce competition by using the main vegetation factors - soil, water, nutrients and light. This can be ensured by optimizing the reciprocal arrangement of the plants. In this way, a sufficient amount of soil for the development of the root system and light for photosynthetic activity can be provided.

In fact, this can be done by changing the seed application schemes in the soil.

The purpose of this study is to justify and establish the values of the basic technological parameters of a precision sowing drill working in twin rows. The sowing treatment of the soil, carried out by the cultivation sections of the seed drill and the sowing quality, has been experimentally studied during the operation of the seedbed with paired rows.

Exposition

The experimental seed drill shown in Figure 1 is used to carry out the experimental studies, designed to accurately sow crops in twin rows.

With its three-point attachment, the seed drill is aggregated to a 65-90 kW tractor equipped with an autopilot and a navigation system. Each of the six working sections is composed of a cultivator section (1) and a paired sowing section (2). The cultivator section is composed of two parts. In the front, two discs located at a certain angle to the direction of movement are mounted so as to displace residual vegetation away from the strip. Afterwards, the second part is a battery of four parallel discs, carrying out the actual loosening of the soil layer. The entire section is attached to the spring bar of the coulter so that regardless of the set depth of work, the deposited sedimentary mineral fertilizer remains unaffected by the needles of the discs. The construction of the needle disks allows them to turn with the convex or concave part of the needles, according to the field conditions and the desired effect of their work. The cultivation section has been developed specifically for research to satisfy the condition of reducing the number of passages on the soil surface while optimizing the process.

In the sowing section (2), two vacuum sowing machines are used, the sowing discs being driven by a common transmission shaft receiving movement from the drive wheels. A gearbox gearbox is mounted between the gears and the transmission shaft.

The pushing wheels of the section allow the depth of sowing to be adjusted over a wide range according to the agro-technical requirements. Drill type boots are used in the drill. By means of a locking mechanism in the articulated frame. The frame of the working section is fixed to the main frame in the transport or working position.

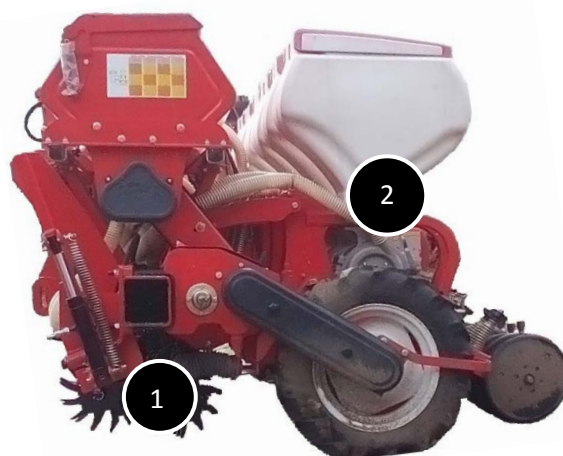


Fig. 1. Drilling machine, sowing seeds in twin rows
1-cultivator section with needle disks; 2-drilling section

If necessary, the movement to the sowing discs may be interrupted by a clutch whereby the seed drill can be transformed from sowing to a pair of rows into standard sowing.

Even seed sowing and appropriate seed density are one of the main factors determining the yield of different crops. In traditional technologies, the provision of these conditions depends on a number of factors that are probabilistic and difficult to manage. These peculiarities have a pronounced impact when performing a precise sowing where it is necessary to maintain a sustainable sowing rate with a uniform distribution of the seeds in the longitudinal and transverse direction by sowing the seeds at the same depth and without being traumatized [1, 2, 10].

Two active experiments are conducted in accordance with the tasks set. By their nature, they are regression analyzes with one manageable factor, conducted in production conditions (on the field).

For conducting experiments, the machine speed is included as the driving factor. In practice, recommended values for this factor are indicated, both in the work of cultivating work organs and in the work of the seed drills. The values adopted for the controllable factor are in accordance with the recommended values given to it in the literature [2,3,5] and satisfy the joint action of the investigated machine parts.

The task in conducting these trials is to evaluate the quality of the sowing and sowing. The parameters (optimization parameters) on which this assessment was carried out are: Y_1 - the degree of crushing of soil aggregates; Y_2 - alignment of the profile of the treated strip and - Y_3 deviation from the set depth of sowing.

The degree of crushing of the layer (Y_1) is determined by 8 samples taken from the two diagonals of the area treated at two working runs of the cultivation section. During the operation of the cultivation section, the moving section behind it is switched off to prevent interference. Each sample is taken using a metal crucible that is drilled into the soil at the depth of the sieve treatment. The collected samples by means of a sieve classifier are divided into fractions according to the average size of soil aggregates: ≤ 50 mm and > 50 mm, weighed to the nearest 10 g.

Parameter values Y_1 are characterized by the weight ratio of the fraction of ≤ 50 mm to the weight of the whole sample, expressed as a percentage. According to the agro-technical requirements [6], the quantity of soil aggregates smaller than 50 mm should be not less than 75%.

Aligning the field microprojection is an important prerequisite for even seed sowing in depth. When examining the parameter Y_2 , a "conditional line" [5] is used. Here the two processes $h(t)$ $a(t)$ are considered separately, such as the profile of the soil surface before the experimental installation and the surface of the soil after the installation. By tracking variance of the coefficient of variation in both processes, information is received about how the parameter Y_2 changes. Before and after each experiment, the soil microprofile is counted in every 0.2 m at 8 points located in the same part of the treated portion of 5 m length. Positive is the effect of the cultivation section when the process $a(t)$ is characterized by a smaller coefficient of variation than that of the process $h(t)$.

For the sowing quality, the sowing section of the experimental plant for maize sowing was observed. The sowing is carried out directly on soil cultivated by the cultivation section.

The control factor participant takes the same natural values as in the cultivation section: 4, 5, 6, 7, 8, 9 and 10 km / h. The depth of sowing was measured at 8 points from a section where the plant was operating in an established mode. The distance between the measurement points depends on the sowing rate of the selected maize hybrid. Parameter reading is performed after mass seed germination. By carefully subtracting the plants together with the seeds in the experimental area and measuring their ethylated underground part, the depth of sowing is determined, then by the calculated dispersion and average depth of sowing, it is monitored where the parameter has the lowest coefficient of Variation.

In both studies, the cybernetic approach in which a research object is presented with the so-called "black box" is used. In accordance with this principle, the reaction of objects with one control factor x and one parameter Y can be represented by a regression equation:

$$E[Y/x] = \eta(x), \quad (1)$$

where: $E[Y/x]$ Is the conditional average of the parameter Y ;

$\eta(x)$ - unknown to the factor x , so call the "regression function".

Based on the data obtained from a relevant experiment, regression function approximation can be sought. In general, the sought-after regression model has the form:

$$y = \eta(b_0, b_1, \dots, b_m, x), \quad (2)$$

where: $b_0, b_1, \dots, b_m$ are the experimental coefficients of regression.

The task in conducting trials is to evaluate the performance of a precision sowing machine with twin rows. The parameters (optimization parameters) on which this evaluation is performed are essential for the suitability of the machine when applying the Strip-till technology.

To determine the optimal operating mode of the sowing machine, optimization methods are used by a desirable function [6].

For this purpose, the assigned functions of Y_1 , Y_2 and Y_3 are represented by a generic desirable function, which is of the type:

$$D = \sqrt[3]{d_1 \cdot d_2 \cdot d_3}, \quad (3)$$

where d_1, d_2, d_3 are the private desirability functions defined by the formula:

$$d = \exp[-\exp(-Y_i)] \quad (4)$$

In determining the desirability function, a limitation of the type of $Y_i \leq Y_{\max}$ is used. For Y_1 the limit of limitation is 25%, which provides the necessary structure of soil aggregates before sowing. For indicator Y_2 , the upper boundary of the limitation is 7%, which is a prerequisite for the uniform application of the seeds in depth and consequently also for their coalescence. Dredge crops require at least 95% of all seeds to be sown at the desired depth, indicating that the upper limit of the Y_3 limit is 5%. For the generalized desirability function, an appropriate regression model is sought and it is the optimal value of the controllable factor. With the obtained optimal value of the factor, each of the indicators is calculated by the regression model established for each of them.

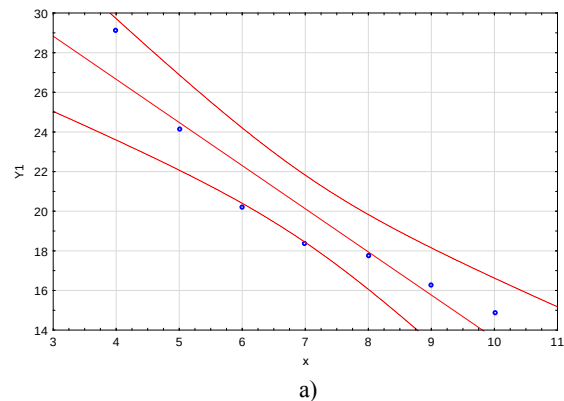
The processing of all the results of the experiments carried out, as well as the determination of the necessary numerical characteristics of the studied parameters, was performed with the help of the specialized software "Statistics" 13.

The results of the experiments are presented in Table 1 through the mean values of each of the parameters.

Table 1. Results from the modified seed drill experiments

Working speed - x , km/h	Optimization parameters, %			Summary function of the desirability
	$\bar{Y}_1$	$\bar{Y}_2$	$\bar{Y}_3$	D
4	29,1	3,0	11,3	0,306
5	24,2	3,0	8,5	0,417
6	20,2	2,1	4,1	0,632
7	18,4	1,9	4,1	0,685
8	17,8	1,7	4,5	0,710
9	16,2	1,5	13,6	0,544
10	14,9	0,9	19,0	0,504

The data in the table shows that as the speed increases, the parameters Y_1 and Y_2 decrease, i. e. the performance of the seed drill for these parameters improves. With respect to parameter Y_3 the results show that initially it starts to decrease with increasing speed but after 8 km / h sharply increases. The quality of the machine requires all three parameters to be kept as low as possible. These levels can be seen separately in Fig. 2, tracking the regression lines for them.



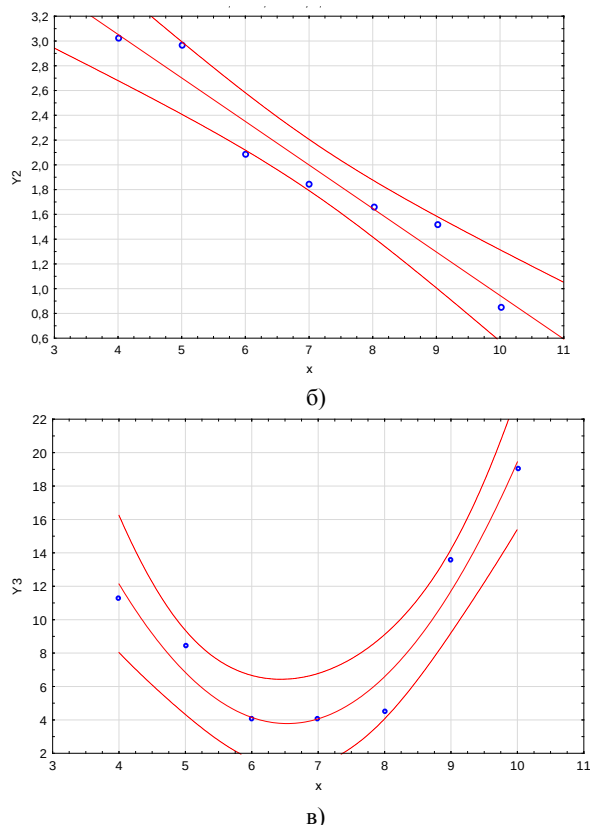


Fig. 2. Lines of regression from single-factor experiments: a) - a regression line for Y_1 ; b) - regression line for Y_2 ; c) the regression line for Y_3

The regression lines presented are derived from the corresponding regression equations (5) at a confidence interval of 95% (dashed lines in the graphs).

$$\begin{aligned} Y_1 &= 35,364 - 2,177 \cdot x \\ Y_2 &= 4,459 - 0,351 \cdot x \\ Y_3 &= 59,379 - 17,021 \cdot x + 1,303 \cdot x^2 \end{aligned} \quad (5)$$

Narrower confidence intervals show that regression models very well approximate experimental results, and 95% probability would describe the process in a new series of experiments. Confirmation of the adequacy of the models gives the probability p (6) obtained for each of them.

$$\begin{aligned} p_1 &= 0,0012 \\ \alpha = 0,05 > p_2 &= 0,0003 \\ p_3 &= 0.0035 \end{aligned} \quad (6)$$

In order to find the optimal operating mode of the experimental machine, optimization of the results was performed by a generalized desirable function. The data from the optimization carried out are presented in the last column of Table 1. From the data in Table 1 it can be seen that at a machine speed of 8 km / h there is a good desirability function ($D = 0,7$) where the optimization parameters satisfy restrictions $Y_1 \leq 25\%$, $Y_2 \leq 7\%$ and $Y_3 \leq 5\%$. The regression model for the generalized desirability function is a second degree polynomial (7) whose regression line is represented in Fig. 3.

$$D = -1,144 + 0,486 \cdot x - 0,032 \cdot x^2 \quad (7)$$

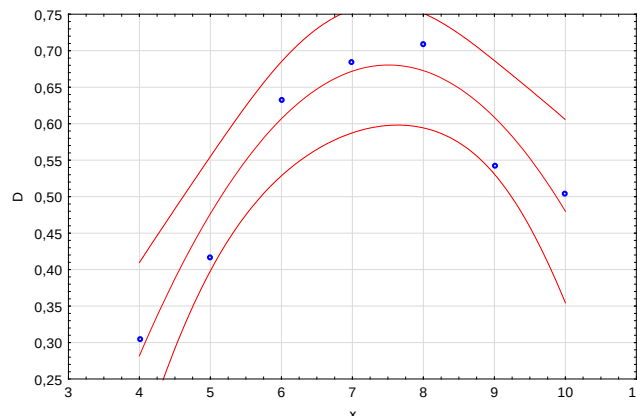


Fig. 3. Line of regression for the generalized function of desirability

The coefficient of expression (7) shows that 91% of the change in D or, respectively Y_1 , Y_2 and Y_3 and will be due to the speed of the machine. The presented regression line shows that optimal machine operation is achieved at a seed drill speed in the range between 7 km / h and 8 km / h, preferably at higher speeds.

Conclusion

The study shows that, with appropriate technological adjustments, the seed drill provides the necessary agro-technical requirements. From the obtained regression models for the studied parameters, it is seen that for the best possible results, it is preferable to work at a higher speed. This is confirmed by the optimization task, which shows good results at a speed of 8.0 km / h.

Literature

1. Aleksandrov V. and others, Reference constructor сельскохозяйственных машин. Machine Building, Moscow, vol. 2, 1967
2. Vagin A. et al., Mechanization of protection of soil from water-borne erythrobes in a non-groundwater subsoil. Colos, Leningrad, 1977
3. Galushka I., I. Ovchinnikov, Apparatus for the local mineral deposits in the SAD. Mechanization and Electrical Engineering, Uroжай, Киев, выпуск 8, 1967
4. Georgiev I., Fundamentals of simulation and modeling of agricultural machinery. Zemizdat, Sofia, 1973
5. Demirev G., K. Bratov, Agricultural Machines I. Rousse, 2012
6. Markov N., Research on chiselous working bodies of machines for deep loosening of surface-soaked soils. Autoreferat, Sofia, 1986
7. Mitev G., A. Pavlikianova, K. Bratov, Manushkov, Study of the water-holding capacity of soil mixtures with water-accumulating materials. Scientific Works of "Angel Kanchev" University of Rousse, 2011
8. Panov I., V. Vetohin, Physical Principal Mechanics of Soil. Kiev, 2008
9. Fishniko G., Mechanization of orphanages under the mountain range. Mechanization and Electrical Engineering, Uroжай, Киев, выпуск 8, 1967
10. Srivastava, A. K et al. Engineering principles of agricultural machines. American Society of Agricultural Engineers, 1993

THEORETICAL STUDY OF THE MOTOBLOCK STABILIZING ON A SLOPE WORKS

Prof. Doc. Eng. Bulgakov V.¹ PhD., Prof. Doc. Eng. Adamchuk V.² PhD., Doc. Eng. Ruzhylo Z.¹ PhD., Doc. Eng. Usenko M.³ PhD., Prof. Doc. Eng. Beloev H.⁴ PhD., Prof. DrSc. Eng. Borisov B.⁴ PhD., Doc. Eng. Mitev G.⁴ PhD.

¹National University of Life and Environmental Sciences of Ukraine, 15, Heroyiv Oborony Str., Kyiv, 03041, Ukraine

²National Scientific Centre, "Institute for Agricultural Engineering and Electrification",
11, Vokzalna Str., Glevakha-1, Vasylkiv District, Kiev Region, 08631, Ukraine

³Lutsk National Technical University Ukraine, 75 Lvivska Str., Lutsk, 43018, Ukraine

⁴"Angel Kanchev" University of Rousse, 8, Studentska Str., 7017 Ruse, Bulgaria

Abstract: One of the most acute problems in the effective use of small-sized agricultural machinery, in particular, motor blocks, is the stabilization of their rectilinear motion on the slopes work. The purpose of this study is to increase the stabilizing moment of the motor block, by theoretically justifying its movement across the slope with a stabilizing device. The research uses modeling methods, theoretical mechanics and higher mathematics. As a result of the theoretical study, the conditions for the balance of the running wheels of the aggregate in the structure of the motor block and the agricultural implement when moving along the slope surface, as well as the traction of the wheels with the soil, are determined, taking into account the lateral force leading this unit down the slope. At the same time, as a stabilizing device, a micro-tiller is used, which makes it possible to pre-make a stabilizing groove for the wheels of the motor block. Further, using the developed power circuit, analytical expressions are compiled that allow us to numerically determine the structural and power parameters of a given aggregate, allowing it to stabilize its steady motion when working on a slope.

KEY WORDS: SMALL-SIZED AGRICULTURAL MACHINERY, MOTOBLOCK, SLOPE, STABILIZATION OF MOTION, EQUILIBRIUM EQUATIONS STABILITY.

