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THE EVALUATION QUALITY OF SOWING INDEPENDENCE WITH SELECTED PROPERTIES OF SEEDS

Pavol Findura¹, Miroslav Pristavka^{2*}, Maroš Korenko³, Peter Bajus⁴

Abstract: sowing quality means required vertical (depth) and horizontal (spatial) spacing of seeds in the soil with minimal damage to the seeds. The spatial distribution of seeds (horizontal spacing) is given by distance between the rows and spacing of the seeds in a row. The objective of the study was the evaluation and comparison of the sowing quality of sowing machine jd maxemerge xp with mechanical filling of ladle holes with holding fingers within usage of seeds with different dimensional and shape attributes in agricultural conditions. Sowing machine jd maxemerge xp reached good results for the quality especially when using the angular seeds. It reached the sowing quality expressed by the standard deviation of 46.95 - 50.76 % when seeds pr 37 n01 and for seeds pr 37 n01 it is 47.43 - 48.73 %. Another evaluative criterion is dual sowing of seeds or plants (drr), it was reached the average value 3.65 - 2.45 % for angular seeds and the average of 1.54 – 3.71 % for approximately spherical seeds.

KEY WORDS: SOWING QUALITY, ATTRIBUTES OF SEED, MAIZE,

INTRODUCTION

Efficiency of mechanized crop harvest is affected by the state of plants condition as well as whole range of other biological and technical factors. Therefore, the base for achievement of a generous harvest is achievement of high germination and uniform emergence of growth. In a common practise, farmers use seeds produced by a different manufacturers. These seeds are often dimensionally erratic and that affect, among other factors such as quality of soil preparation, the quality of sowing significantly (Gorzelay, 2009).

The spatial distribution of seeds (horizontal spacing) is given by distance between the rows and spacing of the seeds in a row. The distance between rows is adjustable within a sowing machine according to seeding crops. Final seedling emergence and the rate of speed of emergence are influenced by bulk density and aggregate size of seedbed (Dimitrov et al., 2012).

Precision sowing has been a major thrust of agricultural engineering research for many years; however, most of the research and development work has dealt with seeders for agronomic crops (Karayel et al., 2004). It was also stated that a seeders should place a seed in an environment in which the seed will reliably germinate and emerge. A number of factors affect the spacing of plants. The seed selection mechanism may fail to select or drop a seed resulting in large spacing between seeds. The mechanism may select and drop multiple seeds resulting in small spacings between seeds. Seed quality, soil conditions, seeder design and the skill of the operator all play a part in determining the final plant stand. Various types of cleaning, grading, separation and sowing equipment are designed on the basis of the physical properties of seeds. However, no model has been found to describe seeder parameters such as vacuum pressure related with physical properties of seeds.

Later on Karayel and Özmerzi (2002) stated that the variability in seed spacing with precision vacuum seeders increased with increasing forward speed. They found that a forward speed of 1 m.s⁻¹ consistently produced a better seed pattern than 1.5 and 2.0 m.s⁻¹ for precision sowing of melon and cucumber seeds. Field tests

showed that the nominal sowing depth of 60 mm was optimum according to sowing depth uniformity and emergence rate index.

In our case, we focused on sowing the maize (0.762 m). Since the distance between rows during sowing has not changed criterion for evaluation of accuracy of the horizontal spacing of seeds is the distance between seeds in a row (Findura et al., 2008). Seeds variability in the row is affected by soil preparation, physical attributes of seeds, parameters of sowing unit, working speed (Findura et al., 2008). According to (Páltik et al., 2002), following (a,b,c,d) technical parameters of the sowing-machine mostly affect the seeds' distance in row: a) fixing technique of the sowing unit on the frame of sowing machine (parallelogram); b) parameters of the sowing unit (shape of sowing foot, sowing speed within the seeds fall off sowing disc, etc.); c) type of sowing system; d) vertical acceleration of sowing unit and operating speed of the machine, etc (Streit et al., 1992).

The objective of the study was the evaluation and comparison of the sowing quality of sowing machine JD MaxEmerge XP (Fig.1) with mechanical filling of ladle holes with holding fingers within usage of seeds with different dimensional and shape attributes in agricultural conditions.