1. Introduction

The presence of slopes (for example, up to 12°) causes difficulties in the operation of any means of mechanization. When the slope of the slope is transverse with respect to the direction of movement of the slope above 5° , a lateral force arises that disrupts the stability of the running of this unit. This negatively affects the conduct of any agricultural operations. This phenomenon can be especially negative in the case of inter-row cultivation of soil, when the deviation of the unit from a given direction of motion leads to damage to a large number of plants. Small-sized machinery when working on slopes is less subjected to slipping than large, because due to the smaller mass there is less side power, which breaks the stability of the unit's travel. To completely eliminate this force, it is necessary to use stabilizing devices.

2. Preconditions and means for resolving the problem

2.1. Analysis of recent research and publications

There are various devices and mechanisms for stabilizing the direction of movement of the agricultural machines when working on slopes [2-4, 10-11]. Among these designs, one should single out those in which alignment of the unit's position with respect to the horizon on the transverse slope is provided, which eliminates the complete slipping of the unit when working on slopes. But in these constructions and, accordingly, in scientific works [1, 5] from this direction theoretical problems are not considered that are related to the implementation of the groove only under the upper wheel of the motor block (unit) that moves in a direction transverse to the slope.

2.2. Purpose of the study

Determination of the condition of balance of the wheels of the motor block and the force of their adhesion to the soil, a lateral force that disrupts the stability of the unit's travel.

3. Results and discussion

One of the promising devices, which solves many problems when the unit operates on slopes, is a microterreaser [2]. It completely removes the effect of the lateral component of the mass on the wheels of the tractor. A serious drawback of this scheme for the French patent is a significant increase in the strength of the unit's resistance, which causes a decrease in traction qualities of the tractor. In the reverse course, it becomes necessary to have

circulating skimmers, which in turn requires the installation of revolving mechanisms for each skimmer separately, which will be controlled by the tractor operator. In another case, when the formation is turned up the slope, the resistance to rolling will increase. These requirements significantly complicate the design of the mechanism, which leads to a decrease in operational reliability and the scope of its application.

The question arises: is it possible to apply such a mechanism, in which only the upper wheel on the slope will move along the groove. We proposed a new device for stabilizing the direction of movement (ensuring the exchange rate stability) of the unit when working on slopes, which is described in [6-9].

This device can remove a hunk and, accordingly, perform a groove of such depth that the motoblock on a slope α will occupy a horizontal position. In this case, the action of the lateral component of the mass on the wheels of the motor block, which tries to move the motor-block down the slope, is completely eliminated. Nevertheless, to ensure rectilinear motion of the motoblock on the transverse slope, it is sufficient to remove the formation (to make a groove) of such a depth that the angle of the motor block relative to the slope is not equal to zero, but only slightly reduced by a certain amount.

Define lateral efforts on the dynamic performance of the motor block and justify the expediency of applying the mechanism of the proposed type. Let this device (its disk) fall off the layer down the slope α and make a groove (Fig. 1).

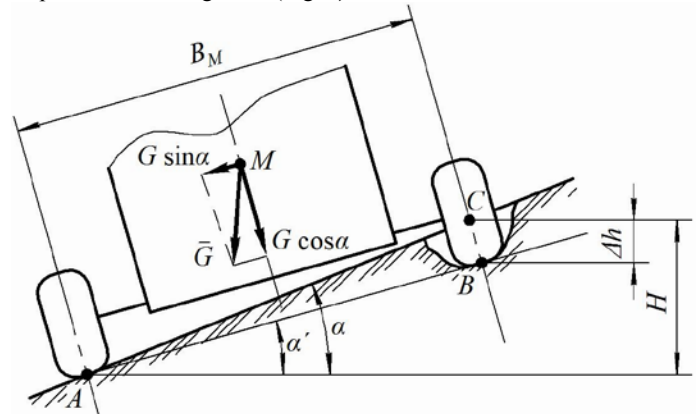


Fig. 1. – Scheme of location on the slope of the motor block with a stabilizing device

The upper wheel starts to move along the groove, and the motoblock with the wheel gauge of the wheels B_M occupies a new position on the transverse slope of the value α' .

Thus, the motoblock operates on the transverse slope α' by the value:

$$\alpha' = \arcsin \frac{H - \Delta h}{B}, \quad (1)$$

where H – vertical distance between the upper and lower wheels of the motor block on the slope α ; B_m – width of track of wheels of a motor-block; Δh – the preset depth of immersion in the ground of the device disk.

Due to the insignificant difference between the angles α and α' we assume that the point B (the point of contact of the wheel with the soil) is on the wheel axis.

Substitute the value of H in the equation (1) and after the transformations we get:

$$\alpha' = \arcsin \left(\sin \alpha - \frac{\Delta h}{B_m} \right). \quad (2)$$

Since $\alpha' < \alpha$, the main factor that causes the lower wheel and motoblock to deviate altogether from the given direction is reduced. At the same time, the lateral force does not act on the upper wheel, it is zero, since it moves in the groove. Consequently, the coupling mass is increased and the traction characteristics are increased.

Normal soil reactions of the upper and lower wheels, respectively:

$$\left. \begin{aligned} Z_1 &= \frac{1}{2}G, \\ Z_2 &= \frac{1}{2}G \cos \alpha'. \end{aligned} \right\} \quad (3)$$

Therefore, the upper wheel has the ability to develop a greater traction force than the lower one by the amount:

$$(Z_2 - Z_1)\varphi = \Delta P_k = \frac{1}{2}\varphi G (1 - \cos \alpha'), \quad (4)$$

where G – weight motoblock, which is on the wheels; φ – coefficient of lateral traction of the tire to the soil.

It is interesting to compare the indices of stability on the basis of an analysis of the equilibrium conditions of the wheels of the motor block with and without a stabilizing device.

The wheels of the motoblock, which are stationary on a terrain with a transverse slope α , will not slip sideways if the following condition is met:

$$\varphi G \cos \alpha \geq G \sin \alpha. \quad (5)$$

Because of the small difference, we take $\alpha \approx \alpha'$, then from Fig. 2 it can be seen that the equilibrium condition of the wheels of the motor block, which has a stabilizing device, will look like:

$$\begin{aligned} \frac{1}{2}\varphi G (1 + \cos \alpha) &\geq \frac{1}{2}G \sin \alpha, \\ \varphi(1 + \cos \alpha) &\geq \sin \alpha. \end{aligned} \quad (6)$$

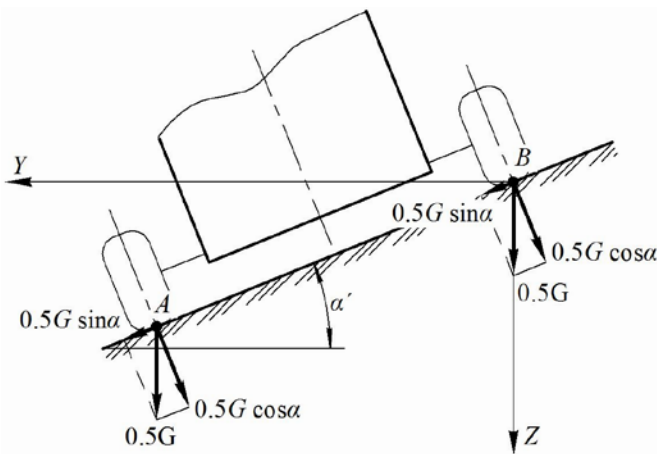


Fig. 2. – The scheme of forces that act on the wheels of the motorblock on the transverse slope

Comparison of equations (5) and (6) shows that the equilibrium conditions in the second case are significantly

improved. In this case, the action of the lateral force $0.5G \sin \alpha$, which tries to move down the slope of the lower wheel, is transmitted to the upper wheel. We transfer the lateral force $0.5G \sin \alpha$ from the point A to the point B and decompose it into components:

$$Y = 0.5G \sin \alpha \cos \alpha, \quad (7)$$

$$Z = 0.5G \sin^2 \alpha. \quad (8)$$

The first component causes slipping, the second – loads the upper wheel. Therefore, the total traction force of the wheels is:

$$R = 0.5G_2 \varphi \cos \alpha + (0.5G_2 + 0.5G_2 \sin^2 \alpha) \varphi. \quad (9)$$

Thus, the equilibrium condition in the final version will be:

$$0.5G_2 \varphi (1 + \cos \alpha + \sin^2 \alpha) \geq 0.25G_2 \sin 2\alpha. \quad (10)$$

Comparing this equation with the condition of the balance of the wheels of the motoblock without a stabilizing device (from formula (5), we notice that the force that tries to move the motor-vehicle down the slope decreases more than twice. The reduction factor can be calculated by the equation:

$$n = \frac{G \sin \alpha}{\frac{1}{2}G \sin \alpha \cos \alpha} = \frac{2}{\cos \alpha}. \quad (11)$$

The force of traction of the wheels with the soil in the second case is greater by the value:

$$\Delta G = R - \varphi G \cos \alpha = 0.5G \varphi (1 - \cos \alpha + \sin^2 \alpha).$$

And the magnification factor will be:

$$n_1 = \frac{R}{\varphi G \cos \alpha} = \frac{1}{2} \cdot \frac{[1 + (1 + \sin^2 \alpha)]}{\cos \alpha}. \quad (12)$$

We have an improvement in the operation of the unit with a stabilizing device (the traction of the wheels with the soil increases, the lateral force decreases, which raises the stability of the stroke).

For example, the equilibrium condition on the slope of the slope of 12° (0.21 radians) by the formula (11) improves approximately by 2 times.

4. Conclusions

The above theoretical justification of the operation of the stabilizing device with the disk to the motor block at work on the transverse slopes makes it possible to determine the equilibrium conditions of the wheels of the motor block and the force of their adhesion to the soil, the lateral force that disrupts the stability of the unit's travel.

The above calculation technique can be used as a separate technique for carrying out important calculations and as a basis for further research on the operation of the whole unit.

5. References

1. Amelchenko P.A. Research in the field of some parameters of steep and low-tractors: thesis of cand. dis. of tech. sciences. – Minsk, 1974. – 19 p.
2. Adaptation to a tractor for working on slopes. Patent of France №80113, MKI A 01 V. / J. Bush. Declared. 13.07.61; Publ. 04.02.63, abstract journal №10, 1964.
3. Stabilizing device for agricultural aggregates working on slopes. Patent of Ukraine № 1101187, MKI A 01 B 69/00 / A.N. Golozubov et al. – №3560544 / 30-55; Claimed. 14.06.83; Publ. 08.07.84, Bul. №25.
4. A tool for tillage on slopes, Patent of Ukraine №1168111, MKI A 01 B 33/02 / Sh.M. Grigoryan and others – № 3743508 / 30-15; Claimed. 28.02.84; Publ. 23.07.85, Bul. №27.
5. Mshvildadze O.P. Fundamentals of the creation of technical means, stabilizing the direction of motion of the steep-shaft unit: thesis of cand. dis. of tech. sciences. – Tbilisi, 1986. – 52 p.
6. Usenko M.V. Investigation of the interaction with the soil of the disk stabilizing device when working on slopes // Interdepartmental thematic scientific collection "Mehanizatsiya te

elektrifikatsiya silskogo gospodarstva". – Glevaha: NSC "IMESG". – Vol. 92, 2008. – p. 133-139.

7. Motoblok. Patent of Ukraine №1491354, MKI A 01 B 15/20 / M.V. Usenko and others. – №. 4342989 / 30-15; Claimed. 15.12.87; Publ. 07/07/89; Bull. №. 25.

8. Trepenkov I.I. Ekspluatatsionnyye pokazateli sel'skokhozyaystvennykh traktorov / I.I. Trepenkov. – M.: Gosudarstvennoye nauchno-tekhnicheskoye izdatel'stvo mashinostroitel'noy literatury, 1963. – 272 s.

9. Vasilenko P.M. Vvedenie v zemledelcheskuyu mehaniku. – Kiev: Selhonzobrazovanie, 1996. – 252 p.

10. Khukhuni T.V. Investigation of some issues of stability of tractors on the slope: thesis of cand. dis. of tech. sciences. – Tbilisi, 1964. – 19 p.

11. Yakubovich A.I. Investigation of traction-coupling properties of a steep-angle tractor of 1.4 T class with all leading stabilized wheels: thesis of cand. dis. of tech. sciences. – Minsk, 1974. – 19 p.

OPTIONS FOR USING HYDRODYNAMIC CAVITATOR TO SPEED UP SEED GERMINATION

Ivanov Yevgeny G., Candidate of Technical Science, Associate Professor of Engineering Department, Nizhny Novgorod State Agricultural Academy

ВАРИАНТЫ ИСПОЛЬЗОВАНИЯ ГИДРОДИНАМИЧЕСКОГО КАВИТАТОРА ДЛЯ УСКОРЕННОГО ПРОРАЩИВАНИЯ СЕМЯН

Polosova Valentina P., Candidate of Philosophy, Associate Professor of Foreign Language Department, Nizhny Novgorod State Agricultural Academy

97 Gagarin Ave., Nizhny Novgorod, 603107, Russian Federation, ivanov.e.g@mail.ru

Abstract: *Acoustic cavitation in water causes water's break in vacuum phase of passing of sound wave and then collapse of this break in manometric phase. These processes are taking place 3000 times a second all over the functional volume of cavitator. This leads to seeds' awakening and massaging, improves metabolism and stimulates their development and functioning. There are four technology areas in cavitator: 1) internal functional space, 2) central part of space, 3) passive space from the outside of resonator (housing), 4) external heat space around cavitator.*

The Academy conducted study on seed treatment in each of these areas. Moreover, in passive area and in external space experiments were performed both in wet and dry options. Analysis of experimental results showed: first, all kinds of treatment in all zones of cavitator have advantages over conventional soaking seeds; secondly, each of the processing forms has its own advantages: 1) dry processing is characterized by thermal and vibrational effects on seeds, it requires their direct contact with the resonator, 2) wet processing in passive zone is characterized by additional water exposure and transmission of vibration effects from resonator over long distances, that enables to increase size of functional area and pre-processing performance, 3) processing in central part of the active zone provides essential decrease of exposure time from tens of minutes to 3-5, that allows using this method in industrial agriculture, 4) processing in turbulent flow of active zone damages seeds and is suitable only for solid seeds and seeds difficult to germinate. Using cavitator improves seed germination by tens of percent when shortened processing time. This reduces the labor intensity, improves pre-processing performance and leads to higher yields.

Keywords: ACOUSTIC CAVITATION, WATER STRUCTURE, SEEDS, HYDRODYNAMIC CAVITATOR, ACTIVE ZONE, RESONATOR, PASSIVE ZONE, WET PROCESSING, DRY PROCESSING.

1. Introduction

An important task in agricultural production is to increase and accelerate the germination of seed and forage grains. In plant growing pre-sowing treatment provides higher yields in the same proportion. In fodder production, when germinating forage grains for the preparation of vitaminized fodders, the increase of germination improves feed quality due to the increased content of proteins, carotenes, vitamins. This process is also important for bakery production.

The improvement of germination technology is also of great importance, since acceleration of this process reduces production costs, production space, equipment and maintenance costs, labor intensity. Very often the cost of the operation determines usefulness of germination.

2. Preconditions and means to solve the problem

The following traditionally known methods of stimulating wakening and development of seeds can be called: heat treatment, soaking, bubbling, which can be used both individually and in combination, but their effectiveness is low - germination time is several days, germination rate increases slightly.

A necessary condition for accelerating development of the industry is using for both existing and promising technological processes new physical operation and physical effects. The following new methods for seed evocation can be called: seed treatment by electric fields in the range of ultrahigh frequencies,

radioactive and X-rays, explosive effect, etc. However, these methods, firstly, can be harmful to the plants and to the operators; secondly, their effectiveness is insignificant in comparison with traditional methods. Most interesting is acoustocavitation treatment of seeds which provides balanced multi-component effect on the seeds.

3. Solution of the problem

The essence of acoustic cavitation is that when sound waves are emitted in aqueous medium, in each of its nucleus (irregularity) with frequency $f = 3000$ times per second, the pressure changes from the vacuum magnitudes (values) breaking the medium, to the manometric ones that ensure the collapse of each of these ruptures. In this case, the phase of formation of rupture cavity provides pumping elastic energy into it, and the collapse phase ensures the compaction of this energy, both in space and in time (fig.1).

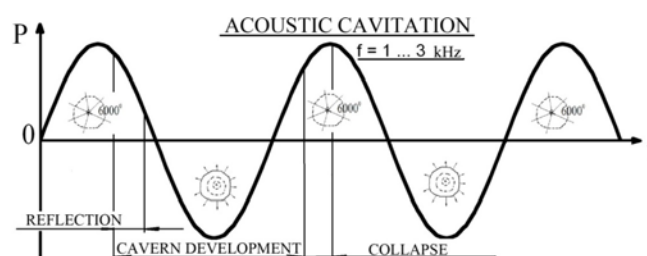


fig.1. Mechanism of the acoustic cavitation

High concentration of energy after collapsing provokes formation of electrodynamic, electrostatic processes, a number of chemical reactions, formation of secondary shock waves with high pressure gradient in their fronts, significant degree of deformation of liquid microparticles - clusters, followed by their destruction and formation of new ones, thorough grinding and mixing of foreign inclusions in water at the molecular level [1].

The listed (by far not all) processes affect the seeds placed in the cavitation area, causing their awakening, massage, volume deformation, create standing waves along each seed, change the properties of the medium, equally dissolve air and nutrients, bring them to the cell membranes, increase the permeability of these membranes.

As a result, the intensity of metabolic processes in the cells increases, seed evocation and development are activated [2].

Previously piezoelectric and magnetostrictive methods were used as a source of sound formation, but crystals-emitters of these methods can emit only limited power, above which they are destroyed.

More promising is the hydrodynamic method of generating acoustic waves [3], for example, interacting of circumferential (external) and input flows in the volute. In this case, sound signal is formed in the volute due to the competitive interaction of these multidirectional flows, and in the resonator which is made in the form of a cylindrical casing (body), this signal is amplified by almost two times (doubled) due to the formation of a standing wave (fig.2).

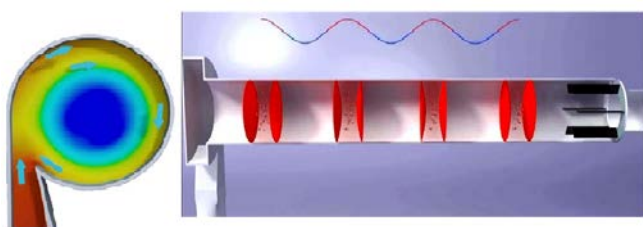


fig.2. Cavitator emitter and cavitator body with a standing wave

In the hydrodynamic cavitator (fig.3), it is possible to treat seeds with the following technological methods:



fig.3. The appearance of vortex cavitator with water jacket.