MATERIAL AND METHODS

Measurements were made on the farm Agrodivízia (Agro-division) Selice, Ltd. Process of soil cultivation produced the blackland soil type - mainly carbonated blackland, blackland "cernicka" and blackland's "arenicka". These soils are characterized as deep soils with deep humus horizon. They are clayey-sandy up to clayey soils with alternating graininess on the horizons of soil profile. Humus content in topsoil was determined at range 1.3 to 3 %. Soil reaction in topsoil was determined as pH 7.1 to 7.6. Soil samples were collected by soil measurement equipment NH-90 (Fig.2A). Measurement equipment was fixed on quadricycle Polaris 550 EFI X2. The samples were collected from soil depth 300 mm.

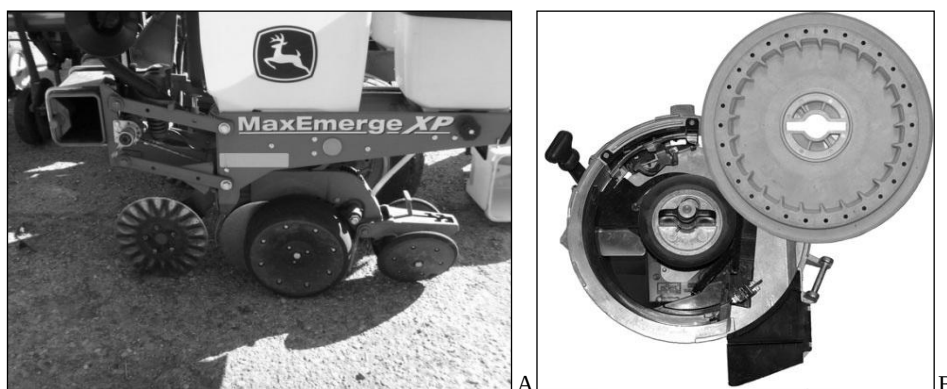


Fig.1: A - Sowing-machine JD MaxEmerge XP; B - Detail of sowing system

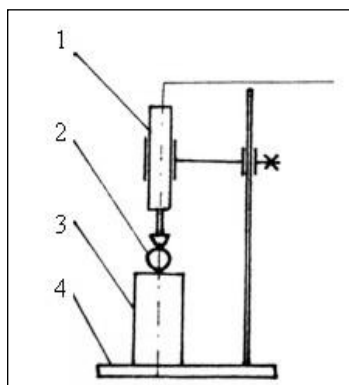


Fig.2: Technique of measurement of grains dimensional characteristics: 1- induction sensor, 2- grain, 3- rest, 4- laboratory metal holder

The sowing depth is also considered as one of the key factors. The best uniformity of sowing depth was obtained at the nominal sowing depth of 60 mm. For both seeders, either decreasing or increasing the nominal sowing depth from 60 mm resulted in a higher coefficient of variation for depth. The maximum emergence rate indices occurred when the nominal sowing depth was 40 and 60 mm, and the least mean emergence time was obtained at the nominal sowing depth of 40 mm. It can be concluded that the position of the seed in the soil effects mean emergence time and the emergence rate index of plants.

The sowing quality was evaluated within the sowing-machine JD MaxEmerge XP. This seeding machinery allows sowing of wide-rowed crops within the conventional as well as the soil conservation technologies. The sowing machine JD MaxEmerge XP operates on the principle of mechanical filling of ladle holes where seeds are drifted by holding fingers to the place of seeds falling. A variety of influences will affect the variability of seeds distances (later plants in the row) that will cause an inaccuracy of seeds placement to a larger or lower degree.

Apart from the impact of sowing system there will also operate other working parts of sowing unit within storage, covering and pushing the sow seeds into the sowing furrow. Unwanted seeds rolling and thus inaccuracy of seeds placement in the furrow also cause among the mentioned factors in introduction high of seeds falling (Table I).