*** in the passive space from the outside of the casing, that is:**

- as "dry" treatment on the surface of the resonator;

- as "wet" treatment in the space of the body enclosing the resonator and filled with tap water;

- as "wet" treatment in the space of the casing filled with water treated in cavitator;

**** in the active (internal) space of the casing, that is:**

- in the central part of the active space;

- in the wall (peripheral) part of the active space of the fixed casing (body);

- in the wall (peripheral) part of the active space of the rotating body;

***** in the outer space referred to the cavitator, that is:**

- in the form of dry (by heating) treatment over the cavitator;

- in the form of wet-heated treatment over the cavitator;

- in the form of soaking seeds in water, which has been treated on a cavitator.

Dry treatment when seeds (fig.4) come into contact with the outer surface of the resonator (*) makes possible to increase germination of sunflower seeds from 82% to 96% due to the following factors: heating, possible low-intensity radiation, mechanical vibrations at frequencies of 50-3000 Hz.

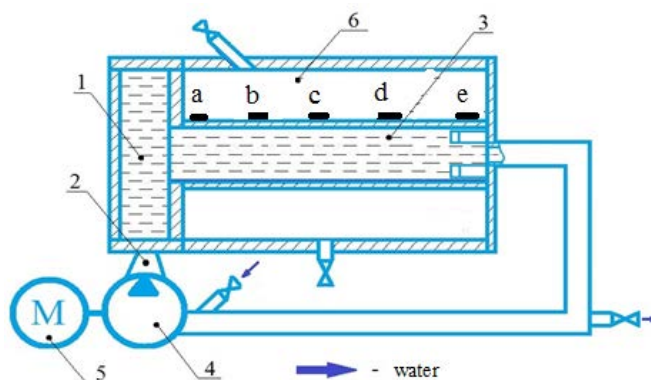


fig.4. "Dry" treatment on the surface of the resonator

The advantage of the situation in question is that the best results correspond to the middle part of the resonator (c, fig.4, fig.5), where the antinode of the standing wave is located, and to its end (e, fig.4, fig.5), where the local focus of acoustic cavitation formed from the vortex flow of the guiding device is located. That is, the zones of maximum intensity of acoustic cavitation have the most beneficial effect on the seed evocation and development.

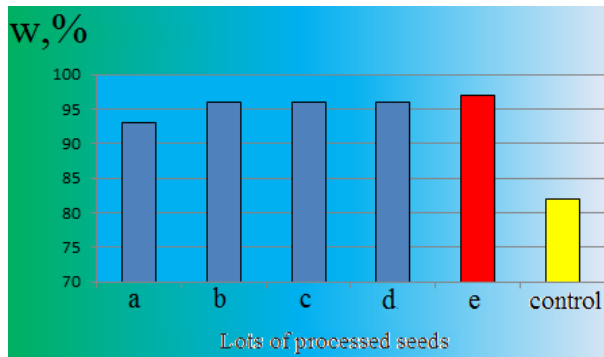


fig.5. Results of "dry" treatment on the surface of the resonator

Filling the enclosure with just tap water expands the means of action on each seed, firstly, due to the fact that body vibrations are transmitted not only to the internal space, but also to the outer space (fig.6).

Although the external elastic vibration is characterized by divergent directions, and because of this its intensity decreases, nevertheless, in the outside wall area of the casing cavitation processes are likely to occur [4].

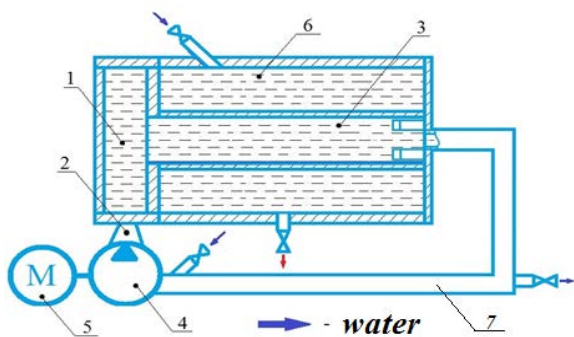


fig.6. Principal scheme of vortex cavitator with water casing : 1- cyclone; 2 – nozzle; 3 – resonator; 4 – pump; 5 – driving engine; 6 – water casing; 7 - return line

Secondly, in this case presence of water combines processes of seed evocation and soaking. Water ensures delivery of nutrients, oxygen and other vital components to the seed cells. Thirdly, due to cavitation processes (although limited), water gets additional positive qualities due to its structure change [5]. As a result, germination of low-quality wheat seeds increases from 44% to 88% (fig.7).

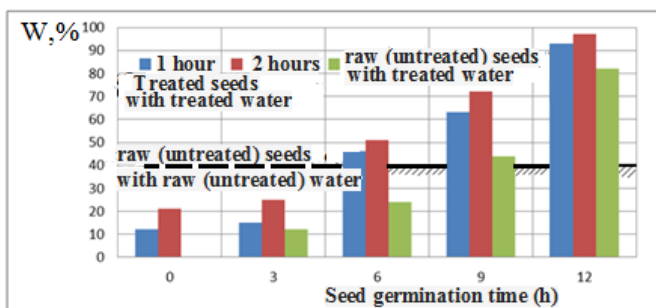


fig.7. Germination of wheat seeds after different treatments on a cavitator in comparison with traditional soaking

The efficiency of seed germination increases significantly, if during wet seed treatment in the casing space, the usual tap water is replaced with water treated in active zone of the cavitator (fig.8).

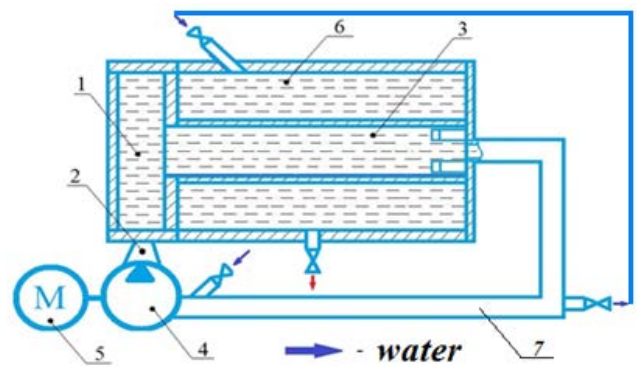


fig.8. Scheme of water supply from the cavitator in the cover

This happens because water changes the structure of clusters, obtains additional properties, and gets biologically active. Thus, it is possible to further increase germination to 96% and to shorten times of treatment from several days (with conventional soaking) to several hours [5]. In this case, germination dependence on the cavitator working mode and on the seed treatment time can be represented as a surface that increases with increasing holding time and decreases with increasing treatment temperature, especially in the range $45^{\circ} - 70^{\circ}$, which is due to partial destruction of protein (fig.9).

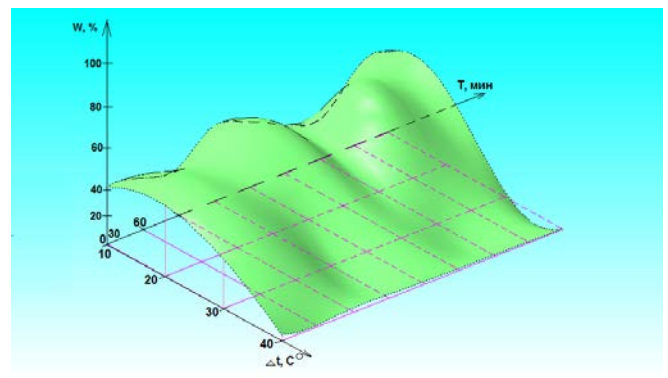


fig.9. The surface of barley germination as function of cavitator operating mode and treatment exposure

The seed treatment in the central part of the active space (**) of the body 3 (fig.4.) is accompanied by high turbulence of water flow rotating at speed of 30 m / s, by intense exposure of ordinary and acoustic cavitation, by impacts of free surfaces of air and vapor cavities with each seed, by thermal action, ionizing action of low intensity, high gradient fronts of shock waves arising from collapse of cavitation caverns, etc [6].

In this case, the necessary time for seed treatment is reduced from a few hours to 2 - 5 minutes (fig.10.), that allows to use this treatment method as an industrial one and combine sowing and pre-sowing seed treatment in one operation.

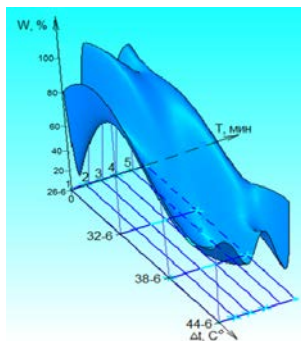


fig.10. Processing of sunflower seeds in the active zone of the cavitator and its results

The placement of seeds in the peripheral part of the casing 3 provokes their relative movement with speed $\approx 30 \text{ m / s}$, high friction, shell destruction and, at excessive treatment time, mechanical seed failure. Therefore, this kind of treatment is recommended only for seeds with extremely strong and thick shells at small and accurate exposures. To exclude the processes of destruction, it is advisable to make a casing or an underlying layer (for example, in the form of a grid) rotating at the speed of seed rotation (fig.11).

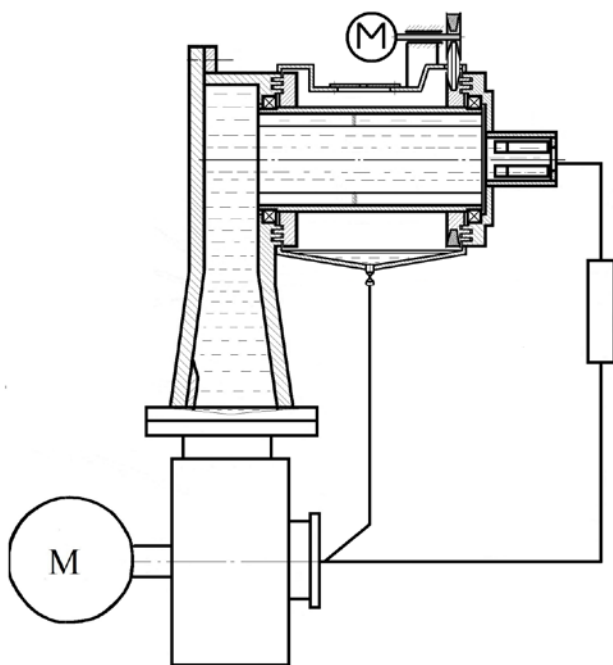


fig 11. The cavitator project with a rotating body

In this case, the effect of friction, macrocavitation, steam and air bubbles on the seeds will be eliminated, that will accurately dose the impact of the core on the seeds and at the same time select the most viable seeds, as the diseased seeds will rise to the axis of rotation [7].

When processing seeds in the external space of a cavitator (***) without water, functional factors are heat action and effect of fields of physical nature. At the same time, as the treatment period is increased in all modes of the cavitator operation, the germination increases to extreme values ($W \approx 93\% \div 94\%$), after which there is

an overabundance of influence and vital activity of seeds is inhibited ($W \approx 85\% \div 88\%$). The transition to low-cost (high-temperature) regimes, firstly, shifts the extremum value to the region of smaller exposures (with $\tau = 7.5$ hours at $t = 30^\circ$ to $\tau = 4.5$ hours at $t = 73^\circ$), secondly, reduces the parameters of the treatment process - for example, the highest germination rate from 94% at $t = 30^\circ$ to 89% at $t = 60^\circ$, since in this case the cavitator operates in a non-optimal mode and therefore the amount of negative influence on the seeds increases and the share of positive influence decreases.

However, the rational use of heat at low-cost (high-temperature) modes of the cavitator operation can greatly stimulate seed evocation and development and thereby ensure comparability of the germination indicators with high consumption regimes, in this case the damage from insufficient influence of direct process of cavitation is compensated by thermal effect.

The process parameters also depend on the degree of seed removal from the cavitator - the most significant option is the placement of seeds in contact with the resonator (Fig.5).

It should be noted that the germination of seeds treated on a cavitator in all modes in the air exceeds the germination of control samples ($W \approx 85\%$).

4. Conclusions

1. All types of pre-sowing treatment with acoustic cavitation are more effective than the known ones:
 - soaking;
 - bubbling;
 - microwave treatment;
 - electrostatic treatment;
 - electromagnetic, etc.
2. The most significant cavitation zones are:
 - active internal space of the casing;
 - passive space of the enclosure around the body (casing).
 The external space of the cavitator is less significant area of the workspace.
3. The use of passive space for seed germination allows to increase the germination capacity and to accelerate significantly germination process. This fact makes it possible, due to the acceleration of germination, to increase the yield in plant growing, or to improve significantly quality of highly vitaminized animal feed in feed production. At the same time, due to the acceleration of germination process, the necessary production areas, equipment costs, labour intensity, production costs are reduced and flexibility of technological process is provided.
4. Using active zone of the casing for seed germination makes it possible to increase the productivity of the sprouting process tenfold and to combine this process with the technological operation of sowing.
5. The use of water treated in the cavitator makes it possible to accelerate seed germination by traditional methods - soaking, bubbling, etc. without direct application of cavitator itself.
6. The space above the cavitator is also favorable for germination and can be used when the cavitator performs another technological operation (heating, water treatment, etc.) when several processes are simultaneously combined.

5. Literature

1. Ivanov E.G., Dispersing of peat in a vortex cavitator and a pump with standard packing, E`nergobespechenie i e`nergoberezhenie v sel'skom hoziaistve, Trudy` vos'moi` Mezhdunarodnoi` nauchno-tekhnicheskoi` konferencii 16-17 maia 2012 g., Moskva, GNU VIE`SKH, 2012, Ch. III, pp. 381- 386.

2. Ivanov E.G., Predposevnaia obrabotka semian na vikhrevom kavitate (Presowing treatment of seeds on the vortex cavitator), E.G. Ivanov, E`nergoobespechenie i e`nergoberezhenie v sel'skom hoziai'stve, Trudy` vos`moi` Mezhdunarodnoi` nauchno-tekhnicheskoi` konferentsii 16-17 maia 2012 g., Moskva, GNU VIE`SKH, 2012, Ch. II, pp. 53-59.
3. Evolution of hydrodynamic cavitator. Ph. D, Ivanov E., Russia, Nizhniy Novgorod. Nizhniy Novgorod State Agricultural Academy, Associate professor, Mechanization in Agriculture, Year LXI, ISSN 0861-9638, issue 2/2015, Bulgaria, pp.17-21.
4. Agafonov V.V. Kavitationnoe prorashchivanie semian iachmenia dlia uskorenogo polucheniia soloda (Cavitation germination of barley seeds for rapid production of malt), V.V. Agafonov, E.G. Ivanov, E.E. Chavachina, Vest. neyk NGIE`I, 2016, No.8(63), pp. 55-64.
5. Ivanov E. G. Activation of information of water quality by means of acoustic cavitation. . Ivanov E.G., Kokorin N.V., Chavachina, Vest. neyk NGIE`I, 2017, No. in the press.
6. Evgeniy G. Ivanov. Seed germination with use of acoustic-cavitation technologies, 15 th International scientific conference «ENGINEERING FOR RURAL DEVELOPMENT», Proceedings, Volvmel5 May 25-27, 2016, Ielgava, Latvia, 2016, pp. 278-284
7. Application for invention №2016150758 RU, F25B29/00, F24J3/00. Vortex cavitator/ E.G. Ivanov, V.S. Ugarov , B. A. Gordeev, N. V. Kokorin, A.E. Ivanov. - stated 22.12.2016.

METHODS OF CONTROL AND MANAGEMENT OF AGRICULTURAL PROCESSES

Prof. Dr. Kr. Georgieva, Prof. PhD. M. Mihov , Assoc. Prof. Kr. Krastev, PhD, Sofia; Technical University, Faculty of Engineering and Technology - Yambol
Institute of Soil Science Agrotechnology and Plant Protection "N.Poushkarov"

Abstract: In the report the methods for controlling and managing the processes in agriculture are justified and systematized and a methodology for applying the statistical methods for analysis, control and management of the quality of the agricultural processes has been developed. Finally, the factors influencing the quality of technological processes in agriculture are also labeled.

KEY WORDS: STATISTICAL METHODS, QUALITY MANAGEMENT, TECHNOLOGICAL PROCESSES, SAFETY, EFFICIENCY, ANALYSIS, CONTROL.

Processes in agriculture are random, changing in time under the influence of a number of random controllable and unmanageable (controllable and uncontrollable) factors (Figure 1). All this

requires professionals to periodically control and manage their quality by following the agro-technical requirements set in crop technology.

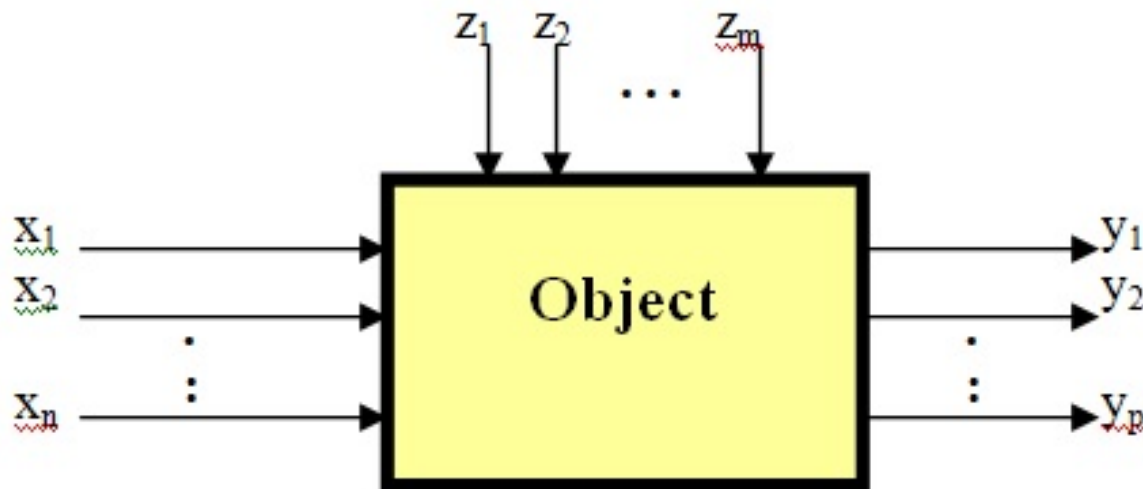


Fig.1. Cybernetic model of control-command object: x_i - input controllable factors; y_k - Entry unmanageable object factors; z_j - Object parameters

Fig. 2 shows the statistical methods for process control and management and in Fig. 3 the place of these methods in the process is defined. Where and when they are used.