Table I: Selected technical data of tested sowing-machine

Type of Sowing machine	JD MaxEmerge XP
High of seeds fallin,mm	505
Diameter od sowing disc, mm	370
Number of ladle elements	15
Fixing of sowing unit	parallelogram
Dept conduction of sowing foot	supporting wheel
Type of sowing foot	double disc

The procedures of shape and dimensional aspects of seeds, methodology of measurements and used devices in this study was obtained and adopted according to Findura at al. (2008). Shape and dimensional attributes of used seeds affect the reliable ladling of seeds and therefore also reaching symmetrical distances in the row. Device iM1610 and converter with amplifier were used for measuring the dimensional characteristics of grain. Our goal was to digitize the process of measurement. A/D converter MA-UNI with the amplifier and the measuring device with data-logger served as the base again. Sensor type W50 with high measurement accuracy (0.2 %), in this case, was used from the company HBM (Hottinger Baldwin Messtechnik). It is the sensor that works on the induction principle of measuring position. Data were automatically recorded into a data file individually in the order: depth, width and length after calibration of sensor and setting the programme NextView 2.5. This provides immediate digitization of information about the

dimensional characteristics of the examined grains. It also caused a risk reduction of human failures within measuring for the reason of incorrect information reading (Fig.2).

Measurements were realized in according with the standard ISO 7256/1 in agricultural conditions where the average speed was 3.09 m.s^{-1} . Measured distances in the row b_{ri} within the evaluation of horizontal seeds placement are classified as following:

- Dual, where distance b_{ri} is
 $0 \odot b_{ri} < 0.5 \text{ (EVR)} - \text{Number } n_0(1)$
- Placement in desiderative distances
 $0.5 \text{ (EVR)} \odot b_{ri} < 1.5 \text{ (EVR)} - \text{Number } n_1(2)$
- Single omission
 $1.5 \text{ (EVR)} \odot b_{ri} < 2.5 \text{ (EVR)} - \text{Number } n_2(3)$
- Double omission
 $2.5 \text{ (EVR)} \odot b_{ri} < 3.5 \text{ (EVR)} - \text{Number } n_3(4)$
- $(k - 1)$ multiple omission
 $(k-1)(\text{EVR}) \odot b_{ri} < (k+0.5) \text{ (EVR)} - \text{Number } n_k(5)$

Where: EVR- is effective distance of plants that is determined by calculation of average value of measured distances b_{ri} . Difference between the truly measured value b_{ri} and calculated effective distance of plants EVR are defined by standard deviation that formulates the variability of plant placement. Above methodology was adopted from mentioned standard and specification according to Páltik et al. (2002).

While study aim is focused on a) characterization of dimensional and shape attributes of seeds, and b) evaluation and comparison of sowing quality of sowing machine with mechanical principle of filling of ladle holes in agricultural conditions, a following seed hybrids was used. Seeds of maize from company Pioneer Hi-Breed Slovakia were used for measurements. It was hybrid PR 37N01. Average harvest of grain was 9.45 t.ha^{-1} during the test. Hybrid has a bountiful harvest in dry and also in wet years. It is designate for the production area of maize. It has a good resistance against the heat stress. Hybrid is able to keep an assimilative area in dry period longer. It grows on a green stalk which is one of the advantages in case of dry period or during the vermin's attack to plants. Quick initial phases of development and good tolerance to cold are reasons for predestination to early sowing. Seeds of big and medium fraction approximately with spherical and angular shape were used within experiments.

Statistical data processing was performed by the analytical software Statistica 10 (TIBCO Software Inc., USA). All of the observed parameters were sampled in min. 20 replication and LSD post-hoc tests were applied to compare mean values. Mean values are presented in the tables (Tab. II, Tab. III and Tab. IV) accompanied with specific standard deviations (in form $\pm \text{s.d.}$). ANOVA test were applied to indicate contrast and statistical differences between tested variables and showed in tables as different letters (a,b,c). Specific parameters are presented in corresponding table legends below tables.

RESULTS AND DISCUSSION

Dimensional and shape attributes of used seeds

Table II shows the average values of length, width, depth and shape coefficients of used seeds are shown in table III. As it was observed that shape attributes have a significant effect on seeding quality and at the end it affects emergency and whole further growth of maize seeds. Shape attributes are defined by the shape coefficients $k_1 - k_4$, if the reciprocal values of coefficients are balanced then seeds will have more ideal spherical shape.