An important place in the process of controlling and managing the processes in agriculture occupies the operator (tractor - driver) in the system "man - machine - object of labor"

The activity of the operator (tractor - driver) in the ergo - man - machine - object of work "system is varied and in general it can be presented as a system with four basic elements (fig.4): receiving information; Evaluation and processing of information; Making decisions; Implementation of adopted decisions.

An ergodic system is a system consisting of several interconnected elements where one of the elements is a person - operator (or group of operators) involved in information processing, making and decision making for efficient system management.

We will not look at all the indicators of the quality of the eroic system, but we will only look at those that influence human activity or depend on the results of its activity.

The time of passing information on the closed loop "man - machine - object of work" is determined:

$$T = \sum_{i=1}^k t_i \quad (1)$$

Where:

T is the time during which the information is held in the i-th element of the machine;

k - the number of successively connected elements of the system (technically, biologically).

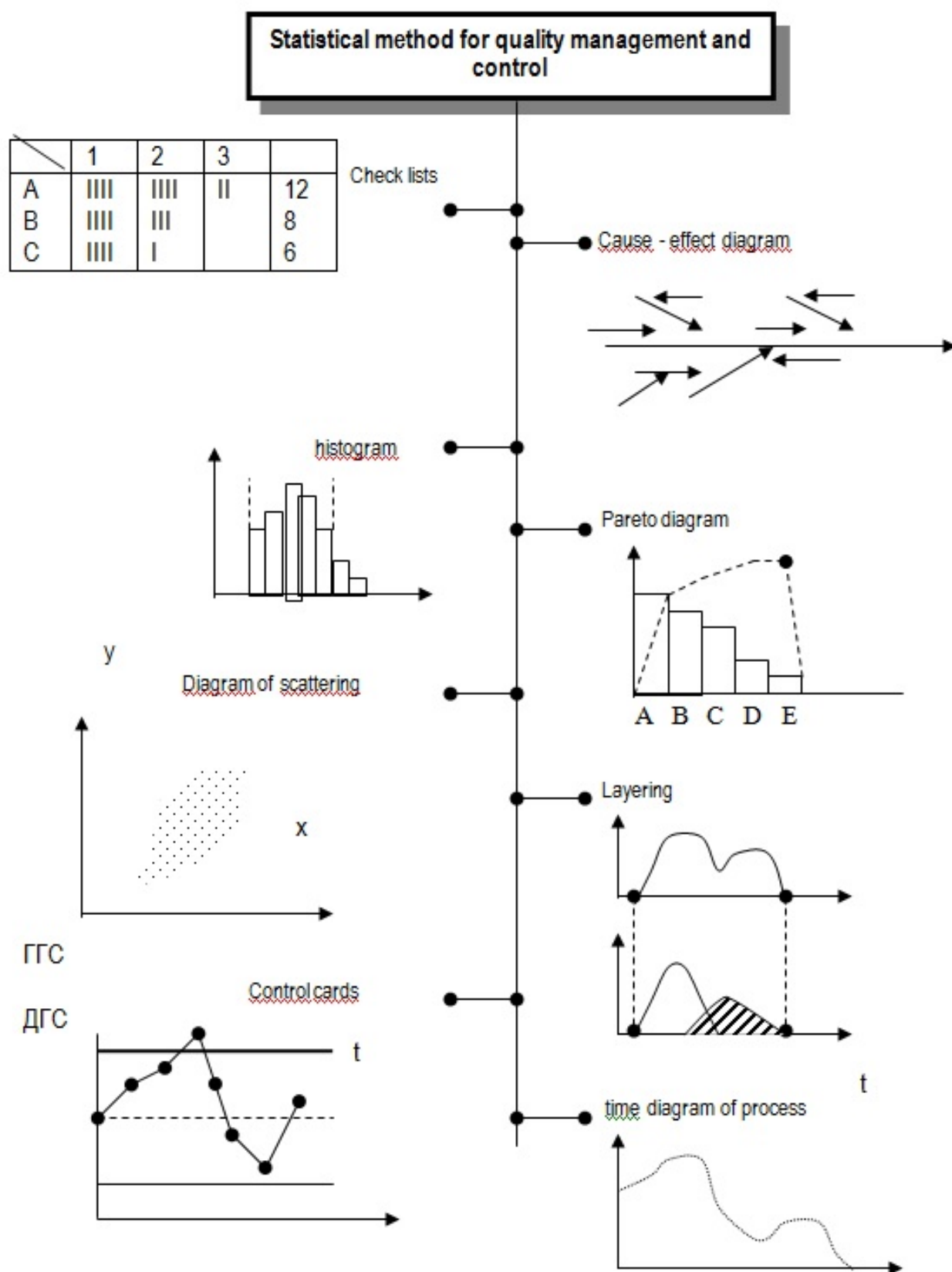


Fig.2. Types of statistical methods for control and management of the quality of agricultural processes

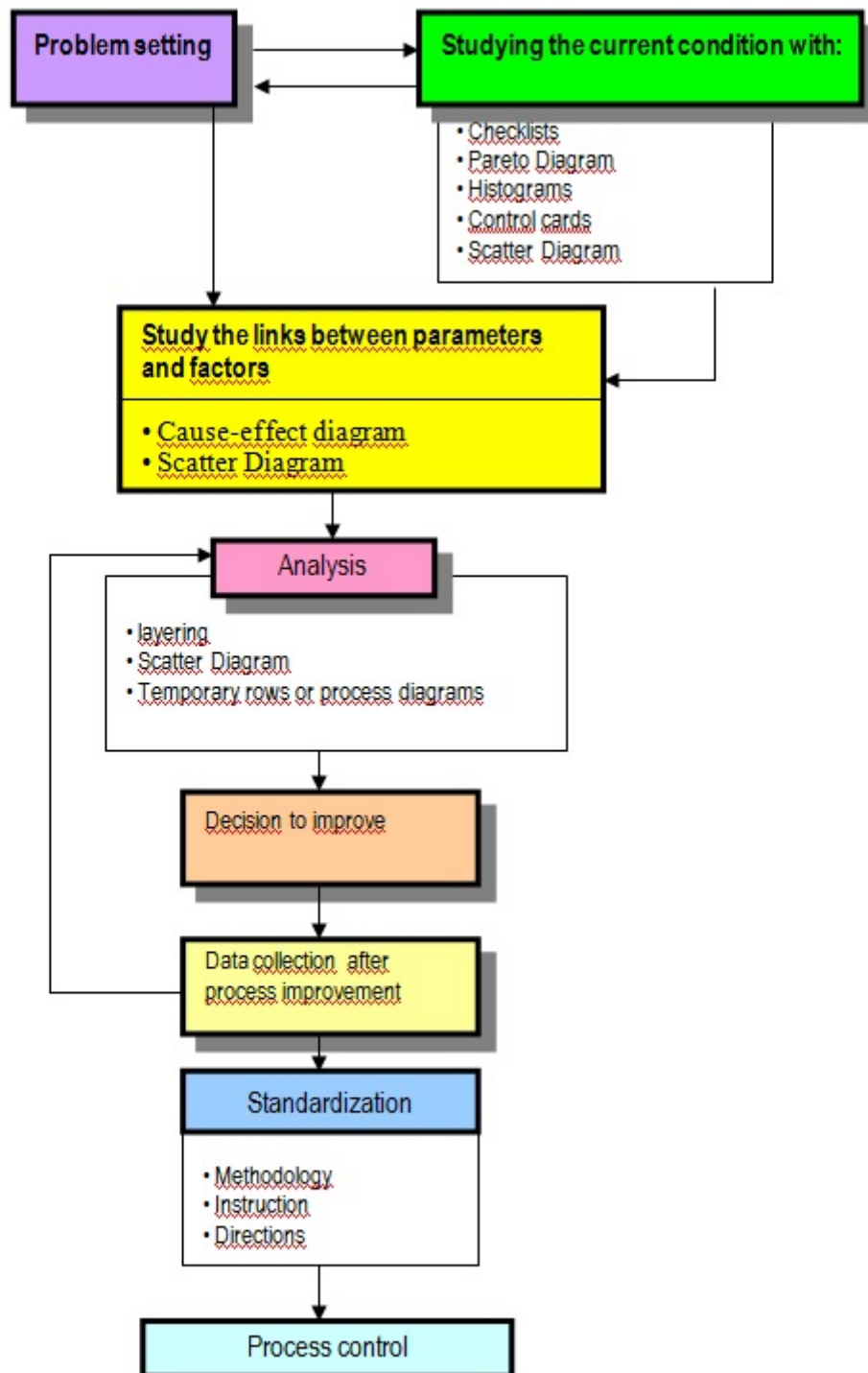


Fig. 3. Scheme for application of statistical methods for analysis, control and management of agricultural processes

The reliability of the system is characterized by the correctness of the decision tasks (P_{IP}) and is defined by the dependence

$$P_{IP} = 1 - \frac{m_{FP}}{N}$$

Where: m_{FP} and N are the number of wrong decisions and the total number of solved tasks.

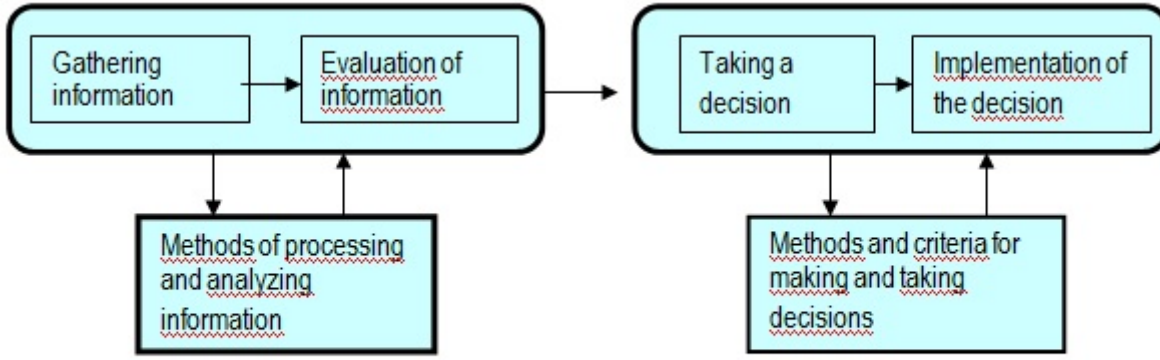


Fig.4. Elements and tasks that are solved by the "man-machine-object of labor"

An important characteristic of the operator's activity is the accuracy of his work, which is quantified by dependence:

$$y = I_H - I_{HP}$$

Where: I_H Is the actual or nominal value of the parameter that is measured, set or adjusted by the operator;

I_{HP} - The actual measured or adjusted operator parameter value.

The timeliness of solving the tasks of the system is assessed with the probability that the assigned task will be solved for a time not exceeding the permissible:

$$P_{CB} = P\{T \leq T_d\} = \int_0^{T_d} \varphi(T) dT$$

where: $\varphi(T)$ Is the function of the density of the time to solve the task by the system;

T_d - The time allowed to pass the information on the system contour.

This probability can also be calculated in a nonparametric way, by the expression:

$$P_{HP} = 1 - \frac{m_{HC}}{N}$$

where: m_{HC} Is the number of untimely solution tasks from the system;

N - The total number of tasks to be solved.

The overall system reliability metric (P_{CM}) is determined by the formula

$P_{CM} = P_{HP} - P_{CB}$, Because the system's performance is evaluated for a certain time interval and the inadequate performance of the tasks leads to the failure of the tasks set up before the system. The work safety of man in the system is assessed on the probability of safe work (P_{BT}):

$$P_{BT} = 1 - \sum_{i=1}^n P_{boi} \cdot P_{zpi}$$

where: P_{boi} is the likelihood of a hazard or human-induced manufacturing situation of this type;

P_{zpi} - the probability of incorrect operation

of the operator in the i-th situation;

n - the number of possible traumatic

situations.

The degree of automation of the system is characterized by the amount of information processed on the automatic devices and is determined by the formula:

$$K_a = 1 - \frac{H_{on}}{H_{cm}}$$

where: H_{on} is the amount of information processed by the operator;

H_{cm} - the total amount of information circulating in the system.

The economic indicato (W_{cm}) that characterizes the full cost of the system is determined by the expression

$$W_{cm} = C_e + E_H (C_{on} + C_u),$$

where: C_u are the costs of creating (purchasing) the mechanical elements in the system;

C_e - the operating costs of maintaining and operating the system;

C_{on} - costs of training and qualifying of the operator;

E_H Is the coefficient of efficiency of capital investment.

The variety of factors influencing the quality of technological processes in agriculture can be grouped into three groups (Figure 5).

Indicators of the quality of the technological processes in agriculture can be divided into three groups.

The first group refers to the indicators characterizing the duration and duration of the works. As it is known, the productivity of the agricultural production depends on the term of the technological processes, which is one of the characteristics of the agricultural production. Only when the field works are carried out in the best, shorter terms the best yields per hectare are reached.

In the second group are included the indicators, which characterize the technological process, ie. These changes occurring as a result of the treatment (depth of processing, degree of loosening, reversal of the soil layer, shear height, clean weeding, degree of contamination of the production with impurities, etc.).

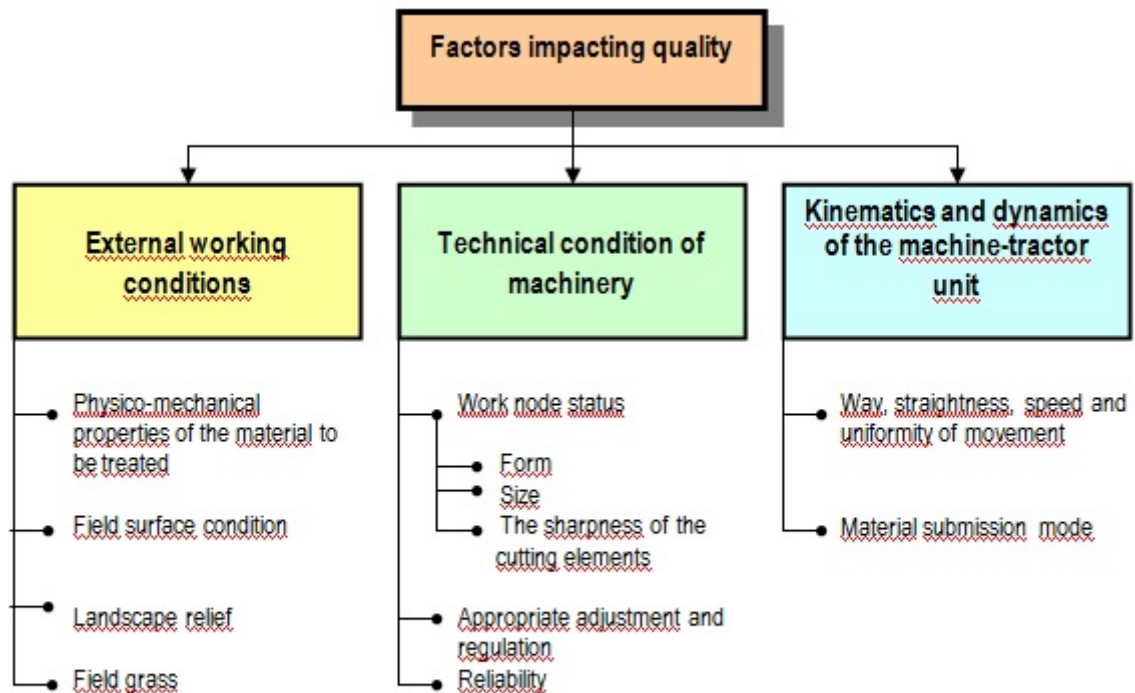


Fig.5 .. Classification of factors influencing the quality of technological processes in agriculture

In the third group are included the indicators describing the material consumption as well as the quantitative and qualitative losses of production (seed consumption, chemical consumption, degree of seed crushing, etc.).

Main conclusions:

1. The methods for control and management of agricultural processes are outlined and methods for their application are proposed.

2. The location of the human operator (or group of operators) in the ergonomic, related to information processing, elaboration and decision making for efficient system management is specified.

3. A classification of the factors influencing the quality of technological processes, which allows to manage agricultural processes in a targeted manner, is proposed.

References:

- 1.Тасев Г. Механизация на земеделското производство.-С.,2014.
- 2.Георгиева К. Съвременни механизирани технологии в земеделието.-Ямбол,2015.
- 3.Тасев Г.,и др. Приложение на статистическите методи за управление на качеството на продукцията.- Шумен,2010.

CURRENT PROBLEMS OF AGRICULTURAL PRODUCTION MECHANIZATION

Prof. PhD. M. Mihov, Prof. Kr. Georgieva, Assoc. Prof. N. Ivanova
Institute of Soil Science, Agrotechnology and Plant Protection N.Pushkarov, Sofia;
Technical University, Faculty of Engineering and Technology – Yambol

Abstract: The report focuses on the current problems of mechanization of agricultural production, and agrarian science is seen as a subsystem of the national economy and as a continuously evolving system, characterizing the objectives of its functioning, composition and structure of its elements, as well as the way of interaction and interconnection Between its elements.

From a system point of view, mechanized technologies in agricultural production, based on agricultural mechanics, are inseparable from the processes of their organization and management.

KEYWORDS: AGRICULTURAL PRODUCTION, MACHINE TECHNOLOGY, MACHINE SYSTEM, NATURAL RESOURCES, IMPACT OF TECHNOLOGY.

The current problems of the mechanization of agriculture are as follows:

- Rational use of natural resources; Increasing environmental requirements for agricultural machinery;
- Development of resource-economical ecological machinery for agriculture. .
- Intensification of agricultural production;

- Developing a strategy for the development of agrarian science.

Natural resources - these are the means of existence for people which are not created with human labor, but are found in nature. These include water, soil, plants, animals, minerals that are used either directly or in a processed form and can be exhaustible and inexhaustible (Fig.1).

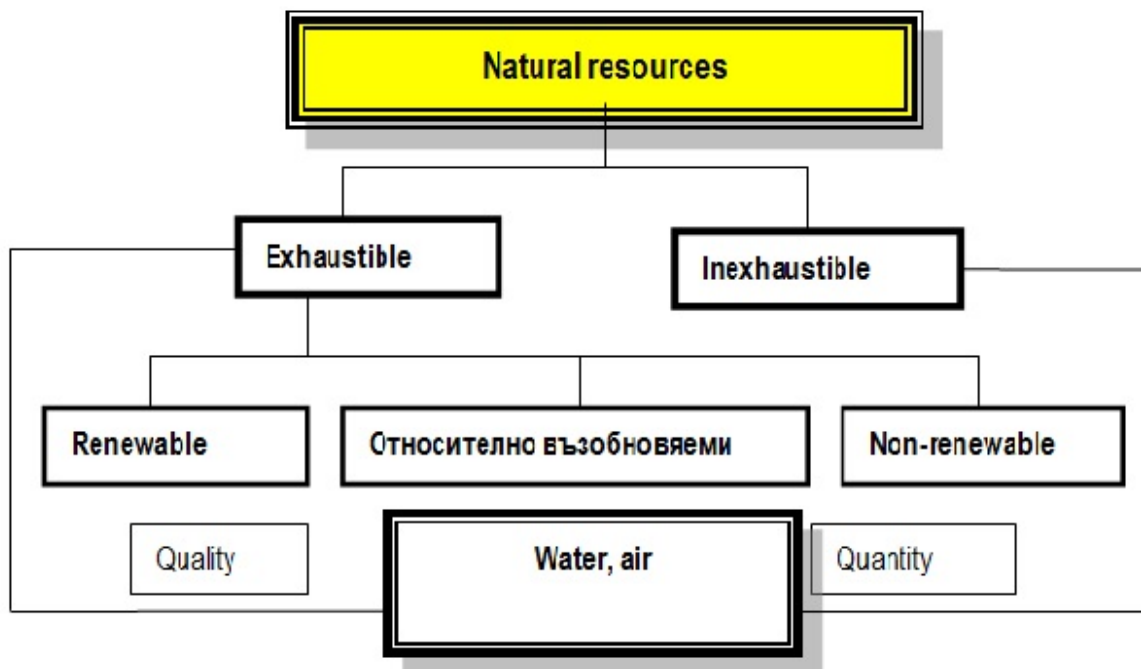


Fig 1. Classification of natural resources based on exhaustiveness and renewability.

Exhaustible resources are divided into renewable, relatively renewable and non-renewable.

Non-renewable resources - these are resources that do not recover or recover very slowly than they are used by humans in the foreseeable period of time. To them belong the riches of the bow, ie. Useful minerals. Using these resources inevitably leads to their exhaustion. Preserving these resources is based on their rational use. Soil can be attributed towards relatively renewable resources - the soil surface on land, where plant and forest resources grow. Soil is one of the most valuable and scarce resources.

Renewable resources include vegetation, the animal world and some mineral resources, such as salts that settle down from lakes and lagoons. The recovery of these resources goes at different speeds. The rate of the renewable resources should be in line with

the rate of renewal. Otherwise, renewable natural resources may become non-renewable.

Space, climate and water resources are inexhaustible resources.

In agriculture, where the soil is the basis of all material goods, the main wealth on which the existence of man depends, agricultural machinery is used, which, if it does not meet certain requirements, can cause environmental pollution.

Modern highly mechanized agricultural productions create a whole range of anthropogenic factors that have a negative impact on the environment. Particularly significant and multifaceted are the impacts of the operation of mobile machinery in direct contact with soil, plants, moisture, air and other components of the biosphere.

Dangerous and irreversible processes of disturbance of the ecological state of the environment arise as a result of the impact of the machine - tractor aggregates (Fig.2).

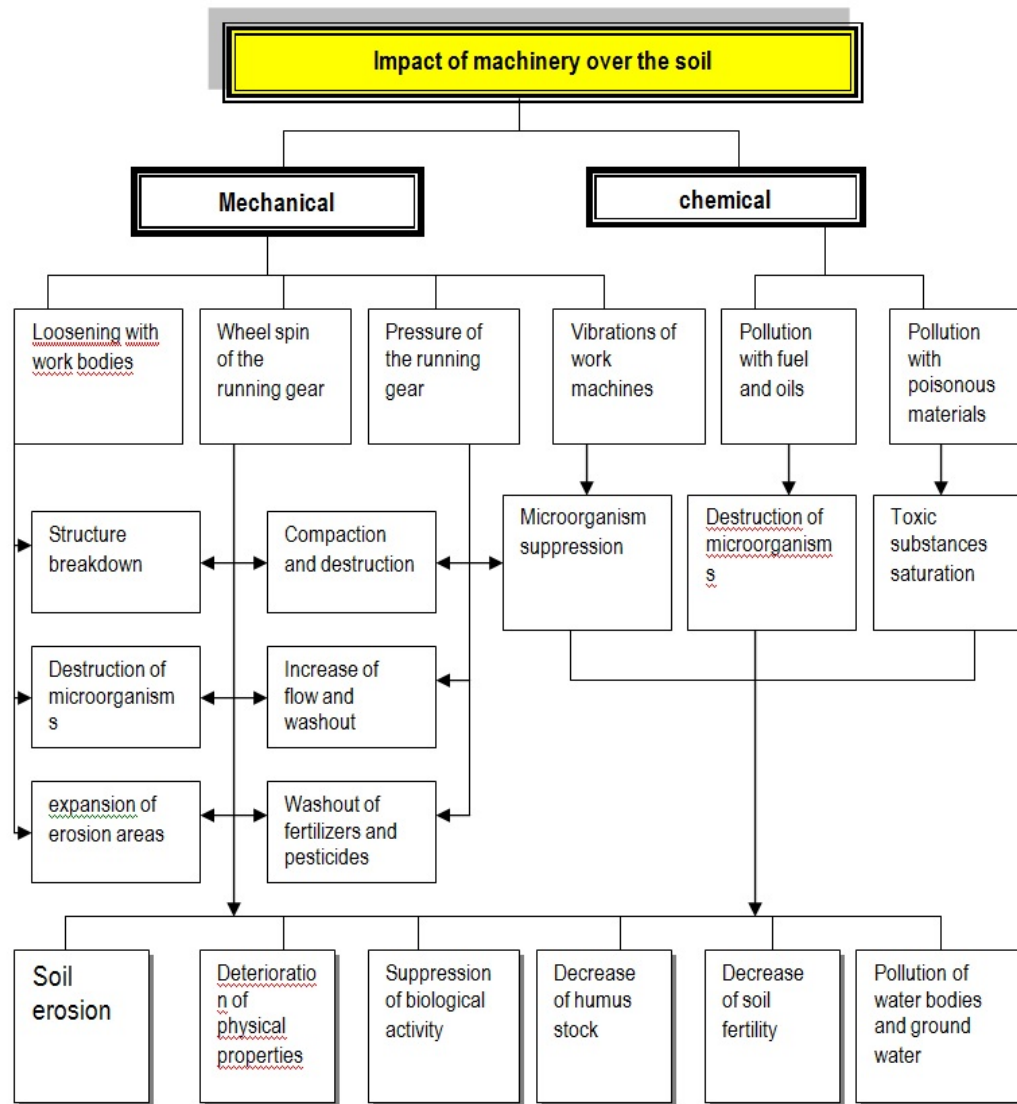


Fig.2 .. Impact of mobile machinery on the soil.

The analysis of the results of the multi-annual research as well as the study of the international experience allows to formulate the basic requirements for the mobile agricultural machinery. It should be characterized by:

- High structural reliability and high efficiency in performing technological operations in accordance with agrotechnical requirements and minimizing soil pollution with fuels, lubricants and plant protection chemicals;
- Sustainable impact of work organs on the soil, ensuring the preservation of the fertility of the soil and significant reduction of the energy consumption;
- Minimal soil dusting of the working organs on the soil, reducing the influence of the machines on the water, wind and mechanical erosion, as well as the maximum preservation of the moisture in the periods of drought;
- Optimal combination of working organs, adapted to the different soil conditions, providing high efficiency soil treatment and intensive weed control with minimal use of herbicides;
- Creation of promising combined machines, aggregates and working bodies, minimizing the cultivation of the soil in the cultivation of different crops.

World experience shows that the problem of intensification of agricultural production through universal increase of labor productivity is a task both for science and for practice, and the main

factors for realization are: knowledge, new technologies, new machines, qualification and information.

Consequently, the engineering sphere under the new conditions is a basic engine for productivity growth, and in the field of agriculture, the realization of this goal in the agrarian policy is possible through the optimization of:

- Machine system;
- The system of machine technology for production of products;
- The system of using the technique.

The development of agricultural production should be based on high-energy aggregates and strict compliance with the requirements of technologies for production of quality production, ecologically clean.

Trends in the development of agricultural machinery are:

- Multilateral expansion of the nomenclature of machines and assembly units and assemblies;
- increased productivity and reduced labor, maintenance, repair and regulation costs;
- automation of control and management of MTA;
- environmental protection;
- technical aesthetics and creation of comfort and safety conditions of mechanists;
- widespread use and further upgrading of electric and hydro-drives in tractors, combines and other complex machines.

It is proven that the most powerful and economical factor of productivity is the system of efficient use of the machinery.

The system for using the machinery must solve the following economic, technological, technical and organizational problems:

- economic problems:
 - cost optimization related to the operation of machines;
 - establishment of a system for renovation of the park of machines;
 - an individual approach to pay for work;
 - motivation of the mechanics for high quality of the technological operations.
- technical issues:
 - selection and utilization of resources - economical technologies of the production processes;
 - preparation of the aggregates for the implementation of the technical processes, quality control system;
 - use of aggregates over the season to achieve optimal annual load and transitions.
- technical issues:
 - Choice of optimal periodicity for maintenance and repair of machines;
 - developing a system for supplying spare parts to maintain the machine's working ability;
 - creating an optimal logistics system for distribution and management of spare parts and resources stocks;
- organizational problems:
 - formation of efficient enterprises for agricultural production;
 - Creating an efficient service system of agricultural technology and technology.

Development of resource-saving ecological machine technologies for agriculture.

The basis of the developed resource - saving ecological machinery technologies for agriculture. Specific crop varieties, soil and climatic conditions intended for the final production should be laid down.

In the source data and varieties of agricultural crops should be included:

- the potential of the variety of productivity;
- susceptibility to disease and pest damage;
- mechanical characteristics;
- variety of use of the given variety;
- a place in the crop rotation;

- Continuous storage mode.

Characteristics of soil conditions include:

- Mechanical composition;
- humus content;
- tendency to thicken.

Characteristics of the natural conditions are:

- Sum of annual rainfall by periods;
- Number of solar by period of basic field work;
- Number of days without precipitation;
- Temperatures for the growing season of an agricultural crop (from sowing to harvesting).

In the machine technology, the destination of the final agricultural product (grain, root crops, etc.) must be clear. For what purposes the crop is grown: seed, industrial needs, animal feed, etc.

The process of creating new technologies must be accompanied by a developed technical specification for the technology that will implement the technology.

The technology can be recognized as new if it allows to increase yields above 10% compared to the achieved level, provided that the environmental performance, shelf-life and environmental impact indicators are not lower than the achieved analog technology , Which has been used so far.

The test is conducted with a comprehensive assessment of technology and machines in interaction with humans, nature and end product.

Agrarian science should be seen as a subsystem of the national economy and as a continuously evolving system, characterizing the objectives of its functioning, composition and structure, as well as the way of interaction and the interrelation between its elements.

From a system point of view, industrial technologies in agricultural production, based on agricultural machinery, are inseparable from the processes of their organization and management. And the more complex the technology, the greater the efficiency gains of using these two elements (organization and management) of production systems. In fact, agricultural mechanics are an integral part of industrial technology, and the latter are part of the technological process of the modern production system.

The technological processes in agriculture (the production system) are realized in a complex organizational system (fig. 3), which has input and output connections with external systems.

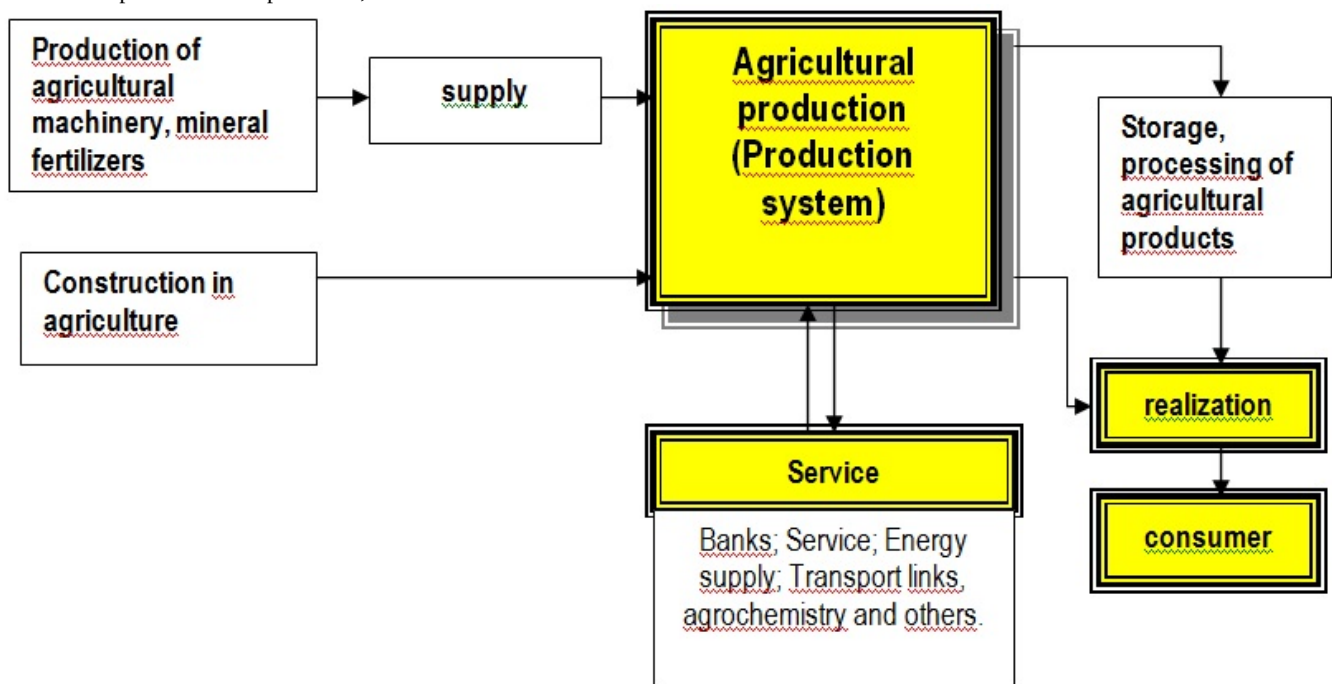


Fig.3. Organization structure of agricultural production

Systems in agriculture in aggregate have two main elements: organic (land - plants - animals) and service (human - technics). Therefore, agricultural production is:

- a complex system that is dependent on the government system;
- an open and highly dependent system of industry, investment, population;
- a manageable system, the main element of which is the person to be motivated.

To develop a strategy for the development of agrarian science, it is necessary to use a general scheme (fig. 4), considering agricultural production as an "open system", which has three states:

- future state (where do we want to be?);
- current state (diagnosis and identification of where we are currently?);
- transition (where and how do we manage?).

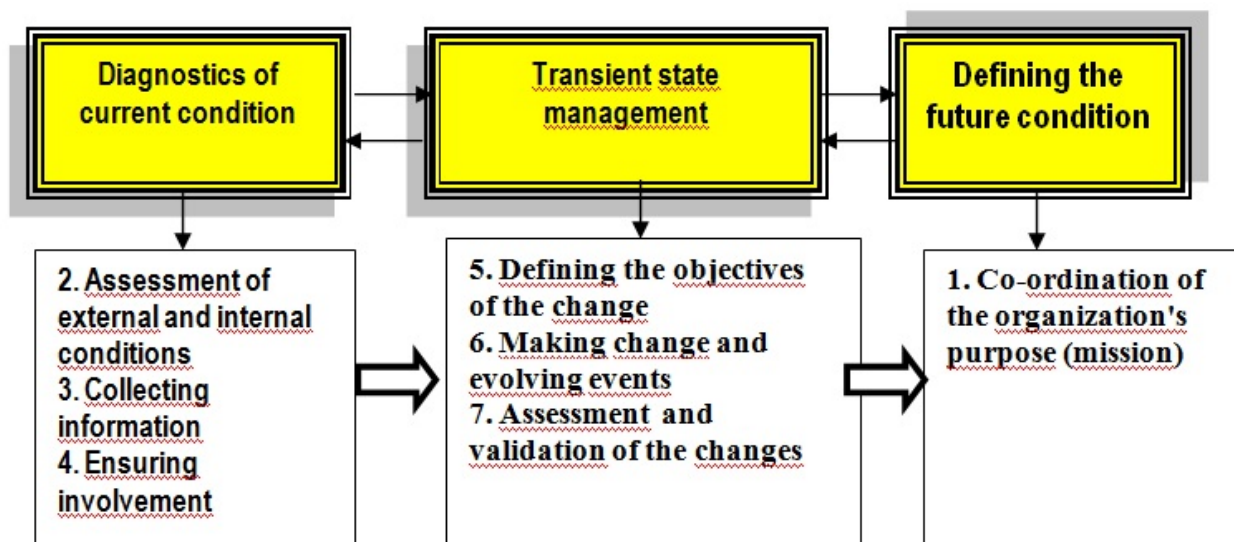


Fig.4. Organizational development process

In conclusion, agricultural production is a complex system, a system where many interests and factors are encountered, an open system that is exposed to risks - natural and environmental, but agrarian science, if interwoven in any element of this system, will improve its functioning efficiency.

Resources :

1.Тасев Г. Механизация на земеделското производство.-С.,2014.

2.Георгиева К. Съвременни механизирани технологии в земеделието.-Ямбол,2015.

3. Михов М., И.Гайдаров. Влияние на техническото състояние на тракторите и самоходните земеделски машини върху околната среда, сп.Механизация на земеделието, 2001, N4, с.12-14.

4.М.Михов, Г.Тасев - Техническо обслужване и ремонт на машините, С., 2012 г., стр.149.