Table II: Dimensional attributes of used seeds

Variant (calibration)		PR 37 N01 LF (big angular)	PR 37N01 MF (medium angular)	PR 37 N01 LR (big spherical)	PR 37N01 MR (medium spherical)
Germinability %		99	98	99	99
Seeds dimensions, n=20	length l	^a 10.98 ±0.12	^a 10.75 ±0.11	^b 10.11 ±0.25	^c 8.89 ±0.14
	width s	^a 8.78 ±0.09	^c 7.87 ±0.12	^a 8.84 ±0.08	^b 8.01 ±0.11
	depth h	^a 4.89 ±0.05	^b 4.69 ±0.08	^c 6.44 ±0.09	^c 6.53 ±0.05

l, s, h - average length, width and depth of seeds; different letters (a,b,c) means significant difference; LSD test; $\alpha=0.05$; s.d. – standard deviation; n=20

Orientation by pushing provides a fast, cheap, and robust way of quickly bringing seeds from a completely random orientation to a known orientation within narrow bounds that could be exploited in a planting mechanism. The results also highlighted that not all hybrids were equally well suited for seed orientation by pushing. Cuboidal or boxy kernel shapes behaved more predictively, rounder shapes exhibited more variability and weaker stable points, a property that could become more important once the unavoidable vibrations of a planter travelling down the field are considered in a seed oriented planting system.

Sowing quality evaluation of selected sowing-machines according to seeds placement

Therefore, precondition of success within this technology is among all others the usage of quality seeds that are placed in row into required depth and at required distance (Testa et al., 2016). The study was observed and concluded at the basis of the analysis of seeds falling trajectories, it was found that the variations of positive differential pressure (Δp) and release angle (θ) had significant effects on seeding uniformity. In order to analyse their effects on horizontal displacement, a coefficient of positive differential pressure variation (X_p) and coefficient of sowing angle variation (X_θ) were proposed and their values calculated (Zhang et al., 2016). In our study it was observed that regularity of the distances changes in dependence on surface roughness, technique of fixing the sowing unit and on working speed (Table IV).

Table III: Shape attributes of used seeds

Variant (calibration) mm ± s.d.		PR 37 N01 LF (big angular)	PR 37N01 MF (medium angular)	PR 37 N01 LR (big spherical)	PR 37N01 MR (medium spherical)
Weight of 1000 seeds, n=15 g ± s.d.		^a 319.79 ±12.16	^b 254.62 ±11.08	^c 359.93 ±13.35	^b 251.64 ±10.93
Shape coefficients, n=20	$k_1 = \frac{l+s}{2}/h$	^a 2.04 ±0.01	^a 2.00 ±0.02	^b 1.49 ±0.2	^c 1.31 ±0.1
	$k_2 = s/h$	^a 1.81 ±0.02	^b 1.69 ±0.01	^c 1.39 ±0.02	^d 1.24 ±0.03
	$k_3 = l/h$	^a 2.26 ±0.03	^a 2.31 ±0.02	^b 1.58 ±0.02	^c 1.38 ±0.03
	$k_4 = l/s$	^a 1.27 ±0.03	^b 1.39 ±0.02	^c 1.16 ±0.02	^c 1.12 ±0.02

k₁, k₂, k₃, k₄- shape coefficients of seeds; different letters (a,b,c) means significant difference; LSD test; $\alpha=0.05$; s.d. – standard deviation; n=20-15, respectively

Standard deviation for sowing maize for distance in a row equal 200 mm should be at sowing system in the range of 18 to 30 mm depending on the operating speed, seeds and type of sowing unit (Páltik et al., 2002). The evaluative criterion of seeds, plants distance variability in the row was value of the standard deviation

of measured distances in the row, a representation of the required and dual seeds placement and percentage representation of the omissions. As it was observed the satisfying quality of sowing maize is considered to be a value of standard deviation from 30 to 40 mm. It was also found out that as a result of these tests, a nominal sowing depth of 60 mm is considered optimum, according

to uniformity of sowing depth and maximum emergence rate index (Özmerzi et al., 2002).

Tests on pneumatic and vacuum precise seeders were carried out to investigate the effects on sowing quality such as up to standard reseeding and miss-seeding etc. The experiment results indicated that the pneumatic seeder is more adaptable to the seed size and shape variation. It was observed that maize seed grading obviously affects the qualified index and reseeding index, but affects miss-seeding index and coefficient of variation little on

condition that all the indexes reach the sowing quality requirements. Moreover, the qualified index of round seeds was 96%, which was higher than a flat seed with the qualified index was 87.4%. There was great distinction between them. The sowing quality of vacuum seeders was not so good whether the seed graded or not, and has not significant influence on the whole indexes of it. The experiment also shows that pneumatic seeders have better performance than the vacuum seeders (Liu et al., 2010).