STUDYING CORRESPONDENCE OF RAGWEED POLLEN'S AIRBORNE CONCENTRATION AND THE NEW GREENING MEASURES UNDER THE COMMON AGRICULTURE POLICY

M.Sc. Surek Gy.¹, M.Sc. Mátyóki G.², M.Sc. Csonka B.³, M.Sc. Kajtor-Apatini D.², M.Sc. Udvardy O.², M.Sc. Nádor G.¹, Prof. M.Sc. Kazinczi G. PhD.⁴, M.Sc. Vojnich V.J. PhD.⁵, M.Sc. Magyar D. PhD.²

Government Office of the Capital City Budapest, Department of Geodesy, Remote Sensing and Land Offices, Budapest, Hungary¹

National Public Health Center, Department of Air Hygiene and Aerobiology, Budapest, Hungary²

Hungarian State Treasury, Department of Direct Payments, Budapest, Hungary³

Kaposvár University, Faculty of Agricultural and Environmental Sciences, Institute of Plant Science, Kaposvár, Hungary⁴

Pallas Athena University, Horticulture and Rural Development, Kecskemét, Hungary⁵

vojnich.viktor@kfk.kefo.hu

Abstract: Common ragweed (*Ambrosia artemisiifolia*) is considered as an invasive alien weed species. Based on the former field surveys, five million hectares, cca. 85% of the Hungarian agricultural area is endangered by ragweed; while around 0.7 million hectares are strongly infected. Cereal stubble is a major habitat of late-growing ragweed populations. Almost 60% of allergic patients (meaning 1.5-2 million people) suffer from ragweed pollen allergy in Hungary. Pollen concentration was measured in the air using Hirst-type pollen traps from year 2000 to 2016 at 19 monitoring stations in Hungary. A map of the crop types were created, using declared parcels of area based payments, validated by remote sensing data. Linear regression was applied to calculate relationship between seasonal pollen index and crop types at each monitoring stations. Our results showed that the land cover area of cereals, corn and sunflower showed positive correlation with ragweed pollen concentrations. This positive correlation had been changed in 2016 that is why we had started to analyse the changes of the system and their potential effects. Unexpectedly, the pollen concentration decreased rapidly in early September of 2016. No precipitation occurred at this time, i.e. reduction of pollen level could not be explained by the wash out of pollen grain from the air by raindrops. Among the possible reasons, the effect of the newly introduced greening obligations related to the area based direct payments (based on the EC regulation 1307/2013) was concerned. The new diversification requirement under the greening contains the possibility of planting catch crops between successive plantings of a main crops, that is why it have a direct effect on the arable stubble management. It is supposed that the late-growing ragweed populations may be suppressed by the catch crops. In order to perform effective ragweed eradication, further studies are needed to optimize agricultural technologies of stubble management.

Keywords: RAGWEED, POLLEN, GREENING, REGULATION, STUBBLE

1. Introduction

Common ragweed (*Ambrosia artemisiifolia*) is considered as an invasive alien weed species. Based on the former field surveys, five million hectares, cca. 85% of the Hungarian agricultural area is endangered by ragweed; while around 0.7 million hectares are strongly infected. Cereal stubble is a major habitat of late-growing ragweed populations. Almost 60% of allergic patients (meaning 1.5-2 million people) suffer from ragweed pollen allergy in Hungary. Pollen seasons are characterized by high pollen levels (>30 pollen/m³) from early August to the end of September, but very high levels (>100 pollen/m³) dominate between the periods of mid August and mid September. There are several methods to control ragweed, including agrotechnical, mechanical, physical, chemical and biological ones [1]. Agricultural politics and financing system has a major influence on the ragweed infestation [2,3]. Ministerial decree (10/2015. (III. 13.)) nominates *Ambrosia artemisiifolia* among dangerous weeds, expressing that it's significant presence precludes the payments and leads to non-compliance of Good Agriculture and Environmental Conditions (GAEC). Moreover the new diversification requirement under the greening contains the possibility of planting catch crops between successive plantings of a main crops based on the newly introduced greening regulation of the Common Agricultural Policy, No 1307/2013 of the European Parliament and of the Council. The Member States had been given the choice to implement different measures according to their own priorities and interest [4], but the diversification of arable crops and to maintain ecological focus area (EFA) on 5% of the arable land is compulsory. Greening has been introduced in Hungary since 2015, offering the possibility of counting as EFA arable parcels with land lying fallow, catch crop and nitrogen fixing crops [5]. The aim of our study is to analyse the potential effect of the new greening measures on the airborne concentration of ragweed pollen.

2. Materials and Methods

The study has been conducted for 4 years (2013-2016) including two drought years (2013 and 2015). Ragweed pollen data were collected at 19 sites using volumetric spore traps of the Hirst design [6] situated at roof level. Air is sucked into the trap at a rate of 10 l/min through a 2 mm x 14 mm orifice. Behind the orifice the air flows over a rotating drum (or microscope slide) that moves past the inlet at 2 mm/h and is covered with an adhesive coated, transparent plastic tape. Following its removal from the trap, the tape is divided into segments corresponding to 24-h periods (48 mm in length). Each segment is mounted between a glass slide and cover slip using a mixture that contains basic fuchsin. The samples are then examined by light microscopy and pollen grains were generally identified at 400 × magnification. Slides were examined along two longitudinal transects following the method described in literature. Due to difficulties such as trap failure several datasets contained missing values. Missing values were replaced by the mean daily average pollen count for that day at the site in question. Daily pollen counts summarized to count yearly the total pollen concentration (so-called seasonal pollen index).

A map of the crop types were created based on anonymous database of declared parcels for area based payments (Agricultural and Rural Development Agency, Hungary/MVH). The map was validated with remote sensing methods [7]. For statistical analysis, the following crops types often having ragweed infestation were selected: cereals, corn, sunflower, oilseed rape, soybean and fallow lands. The total annual land cover areas of these crops were calculated within a certain distance (30 kms) from each pollen monitoring station. Linear regression was applied to calculate relationship between seasonal pollen index and crop types at each monitoring stations.

3. Results

High ragweed pollen concentrations were detected between 2013 and 2016 (Table 1). Ragweed pollen levels were especially high in 2014 and 2016 (6842 and 7221 avg. seasonal pollen index, respectively, while lower in 2013 and 2015 (4046 and 5439). Unexpectedly, the pollen concentration decreased rapidly in early September of 2016 (Fig. 1.).

Table 1. Seasonal pollen index of ragweed (*Ambrosia artemisiifolia*) between 2013 and 2016 in 19 monitoring stations in Hungary. n.d.: no data.

pollen monitoring stations	2013	2014	2015	2016	avg.
Budapest	2 241	3 322	2 334	6 389	3 572
Békéscsaba	7 093	12 220	6 273	8 305	8 473
Debrecen	5 583	10 613	5 530	15 924	9 413
Eger	1 514	3 974	3 111	2 514	2 778
Győr	4 219	5 055	9 731	7 394	6 600
Kaposvár	5 344	6 768	10 148	8 611	7 718
Kecskemét	6 551	12 499	8 107	11 830	9 747
Miskolc	n.d.	5 392	3 348	4 676	4 472
Nyíregyháza	5 185	16 262	3 326	5 069	7 461
Pécs	4 142	5 441	5 111	6 645	5 335
Salgótarján	1 831	2 662	2 487	n.d.	2 327
Szeged	2 285	6 866	4 348	5 901	4 850
Székesfehérvár	5 702	7 691	6 218	6 759	6 593
Széksárd	4 418	5 784	4 938	6 733	5 468
Szolnok	5 480	9 114	6 076	6 703	6 843
Szombathely	3 148	2 243	n.d.	4 539	3 310
Tatabánya	1 694	4 925	5 845	9 472	5 484
Veszprém	3 496	6 125	7 968	8 546	6 534
Zalaegerszeg	2 899	3 039	2 996	3 971	3 226
avg.	4 046	6 842	5 439	7 221	5 800

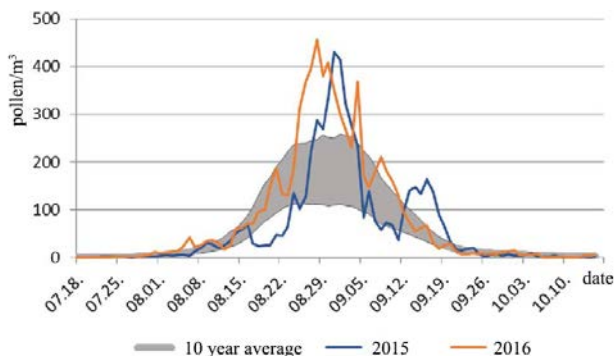


Fig. 1. Pollen concentration of ragweed (*Ambrosia artemisiifolia*) in 2015 and 2016, average of 19 monitoring stations in Hungary.

In this period, the dominant crops were cereals, corn, sunflower, oilseed rape, fallow lands and soybean in descending order of frequency (Fig. 2.)

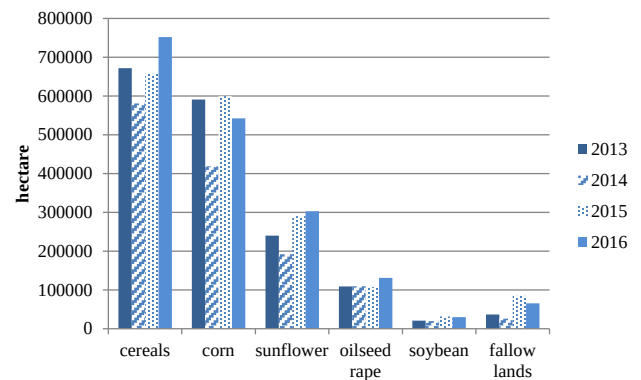


Fig. 2. Total area of crops in 30 km radius of the Hungarian pollen monitoring stations in 2013-2016.

The land cover area of cereals, corn and sunflower showed positive correlation with the pollen concentrations in 2013, 2014 and 2015 (Table 2.). However the correlations of cereals turned to negative in 2016 but this is not a significant trend (Fig. 3.). The correlation was negative in oilseed rape and soybean in all years, except for rape seed in 2015. Fallow lands showed positive correlation only in one year (2014).

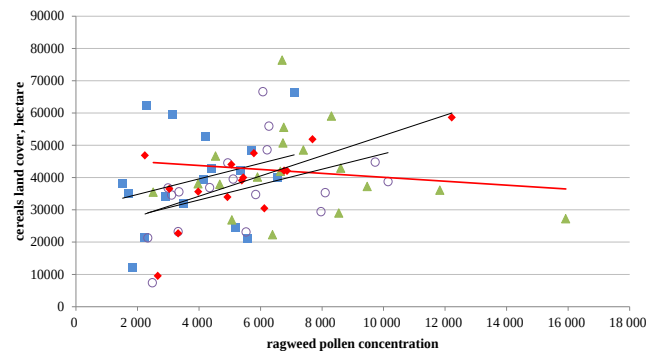


Fig. 3. The effect of total land cover area of cereals (in hectare) on the seasonal pollen index of ragweed (*Ambrosia artemisiifolia*) between 2013 and 2016 at the 19 monitoring stations in Hungary. Square: 2013, circle: 2014, triangle: 2015, diamond: 2016. Trend lines: black: 2013-2015, red: 2016.

Table 2. Result of regression analysis between the seasonal pollen index of ragweed and total area of crop types in 30 km radius of the Hungarian pollen monitoring stations.

year	crop type	degree of freedom	R (crop vs. pollen)	R ² (crop vs. pollen)	significance of trend (p value)
2013	cereals	16	0.486	0.237	0.041
	corn		0.584	0.341	0.011
	sunflower		0.534	0.285	0.022
	oilseed rape		-0.064	0.004	0.801
	fallow land		-0.235	0.055	0.348
	soybean		-0.020	0.000	0.936
2014	cereals	17	0.168	0.028	0.493
	corn		0.548	0.301	0.015
	sunflower		0.559	0.312	0.013
	oilseed rape		-0.385	0.148	0.104
	fallow land		0.028	0.001	0.909
	soybean		-0.302	0.091	0.210
2015	cereals	16	0.423	0.179	0.081
	corn		0.218	0.048	0.384
	sunflower		0.095	0.009	0.707
	oilseed rape		0.133	0.018	0.598
	fallow land		-0.063	0.004	0.803
	soybean		-0.002	0.000	0.992
2016	cereals	16	-0.143	0.020	0.572
	corn		0.398	0.159	0.102
	sunflower		0.133	0.018	0.598
	oilseed rape		-0.591	0.350	0.010
	fallow land		-0.168	0.028	0.506
	soybean		-0.330	0.109	0.182

4. Discussion

Our results showed that the land cover area of cereals, corn and sunflower (especially the latter ones) showed positive correlation with ragweed pollen concentrations. It has three main agro-technical aspects:

- the ragweed infestation of the row crops are high, as to avoid the growth of the ragweed plant in a row crop is either difficult – it requires complex technology and appropriate timing – or rather expensive compared to its benefit;
- after harvesting the crop an intensive development of the ragweed starts, as the strongest competitive vegetation had disappeared and after cutting ragweed plants can intensively regenerate and form side shoots;
- the high seed density of weeds from the previous years (2013 and 2014) remains in the soil and immediately germinates on the stubble after disking as suitable weather conditions exists,

in case the lack of proper mechanical stubble management or planting a new catch crop.

This positive correlation (especially in cereals) turned negative in 2016, in the year of applying catch crop as EFA and more rigorous stubble management rules to comply with the GAEC requirements. Greening measures were introduced in spring 2015, so farmers had limited time to plan the crop rotation. On the other hand year 2015 was effected by drought that is why all the correlations were weak. The correlation was strong in 2013 and 2014. Correlation between cereals and pollen levels was stronger in 2013- a drought year, decreasing the vitality of the row crops- than in 2014. Among the different land-cover types having 'stubble' infested with ragweed cereal stubble had the highest number and area, according the database of the Hungarian Ragweed Information System. In 2016 the catch crop seeded on cereal stubble area had been increased with 28%.

Apparently, ragweed populations growing on cereal stubble are one of main sources of airborne pollen in Hungary. Although proper – weed free – stubble management is required by the GAEC rules since 2008, the EFA requirement under greening seems to have stronger effect on stubble management. Greening forces planting catch crops between successive plantings of a main crops, that is why it have a direct effect on the arable stubble management. It is supposed that the late-growing ragweed populations may be suppressed by the catch crops. Greening also offers to use fallow land as an EFA, and the rule of GAEC - including the eradication of all dangerous weeds – are more strictly kept by the farmers. Proper and the required fallow land management opens the possibility of germinating the ragweed seeds on a way that no arable crop is damaged, and decreasing significantly the seed content of the soil by eliminating the plant before flowering.

Albeit the average seasonal pollen index was high, an unexpected, rapid decrease in pollen concentration was observed in early September of 2016. Similar drop in pollen levels is usually caused by precipitation (pollen grains are washed out from the air). However, no precipitation occurred in this time. It seems that greening may have a positive effect on ragweed pollen concentration, i.e. reduction of airborne allergen burden of the human population. However further studies are needed with an extended period of monitoring the new measure to confirm this suspicion. Greening of cereal crops (stubble) in Somogy county (West Hungary) in 2016 are illustrated in Fig. 4. and Table 3.

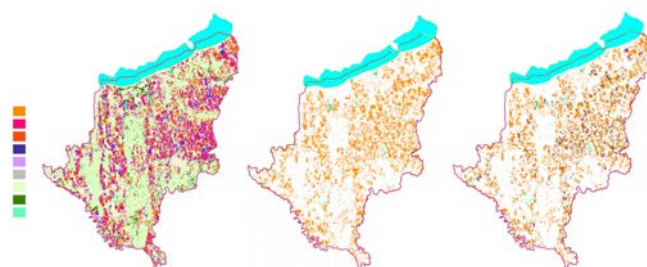


Fig. 4. Land cover map of Somogy county (West Hungary) in year 2016. yellow: cereals, red: corn, orange: sunflower, dark blue: oilseed rape, purple: soybean, grey: fallow lands, light green: forest, dark green: pastures, blue: water. Left: all crops, middle: cereals, right: cereals (stubble) and greening (brown).

Table 3. Quantitative data of greening in Somogy county, in year 2016.

categories	area (ha)
eligible area	309 255
total area of cereals	88 649
total catch crop area (declared for greening)	20 623
total area of catch crops on cereal stubbles (declared for greening)	13 367

The potential effect of this change in the arable land management technology on the pollen levels could be quantified by remote sensing techniques measuring the area and timing aspects of stubble-fields existence with and without the cultivation of catch crops and with and without the presence of herbaceous weeds on the stubble. In order to perform effective ragweed eradication, further studies are needed to optimize the combination of different agricultural technologies of stubble management. Besides greening the application of other agricultural methods could also be considered, e.g. crop rotation, mechanical cutting/disking of ragweed before flowering. The effectiveness of ragweed control measures could be monitored by pollen observation [8] as well as by satellite observation and its validation with on-the-spot observations of ragweed plants.

4. Conclusion

Ragweed area, the air pollen concentration and its correlations with other elements had been monitored in Hungary for many years, and we have noticed an unexpected change in 2016. Looking for the potential reasons, we had found that the Hungarian GAEC and greening rules forces several crop management technological actions targeting the decrease of ragweed infection. Our study found that apparently greening could become an effective tool in ragweed control, as most probably the required activities caused the decrease of the air pollen content at mid-summer period that is why it needs more study and more years to test if it has significant impact on airborne ragweed pollen levels.