Table IV: Sowing quality parameters of monitored sowing system within different seeds attributes in agricultural conditions

Machine	Variant (calibration)	Running speed	PVR	EVR	s.d.	Placement of plants				
						PRR	DRR	JV	DV	TV
		m.s ⁻¹ , ±s.d.	mm	mm	mm	%	%	%	%	%
JD Max Emerge XP	JD Max Emerge XP PR 37 N01 LF (big angular)	a3.12 ±0.68	194	195.6	46.95	83.12	3.65	10.12	4.11	1.54
	PR 37 N01 MF (medium angular)	a3.18 ±0.49	194	191.1	50.76	70.9	2.45	15.57	7.37	3.71
	PR 37 N01 LR (big spherical)	a3.30 ±0.52	194	188	47.43	74.33	0.75	17.73	4.9	2.29
	PR 37 N01 MR (medium spherical)	a2.90 ±0.63	194	195.9	48.73	77.15	2.24	14.23	3.74	2.64

Different letters (a,b,c) means significant difference; LSD test; $\alpha=0.05$; PVR - required distance of plants, EVR - effective distance of plants, s.d. - standard deviation, PRR, DRR - required resp. dual placement of plants, JV, DV, TV - single, double, triple omissions

The value of standard deviation is in the rage from 46.95 to 50.76 mm for angular seeds within sowing machine JD MaxEmerge XP. Required seeds resp. plants placement with an average of 83.12 % for angular seeds and 74.33 % for spherical seeds results in better quality of sowing the angular shaped seeds (Table 4). Another evaluative criterion was dual sowing of seeds resp. plants (DRR), where the angular seeds achieved an average of 3.65 % and seeds with approximately spherical shape of 2.24 %. A similar trend was also reached for single omission resp. non-ladle of seeds, sowing with angular seeds reached 3.67 % and spherical seeds 17.73 %.

Özmerzi et al. (2002) emphasises that the importance of operating at the optimum depth has been shown by a number of researchers where sowing too shallow or too deep results in crop performance and yield losses. The speed of drill machinery on seeds distribution within rows was also studied by Ivančan et al. (2004). It was stated that uniformity of seed size and shape has a considerable effect upon the drill precision, notably on the performance of drills with a mechanical drilling unit. The drill operating speed has a decisive influence on the quality and efficiency of the seeding process. Attempts are therefore made to increase maximally the operating speed and still achieve satisfactory sowing quality. The range of optimal speeds should be defined for each crop separately. It was concluded that an increase of operating speed leads to changes of the values of the drill performance indicators. Thus, an increase in operating speed results in a decrease of drilling precision because the intra-row seed spacing becomes larger than that required. The set seed spacing increased from 7.5 to 8.3 cm in parallel with increasing the drilling speed by 1.8 to 5.2 km.h⁻¹,

respectively. The best intra-row distribution of parsley seeds was recorded at the speed of 1.8 km.h⁻¹ (Ivančan et al., 2004).

In addition stated that high-quality seeds can increase the germination rate. Directional seeding can make corn blades grow regularly and enhance ventilation and light energy utilization in the field.

CONCLUSION

Sowing machine JD MaxEmerge XP is able to sow all tested seeds in the required quality; b) Sowing machine JD MaxEmerge XP reached good results for the quality especially when using the angular seeds. It reached the sowing quality expressed by the standard deviation of 46.95 - 50.76 % when seeds PR 37 N01 and for seeds PR 37 N01 it is 47.43 - 48.73 %. According to the results of the field measurements for evaluation of mechanical sowing machine JD MaxEmerge XP in terms of sowing quality with usage of seeds with different dimensional and shape attributes we can express (a,b) following statement: a) Dimensional characteristics of seeds correspond to calibration which is prescribed by the manufacturer. Another evaluative criterion is dual sowing of seeds or plants (DRR), it was reached the average value 3.65 - 2.45 % for angular seeds and the average of 1.54 – 3.71 % for approximately spherical seeds.