5. References

- [1] Kazinczi, G. – Novák, R.: Integrated Methods for Suppression of Ragweed. National Food Chain Safety Office, Directorate of Plant Protection, Soil Conservation and Agri -environment, Budapest (2014)
- [2] Kiss, L. – Béres, I.: Anthropogenic factors behind the recent population expansion of common ragweed (*Ambrosia artemisiifolia* L.) in Eastern Europe: is there a correlation with political transitions? – J. Biogeogr. (2006) 33: 2156–2157.
- [3] Pinke, Gy. - Karácsony, P. – Czúcz, B. - Botta-Dukát, Z.: Environmental and land-use variables determining the abundance of *Ambrosia artemisiifolia* in arable fields in Hungary. Preslia (2011) 83(2), 219-235.
- [4] Burny, P.: Greening of the Common Agricultural Policy: implementation in Wallonia (South of Belgium). Calitatea (2014) 15(S1), 103.
- [5] Csonka, B. - Tapsonyi, T. - Szabó, E. – Szerletics, Á.: Managing EFA declarations and the development of LPIS in year 2015. GAEC WS – Prague (2015)
- [6] Hirst, J.M.: An automatic volumetric spore trap. Ann. Appl. Biol. (1952) 39(2), 257-265.
- [7] Surek, Gy. – Nádor, G. – Hubik, I. – Gera, D. – Kulcsár, A. – Török, C.: Advances in ragweed identification by remote sensing, Second International Ragweed conference, 28-29 March, 2012, Lyon, France (2012)
- [8] Sikoparija, B. – Skjøth, C. – Celenk, S. – Testoni, C. – Abramidze, T. - Alm Kübler, K. – Belmonte, J. – Berger, U. – Bonini, M. – Charalampopoulos, A. – Damialis, A. – Clot, B. – Dahl, Á. - de Weger, L.A. – Gehrig, R. – Hendrickx, M. – Hoebeke, L. – Ianovici, N. - Kofol Seliger, A. – Magyar, D. – Mányoki, G. – Milkovska, S. – Myszkowska, D. – Páldy, A. – Pashley, C.H. – Rasmussen, K. – Ritenberga, O. – Rodinkova, V. – Rybniček, O. – Shalaboda, V. – Šaulienė, I. – Ščevková, J. – Stjepanović, B. – Thibaudon, M. – Verstraeten, C. – Vokou, D. – Yankova, R. – Smith, M.: Spatial and Temporal Variations in Airborne *Ambrosia* Pollen in Europe. Aerobiologia, 1-9. (2016)

ON THE ISSUE OF REDUCING THE HARMFUL INFLUENCE OF THE MOBILE AGRICULTURAL SYSTEMS UNITS ON THE SOIL

Prof. Doc. Eng. Adamchuk V.¹ PhD., Doc. Eng. Pogoriliy S.¹ PhD., Prof. Doc. Eng. Beloev H.² PhD., Prof. Eng. Kangalov P.², PhD,
Prof. DrSc. Eng. Borisov B.² PhD., Assos. prof. Eng. Mitev G.² PhD.

¹National Scientific Centre, "Institute for Agricultural Engineering and Electrification",
11, Vokzalna Str., Glevakha – 1, Vasylkiv District, Kiev Region, 08631, Ukraine,

²"Angel Kanchev" University of Rousse, 8, Studentska Str., 7017 Ruse, Bulgaria

Abstract: The article is devoted to the problem of increasing the efficiency of using mobile agricultural aggregates by reducing the impact of their running systems on the soil. The work on the efficiency of the use of mobile agricultural units based on the automobile chassis in agroindustrial production is analyzed, which shows the results of studies on the changes in their designs with the purpose of reducing the harmful influence of chassis running systems on soil. One of the ways to reduce the harmful influence of running systems of mobile agricultural units on Execution of technological operations, both in field conditions and in transport operations while driving along the road Mobile roads. The main ways that will ensure the effective use of the automobile chassis in field conditions and on highways are analyzed. It has been found that the most effective is the equipment of automobile chassis with wide – profile tires with adjustable internal air pressure and a tire – pumping control system, which makes it possible to effectively use the chassis both in the main technological operations (in the field) and in transport operations (on the roads). The influence of the air pressure in the tire of the wheel of the running system of the KrAZ – 6322 automobile chassis and the normal load on the contact area of the tire with the supporting surface and pressure on it is established. To use the automobile chassis for performing agricultural operations in field conditions, it is necessary to equip it with wide – profile tires with adjustable internal air pressure and a tire – pumping monitoring system that will reduce the negative impact on the soil of the mobile agricultural unit and expand the list of technological operations on which it can be used.

KEYWORDS: UNDERCARRIAGE, AUTOMOBILE CHASSIS, TIRES, AIR PRESSURE IN TIRES, GROUND PRESSURE, TIRE CONTACT AREA.

1. Introduction

With the growth of the country's economy, the agricultural sector every year increases its share in it. Conducting intensive production of agricultural products allowed to increase the yield of crops. To minimize crop losses, adequate technical support is needed, which in turn should be formed on energy resources with a high annual load and versatility. To address these issues, you can use mobile agricultural units (MAU), formed on the basis of a car chassis for performing technological operations. They are becoming more and more widespread among producers of agricultural products and more and more factories of manufacturers of trucks are creating their modifications for agricultural production [1 – 11]. However, the issue of the influence of running chassis systems on the ground is not given much attention in terms of reducing their negative impact.

2. Preconditions and means for resolving the problem

2.1. Analysis of recent research and publications

With the development of technological progress, the tractor as an energy tool for performing agricultural operations loses its monopoly. Automobile plants Mercedes, MAN, Tatra, KamAZ, Ural, KrAZ, Joskin [1 – 11] create automobile chassis that can be used in agro – industrial production for technological operations with: introducing various technological materials, tillage, sowing, crop care, Transport operations and the like. In the spring period, when the soil has high humidity and is prone to compaction, special attention is paid to the influence of running systems on the soil, but the MAU must have high traction values. To solve this problem, the above – mentioned plants equip the automobile chassis with low – pressure tires with large structural dimensions and an improved terrain protector. Such tires work effectively in field conditions, and on highways will quickly wear out. The speed of movement of such MAU is limited by the characteristics of the tire and will average 25 – 30 km·h⁻¹.

Under such conditions, the main advantage due to which cars have in front of tractors and can reduce the cost of production of crop production is the increase in the transport speed of traffic on

the roads and, as a derivative of it, the use of straight – through schemes for the introduction of technological materials – is leveled. Installations on the car chassis of the serial tires used for road traffic will lead to ultra – high pressure of its running systems on the soil, low load – bearing capacity, and as a result, crop losses [12, 13], increase in energy costs for production due to increased skid.

The foregoing leads to a contradiction, the essence of which is that the MAU based on the automobile chassis are effective in transport operations when driving roads, and at the same time have low possibility in field conditions and have a negative impact on the soil and vice versa: MAUs that have high cross – country capability In field conditions, and compact the soil a little, develop a low transport speed on highways and have a high intensity of tire wear.

2.2. Purpose of the research

The aim of the research is to find ways to expand the technological capabilities of the automobile chassis by reducing the harmful impact of its running system on the soil.

3. Results and discussion

The autofactory KrAZ plant produces KrAZ-6322 automobile chassis, MAU [14, 15] (Fig. 1) was developed at the National Research Center "Institute for Mechanization and Electrification of Agriculture", which are devoid of the drawbacks mentioned above.

The KrAZ-6322 automobile chassis (Fig. 2) is equipped with a centralized control system for pumping the tires of the wheels, which allows reducing the air pressure in them while performing technological operations in the field up to 80 – 150 kPa and increasing it to the recommended 300 – 350 kPa for transport crossings. Also, the pneumatic system allows you to adjust the air pressure during the process operation as the amount of process material in the hopper of the attachment is reduced.

The KrAZ-6322 automobile chassis is fitted with VI – 3 tires, which have the ability to withstand loads when the air pressure in them decreases. This is a diagonal tire with a protector of hanging patency, the maximum load on the tire is 39.3 kN, the pressure of compressed air can be in the range of 0.08 – 0.35 MPa [16].



a)



b)

Fig. 1. – MAU on the basis of the automobile chassis produced by PJSC AvtoKrAZ with machines for the introduction of solid: a) – mineral fertilizers MDA – 9A; B) – organic fertilizers AROD – 11.



Fig.2. – Car chassis KrAZ-6322

The influence of the running systems on the soil depends on the area of contact of the tire of the wheel and the normal load on it. The area of contact, in turn, depends on the size and design of the tire, the air pressure in it and the load on it. With increasing air pressure in the tire, the contact area decreases. An increase in the tire load at a constant pressure in it also increases its contact area.

For the VI – 3 tire, the contact area was determined (Fig.3) according to the standardized procedure GOST 7057 – 2003 [17].



a)



b)

Fig. 3. – Imprint of the tire model VI – 3 at a load of 17.1 kN and air pressure in the tire: a) – 0.20 MPa; b) – 0.08 MPa

As can be seen from Fig. 3 with a decrease in the pressure in the tire, the area of the support surface increases almost twofold, from 814.7 cm² at a pressure of 0.20 MPa to 1616.24 cm² at a pressure of 0.08 MPa. The wheel pressure on the bearing surface is 103.5 kPa with air pressure in the tire of 0.08 MPa, and at a tire pressure of 0.2 MPa, 205.5 kPa.

The results of experimental studies of the effect of air pressure in the tire on the area of its contact and normal load (17.1, 24.7 and 33.2 kN) are presented in Fig. 4.

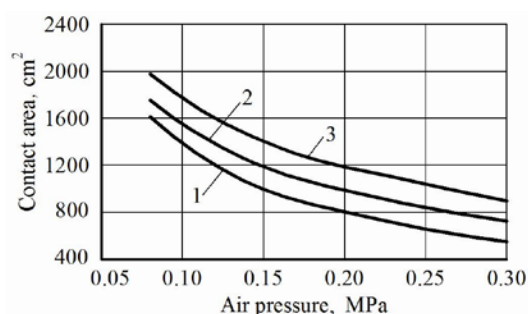


Fig. 4. – Dependence of the contact area of the tire model VI – 3 on the air pressure in it with the load on the wheel: 1 – 17.1 kN; 2 – 24.7 kN; 3 – 33.2 kN

In this case, the average pressure on the reference surface will have the following relationship, which is shown graphically in Fig. 5.

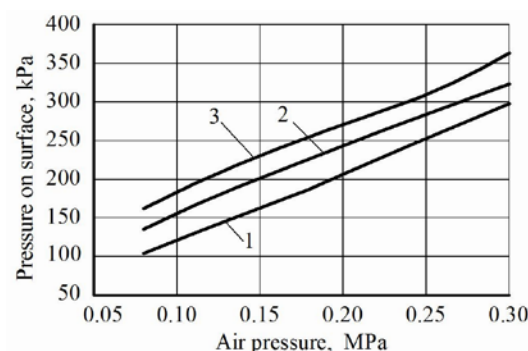


Fig. 5. – The dependence of the average pressure on the bearing surface of the wheel of the MAU on the air pressure in it with the load on the wheel: 1 – 17.1 kN; 2 – 24.7 kN; 3 – 33.2 kN

From Fig. 5 it can be seen that as the air pressure in the tire decreases, its pressure on the bearing surface decreases. So, for example, with a wheel load of 17.1 kN and an air pressure in the tire of 0.08 MPa, the pressure on the bearing surface is 103.6 kPa. As

the load on the wheel increases, the pressure on the bearing surface is predicted to increase. So, with a wheel load of 24.7 kN and an air pressure in the tire of 0.08 MPa, the pressure on the bearing surface is 138.0 kPa.

According to the state standard DSTU 4521: 2006 [18], which regulates the permissible maximum pressure on the soil, differentiated by the granulometric composition and humidity during the passage of running systems on the ground, at 0.6 – 0.7 HB permissible maximum pressure on the ground running systems should be: in the spring 60 – 100 kPa; in summer and in autumn – 120 – 140 kPa.

Given that the contact area of the tire was determined on a solid support surface. In field conditions, due to soil compaction, the wheel will have a large contact area and will reduce the average pressure of the MAU running system to the soil.

Taking into account the above, the MAU on the basis of the KrAZ-6322 automobile chassis, which is fitted with the VI – 3 tire and the tire – pumping system for field operations, will create pressure on the soil within the limits of the DSTU standard 4521: 2006.

4. Conclusions

To use the automobile chassis for performing agricultural operations in field conditions it is necessary to equip it with wide – profile tires with adjustable internal air pressure and a tire – pumping monitoring system that will reduce the negative impact on the soil of the MCA and expand the list of technological operations on which it can be used.

5. References

1. Dzotsenidze T.D. Technological structure and transport support of agricultural production of some foreign countries / T.D. Dzotsenidze, M.A. Kozlovskaya // Tractors and agricultural machinery, 2014. – No. 1. – P. 44 – 47.
2. The electronic resource <http://www.a-mag.eu>.
3. The electronic resource <http://www.doskaurala.ru/index.php?id=4268018780>.
4. Electronic resource <https://www.youtube.com/watch?v=NdeLw7UYXPs>.
5. Izmailov A.Yu. Efficiency of new transport technologies in the agroindustrial complex / A.Yu. Izmailov, N.E. Evtushenko // Agricultural machines and technologists, 2009. – No. 2 (9). – P. 32 – 37.
6. Izmailov A.Yu. Benchmarking for agricultural trucks / A.Yu. Izmailov, N.E. Evtushenko, T.D. Dzotsenidze, A.G. Levshin

// Agricultural machines and technologists, 2012. – № 6. – P.15 – 18.

7. The electronic resource <http://www.pk-agromaster.ru/9800a>.
8. Electronic resource <https://www.youtube.com/watch?v=ygUPc9vIVfQ>.
9. Shkel A.S. Investigation of the technology of introducing liquid organic fertilizers by a transport – technological aggregate for agricultural purposes / A.S. Shkel, M.A. Kozlovskaya, T.D. Dzotsenidze // Tractors and agricultural machinery, 2016. – No. 7. – P. 47 – 50.
10. Dzotsenidze T.D. Functional purpose of cars for rural settlements / T.D. Dzotsenidze, A.G. Levshin, N.E. Evtushenko, M.A. Kozlovskaya, A.E. Myagkov // Tractors and agricultural machinery, 2012. – No. 4, – P. 8 – 11.
11. Adamchuk V.V. Use of an automobile chassis for performing technological operations in agro – industrial production / V.V. Adamchuk, S.P. Pogoriliy // Motrol "Commission of Motorization and Energetics in Agriculture", Vol. 18, No. 8. Lublin – Rzeszow 2016. – P. 93 – 98.
12. Rusanov V.A. The problem of soil re – consolidation by propulsors and effective ways to solve it. – Moscow: VIM, 1998. – 368 p.
13. Kravchenko V.I. Soil compaction by machines. – Alma – Ata: Science, 1986. – 96 p.
14. Adamchuk V.V. Using a truck chassis for fertilizer application / V.V. Adamchuk, S.P. Pogoriliy // Collection of scientific works UkrNDIIP of L. Pogorilogo "Technical and technological aspects of development and technology for the new technology and technology for the Sypian state of Ukraine", Doslidnicke, 2016. – Vip.20 (34). – P. 62 – 70.
15. Adamchuk V.V. On the use of automobile chassis in agro – industrial production / V.V. Adamchuk, S.P. Pogoriliy // Scientific and technical journal "International agroengineering", Kazakh NIIMESH. Almaty. – 2016. – Vol. 2 (No. 18). – p. 4 – 12.
16. GOST 13290 – 90. Tires with adjustable pressure. Technical conditions. – M. IPK Publishing house of standards. – 1991. – 22 p.
17. DSTU GOST 7057 – 2003. Tractori siolskogodarsky. Methods viprobuvannya. – K.: Derzhospozhivstandart of Ukraine – 2003. – 13 p.
18. DSTU 4521: 2006. Agricultural mobile technique. Normi of the nightly systems on the ground. – K.: Derzhospozhivstandart of Ukraine – 2007. – 9 p.

MACHINES AND IMPLEMENTS FOR NON-CHEMICAL WEED CONTROL IN ORGANIC VEGETABLE GROWING

Assoc. Prof. Eng. Angel Trifonov, PhD
Agricultural University – Plovdiv, Bulgaria

trifonov56@abv.bg

Abstract: Organic agriculture finally renounces the use of herbicides. Taking into account the positive qualities of weeds, the aim is not to their complete elimination, but to reduce the available quantity, which is not harmful to yields. With these prerequisites weed control on the non-chemical way is becoming more important as a major place occupied the variety of crop rotation and other indirect ways to control the weeds. For their regulation by a non-chemical route in practice farmers use appropriate machines and devices and therefore pay particular attention to the mechanical implements, automatic systems and thermal control of weeds. In organic farms for vegetables use also cultivators with automatic diverting knives and cultivators with automatic rotating knives, controlled by video cameras and sensors. Robotic machines for weed control have also been developed in recent years, controlled by GPS agricultural navigation.

Keywords: WEED CONTROL, ORGANIC, CULTIVATION, FLAMING, AUTOMATIC.

1. Introduction

Weed control in organic farming is direct and indirect.

Indirect control is an obligatory component of the weed control practices. The practices included in it can be divided into two groups: 1) Protective practices - these are those activities that prevent the entry of new weed seeds or weed reproduction organs into the arable land; 2) Practices to ensure the fast and proper development of crop plants so they can suppress weeds themselves.

Protective practices are the basis of rational weed control. If we do not apply them, it is more difficult and expensive to exterminate the weeds. Some practices are: the use of pure seeds of the main culture - without weed seeds; timely and correct harvesting of the culture; timely weed control in uncultivated areas and the roads, in irrigation and drainage channels; fertilizing with pure manure (without weed seeds), stored in an appropriate manner through the regulation of aerobic and anaerobic processes to complete destruction of viable weed seeds.

It is need first be placed practices supporting crops in their competition with weeds, providing fast and jointly germination of crops, which requires primarily high-quality seeds, providing a uniform crop with optimal density, proper fertilization, timely care in vegetation, proper crop rotation [Kapov, 1999].

The direct weed control is down to exterminate of the emerging weeds, weed seeds in the soil and weed propagation organs. It is performed with various physical-mechanical and biological processes and methods.

Physical-mechanical weed control

In physical and mechanical practices to control weeds most widely used and of most practical importance is soil tillage – ploughing and cultivation [Walter, 1995]. The soil tillage of vegetable crops includes several practices - ploughing, additional surface tillages after ploughing (before sowing or planting), surface tillages during the crop growing, depending on the species composition of weeds and weather conditions during the season.

The aim of the work is to make a review of machinery and equipment in the present stage of weed control in the cultivation of vegetables in organic farms.

2. Weed Control During the Growing Season of Vegetables

Manual hoeing is carried out with a variety of tools such as hoe and variations of the hoe, hand cultivators with knife-bracket, hand cultivators with support wheel (wheel hoe) etc. (Figure 1).



Fig. 1. Different tools for hand hoeing.

On small areas and sufficient manpower can be applied **weeding by hand**. It is very difficult work -associated with an unnatural position of the body of the worker, which leads to rapid fatigue and pains in joints and muscles. To avoid these negative consequences **tractor mounted platforms** have been developed, hung on the linkage of the tractor.

They have from 6 to 12 working stations where workers lie on their stomach, their arms are hanging down to the rows of plants so that they can touch the ground and pull the weeds (Figure 2). The angles of inclination of the panels comply with ergonomic requirements for the convenience of the body of the worker. Tractor moving at low speed and at every workplace is set to alarm button that can be used by the worker to alert tractor driver to stop briefly when a greater density of weeds are in the row.



Fig. 2. Tractor platform for manual weeding.

The mechanical control of weeds during vegetation is carried out by cultivation. It is very important that the first tillage is done in time because the crop plants are very sensitive and easily damaged by cultivator working bodies. When we delay with tilling and the weeds suppress the crop plants, it is necessary to carry out a manual labour after the cultivator. It takes a lot of work and time.

Cultivators for mechanical weeding

Cultivator for row cultivation. These types of cultivators are used for tillage the soil and for killing the weeds between the rows of the crops [Walter, 1995]. The unprocessed area on the left and right of the row is called the protection zone (designation “c” in fig. 3). Tillage between the rows of crops (row cultivation) is carried out at a depth of 4 to 10 cm depending on the type of cultivator, type of soil, number of weeds per unit area and others.

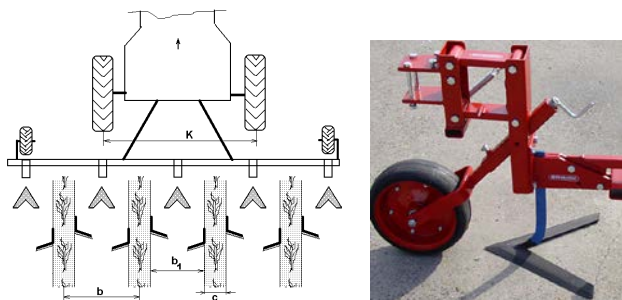


Fig. 3. Scheme of the cultivator for row cultivation and working section: *c* - protection zone; *b* - spacing between the rows; *b₁* - processed area; *k* - distance between the wheels of the tractor.

The work bodies are located in the sections in such a way as to provide a suitable "c" protection zone (Figure 3). It must be wide enough to preserve the stems, leaves and roots of the crop plants. It is usually from 8 cm to 20 cm depending on the crop and the degree of plant growth.

When working at high speeds or in low-growing crops, these cultivators are provided with protective devices in the form of shields, discs or other. The aim is not to put soil over the crop plants. In this type of cultivators the ways of reducing the protection zone are as follows: use of cultivators with a steering wheel and an auxiliary worker seat; use of front linkage cultivators; use of cultivators on self-propelled chassis tractors; use of cultivators with electronic sensors and video cameras.



Fig. 4. Self-propelled chassis with mounted cultivator for tillage of carrots.



Fig. 5. Cultivator for hoeing with rotating teeth bodies with passive action.

Combined cultivators for inter-row and intra-row soil tillage. Several companies, which produce agricultural machinery, offer additional work organs to traditional row crop cultivators. These organs enter into the protection zone and tilling the soil around crop plants without damaging them.

An example of this is the developed cultivator with rotation fingers and passive action. The fingers are made of flexible material (plastic or rubber), placed on a metal disc (Fig. 5). The disc is attached to the axle with bearings. On the disc are also mounted metal fingers, bent to the soil, which ensures the rotation of the working organ and the loosening of the soil near the crop plants [Янчева, 2003].

Cultivators with rotating working bodies with active action. In organic farms weed control in vegetable crops, which is grown on a high flatbed, is complicated by the fact that the inter-row distances are small and the use of ordinary cultivators is limited. Therefore, in most cases, manual weeding and soil tilt with hand tools is applied. These practices are low-productive and require more human resources.

Another way of weed control in these crops is the use of cultivators with active working organs. For the accurate driving of the aggregate in the narrow rows, it is required to use another operator (except the tractor driver) that guides the work organs so that they do not damage the crop plants. This group of machines includes rotating soil-cultivating tillers and brush cultivators.

Rotary brush cultivator with a horizontal axis. It is mainly intended for the mechanized growing of vegetables such as carrots, red beets, leeks, onions [Fogelberg, 1991]. It is composed of brush rollers (Figure 6) with a diameter of 50-60 cm driven by one shaft. The drums tilling the soil between the rows. They are made from a base 1 on which plastic fibers 2 with a diameter of 5-6 mm are fastened, with high stiffness and strength, forming a cylindrical brush.

The drive shaft is connected to the PTO of the tractor through a transmission, gearbox and chain drive. The machine is equipped with an operator seat, handlebar, steering wheels, tunnel type 3 safety panels (Figure 6), which keep crop plants from not being covered with soil. Behind the drums is placed 2-3 mm thick plastic brush that acts as a reflector for the discarded soil.

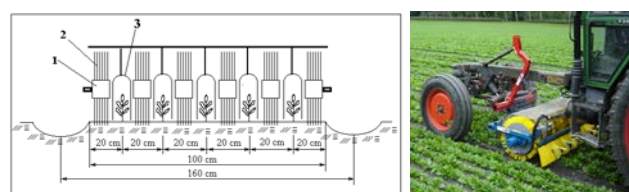


Fig. 6. Brush cultivator (rear view): 1 - drum base, 2 - plastic fibers, 3 - protective tunnel.

Cultivators are hinged and allow joining from the front, rear or between the front and rear wheels of the tractor (as with the self-propelled chassis - Figure 6).

Safety tunnels allow size adjustment depending on crop plants. The brushes process the soil at a depth of 2 to 5 cm and direct the weeds together with the roots to a reflective curtain. As a result of the stroke, the soil is separated from the roots and the weeds remain on the surface of the field where they die for several hours in dry weather because they are mechanically deformed by the brushes.

The working speed of the cultivator is 3-4 km/h and its structural width may be 1.5 to 3.5 m. Apart from brush cultivators with a horizontal axis of rotation, they are also available with a vertical axis of rotation. Brush rotors can be rigidly positioned or displaced side by side by an operator or by an automatic device.

The main advantages of the brush cultivator before conventional cultivators are: a more efficient inter-row processing in the early stages of development of crop plants when they do not tolerate side-pressure; work in smaller protection zones due to safety tunnels of adjustable size and position in relation to crop plants; application to increased soil moisture due to its self-cleaning effect; low probability of clogging with plant mass; more efficient work on stony soils.

Disadvantages of the brush cultivator are: clogging of protective tunnels with stones, relatively low productivity and high cost are reported. But this machine is becoming one of the most promising machines for mechanical weed control in organic farming.

Cultivator with rotary bodies with spring metal fingers. It consists of rotors with axes, parallel to the processed row (Figure 7). They consist of shafts fitted with metal discs and steel springs with a body diameter of 5-6 mm. When the machine is moved forward, the tractor rotates the rotors. The height of the thumbs is adjusted so that they loosen the soil to a depth of 2-3 cm in the interior space and destroy the weeds, while not damaging the crop plants. The machine is particularly suited for crops such as garlic and onions that are already well grown up and cannot be affected by partial strokes on the stems and leaves from the metal springs.

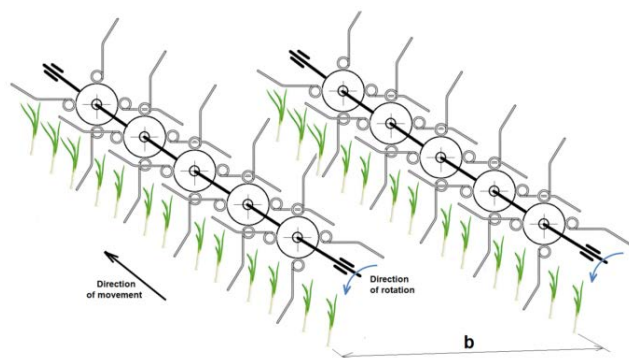


Fig. 7. Scheme of working organs of a cultivator with rotating bodies with spring metal fingers.

Cultivator with automatic diverting knives. Its operating organs are straight metal knives that are controlled by steel arms connected to hydraulic power cylinders or electromagnets. The blades work within the protection zone, at 3–4 cm deep in the soil. Sensitive devices (video cameras, sensors) irradiate the row of crop plants (Figure 8) and send the signals to the executive device that controls the knives. In this way, they surround the crops and re-entered the row again - the unprocessed areas around the plants are reduced to very low values [7].



Fig. 8. Cultivator with automatic diverting knives.

Cultivator with automatic rotating knives. Its working organs are arched metal knives of a specific shape (in a difference of the previous cultivator), they are placed on shafts in order to make a rotating movement (Figure 9). The shafts are driven by gearboxes and hydraulic motors (in some models - from electric motors). The blades work within the protection zone, rotating flat, deep to 3–5 cm in the soil. Sensitive devices (video cameras, sensors) irradiate the row of crop plants and send signals to the executive device that controls the rotation of the knives. In this way, they surround the crop plants and process the entire interior space - the unprocessed areas around the plants are of negligible size [8].

Robot analyses images of the crop immediately in front of the weeder. Applying a predetermined grid and best fit logical deduction techniques individual plants are pinpointed and tracked through the image. The weeding rotors are then synchronized to work around each individual plant, the rotor speed being continually adjusted to take into account plant spacing variations. The InRow rotors are then followed up by a set of inter-row cultivation units to complete the all-round cultivation process. Performance is 2 plants per second per row.



Fig. 9. Cultivator with automatic rotating knives.

Robotic machines for weed control

Such types of machines have also been developed in recent years, controlled by GPS agricultural navigation (Figure 10). In the research project the firm AMAZON together with BOSCH and the Osnabrück University, work on the mechanical secondary vegetation management in biological carrot cultivation with emphasis on the system integration of robots into ecological farming. For this the robot is equipped with an actuator for weed control.

The target is that the robot, thanks to its complex picture processing – initially with help from a man as "picture processors at the telework station" and later on also alone – will recognize the difference between the useful plants and weeds by "eye". Here the field robot has to work under the influence of many disruptive factors and under variable conditions.

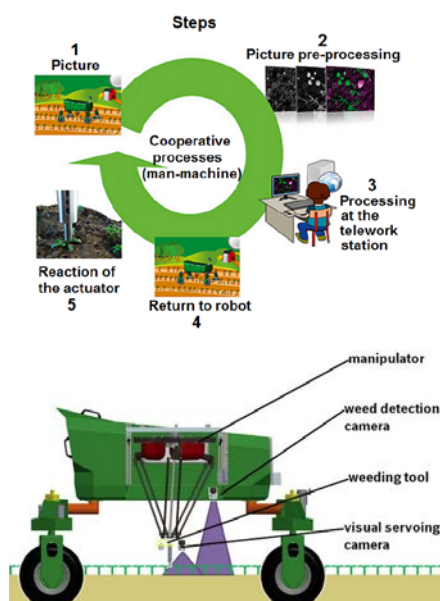


Fig. 10. Web-based robot assisted secondary vegetation control.

Physical ways to kill weeds such as mulching and burning (thermal treatment) are also applied. As a means of weed control, mulching is used to completely prevent light access to weed plants from which they stop to grow and die. It has an effect mainly against the young weed plants. Thermal treatment is applied to heat the weeds with an open or closed flame to make coagulation of the proteins and gradual dying [Трифонов, 2000].

Thermal treatment of weeds. A relatively new approach in organic farming is the use of differences in the thermal resistance of crop plants and weeds depending on their developmental phases.

Effect of flame on weeds. Weeds are harmed by the heat influx created by open flame machines or infrared emitters. This technique heats the weeds to a temperature of 90–100° C for a duration of 0,5–1,0 seconds, in which they do not burn but die for two reasons - dehydration due to cell expansion and cracking and irreversible changes in the protein in temperatures above 50–60° C.

The weed plant perishes after 3 to 7 days. To achieve an effective thermal action on weeds, it is recommended that the working temperature of the flaming technique is above 940–1000° C. This type of cultivator is good to be used in sunny and dry weather.

Both ways of thermal treatment have led to two varieties of thermal cultivators – with open flame and infrared burners. Flame cultivators are with burners operating with gaseous or liquid propane fraction (Figure 11). Depending on how they move around the field, they are hauled on a tractor, hand-moved and portable on the back, which determines their overall device [Ascard, 1992].

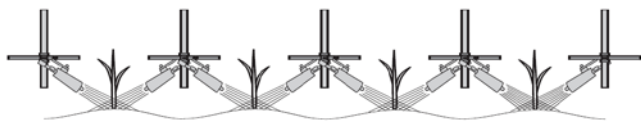


Fig. 11. Scheme of working organs of a flame cultivator for work in a culture that has already emerged.

Thermal cultivators offer a variety of application options, some of which are validated by practice, others are under test. The main ways of using these cultivators are:

a) Pre-emergence thermal treatment of the main crop - this technological operation is widely used in organic farming for the cultivation of carrots, red beets and others. Cultivated plants are thermally treated in the immediate post-emergence rows, and post-emergence mechanical treatment is recommended. Determination of germination time is critical to the effect of heat treatment. In order to determine the exact moment, the germination of several plants is accelerated by covering a part of the row with glass.

b) Post-emergence thermal treatment of the main crop - inter-row treatment is applied when the crop has reached certain sizes. At work, it is recommended to use protective devices to protect crop plants from heat. In some crops, it is necessary to use the devices for lifting their leaves to treat the row spacing.

Thermal treatment is a risky operation and therefore requires a precise estimation of the factors influencing the effect of its application, namely: the type of weeds; species of crop plants; soil condition; heat treatment time.

Technical parameters of the heat cultivators

Research on the work of thermal cultivators has shown that their work depends on many technical factors: temperature and duration of action of the flame; contact area of the flame with the plant; distance and slope of the burner to the soil; position of the burner relative to the treated plants; soil and climatic parameters.

The treatment of the plant is most effective when the flame has a formed core, the weeds are covered by the outer third of the flame, the angle of attack is 30 to 40° with an inclined forward burner, its height from the soil surface is 0,12 to 0,15 m and varies with gas pressure.

The operating speed determines the duration of the temperature impact and the performance of these machines. For open flame cultivators the speed is from 3 to 4 km/h, and for infrared units the speed is 1 to 2 km/h, but they have lower gas consumption per unit of treatment.

I present my construction of a hand-operated flame cultivator PLAM-1L for weeding (Figure 12). This cultivator uses gas propane-butane and is developed at the request of the Demonstration Organic Farm at the Agroecological Center of the Agricultural University of Plovdiv. The cultivator is used successfully for 5 years in the cultivation of 1 ha of onion from seeds and 1 ha of carrots without the use of herbicides, combined with a brush cultivator [Трифонов, 2000].



Fig. 12. A 3-wheeled gas-flame cultivator PLAM-1L for hand-moving

This flame cultivator is manually moved by two workers over one bed. Its traction system is made of two light bicycle wheels and one small front wheel for copying the terrain and maintaining a constant height of the burners.

The cultivator is equipped with two parallel connected bottles 1 (Figure 13) for propane gas. The nozzles 2 are specially adapted to provide a greater flow of gas to the burners. Pipeline 3 is made of a gas-resistant rubber hose. Crank 5 provides an "Idle - workflow" operation of the burners - the switching is done when performing maneuvers at the end of the field.

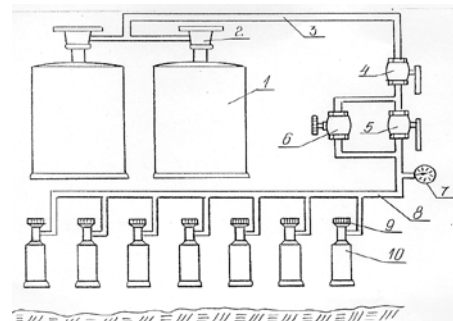


Fig. 13. Principal scheme of the flame cultivator PLAM-1L: 1 - propane gas cylinders; 2 - nozzle; 3 - main pipeline; 4 - central shut-off valve; 5 - "idle - workflow" valve; 6 - throttle flow controller; 7 - pressure gauge; 8 - distributor; 9 - a flame control valve for a flame force in a running position; 10 - gas burner.

An experiments have been carried out with this cultivator on the field of the Demonstration Farm for organic farming at the Agroecological Center of the Agricultural University of Plovdiv with pre-emergence carrots and with onion from seeds once before germination and again immediately after germination.

When re-treating the onion, its tips are burned, but it has an inner leaf-growth area and restores quickly. The cultivator is set in the mode of operation according to Table 1.

The predominant weeds were *amaranthus retroflexus*, *atriplex hortensis* and *setaria viridis*. It has been found that good results are obtained at a gas pressure of 0,2 MPa and at a speed of 4 km/h.

Table 1: Plam-1L Cultivator Operation Mode

Movement speed	3 - 4 km/h
Working width	one bed with a width of 1 m
Burner height	10 - 12 cm
Angle of the burners to the soil	50° - 90°
Gas pressure	0,15 - 0,20 MPa (1,5 - 2,0 bar)
Productivity	0,3 - 0,4 ha/h
Gas consumption per hour	7 kg/h
Gas consumption per hectare	20-30 kg/ha

The results of the work of the flame cultivator are encouraging and give reason to believe that this is a good working machine for successful non-chemical weed control on organic production farms.

Conclusion

Weed control machines and implements for the organic growing of crops are presented such as: ordinary cultivators for row crops, cultivators with passively rotating working bodies, cultivators with actively rotating operating organs for working in the protection zone, brush cultivators, flame cultivators and cultivators with automatic action. Different kinds of cultivators are presented and the conditions under which they must work to ensure a high

quality of the agricultural operation for minimal damage to the crop plants and make recommendations for obtaining better treatment.

In organic farms for vegetables cultivators with automatic diverting knives and cultivators with automatic rotating knives are used, controlled by video cameras and sensors. Robotic machines for weed control have also been developed in recent years, controlled by GPS agricultural navigation.

References

1. Трифонов, А., П. Петров, 2000. Лехови газопламъчен култиватор ПЛАМ-1Л за борба с плевелите при биологичното земеделие. III национална конференция „Екология и здраве 2000”, Пловдив.
2. Каров, Ст. и др., 1999. Преход към биологично земеделие. Наръчник на биологичния фермер. Пловдив, Агроекологичен център на АУ.
3. Янчева, Хр., И. Манолов и др., 2003. Основи на биологичното земеделие. FIBL Швейцария, Пловдив.
3. Ascard, J., 1992. Weed control effect of different flaming systems. Proceedings of International Conference on Agricultural Engineering. Uppsala, June 1-4, 580-581.
4. Fogerlberg, F., Johanson, T., 1991. Mechanical weed control – ultra-row brush weeding in vegetables and sugarbeets. Department of Agricultural Engineering, Swedish University of Agricultural Sciences, Alnarp, Sweden.
5. Rahkonen, J., P. Vanhala, 1991. Response of a mixed weed stand. Department of Agricultural Engineering, University of Helsinki, Finland, 167-169.
6. Sabine Walter, 1995. Nicht-chemische Unkrautregulierung. SOL-Sonderausgabe № 27, FEZ.
7. <http://web97.de-webspace.de/index.php?lang=1&news=26>
8. http://www.garford.com/news_archive.html