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DEVELOPMENT OF EQUIPMENT FOR THE STORAGE OF SOYBEANS WITH ACTIVE VENTILATION

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Abstract: The article gives an overview of the creation of technology and equipment for pneumatic drying and storage of soy without attracting external sources of energy, and as storage capacity, use cheap freight containers, which will reduce the energy costs of the process and the material consumption of equipment.

KEYWORDS: SOY STORAGE AND PROCESSING, DRYING, PNEUMATIC CONVEYING, MODULAR CONTAINER EQUIPMENT, AIR FLOW, AIR CYCLONE, GAS-AIR MIXTURE, RECIRCULATING GRAIN, GRAIN MOISTURE CONDUCTIVITY.

1. Introduction

The idea of the labor is to create technology and equipment for active ventilation and storage soy of without attracting external energy sources, and use cheap load containers as storage capacity, which will let to reduce the energy costs of the process and the material consumption of equipment. To solve this problem, a technology is proposed that provides storage of grain in modernized cargo containers of 20, 30, 40 tons installed vertically.

The aim of the labor is to scientifically substantiate and develop container-modular equipment for recycling drying of soy in the course of long-term storage of soy, adapted directly to the conditions of agricultural producers, which is modularly designed to create a modular series of separate parts on demand.

In this case, soybean is loaded and unloaded by pneumatic conveyor, which eliminates leakage and loss of soybean. When stored by the same conveyor, the soy-air mass moves in a closed circle, thereby actively ventilating the mass. This continues until the desired humidity is reached. Drive by electric motor or from tractor power take-off shaft (PTO), which is convenient for remote farms. At the same time, the energy intensity of the drying process and soybean storage is reduced.

2. Prerequisites and facilities for solving the problem

Soy is a unique plant, a miracle of the wild. Now soy is the leading culture of world agriculture, the pinnacle of perfection and universality in the whole plant world. Soy is central place to solve the protein problem and is very profitable. The prospects of both production and consumption are related to the population of the earth, which has a growing tendency. Without the use of soy products, the nutrition structure in many regions will be unbalanced and insufficient. Soy seeds contain 38-42% protein, 18-23 fat, 25-30% carbohydrates, as well as enzymes, vitamins, minerals. Due to the rich and various chemical composition, soy does not know its own equal in terms of production growth rates, it has long been widely used as a universal food, fodder and oilseed culture. It has no analogues in the arsenal of plant resources in terms of productivity and quality composition. Soy oil contains 58% of the structure of vegetable oils (rapeseed, cottonseed, sunflower, palm, etc.). Total world production of soy is about 130 million tons, where the main producers being the USA, China, Argentina, Brazil, the EU countries, accounting for more than 85% of the world market. The share of Argentina, Brazil and the United States in world exports is about 87%. [1,2].

According to the Ministry of Agriculture of the Republic of Kazakhstan in 2016, about 220 thousand tons of soy were produced, of which about 20 thousand tons was exported. The main region of soy production in Kazakhstan is the Almaty region, where the cultivation area is 150,000 ha. In the future, it is planned to implement the investment cluster program "Mozhoko-2020", envisaging an increase in sawing to 400,000 hectares and producing up to 1 million tons of soy a year. At the same time, further growth in soy production is constrained by the lack of a stable alternative market for specific products. In 2016, Kazakhstan sold 10.8 thousand tons to Sweden, 1.4 thousand tons to Kyrgyzstan, 1.6 thousand tons to Tajikistan, and 6.1 thousand tons to Uzbekistan. A

total of about 19.9 thousand tons of 220 thousand produced. Because of this, soy producers are forced to sell to Chinese buyers for a price two times lower than the world price. In the future, China is willing to acquire Kazakhstan soy in unlimited quantities, as they now have a large demand for soy and soy products, which promises to our farmers the optimism on the issue of the future prospects of production of the product [3].

Besides, in Kazakhstan there is an opportunity to supply not only primary products (soy), but processed soy products (meal, vegetable oil and other related.), so there are already three soy-processing factories: JSC Vita-Soya productivity 150 thousand tons per year, LLP Plant on processing of soy Extra-24 thousand tons per year, LLP Sary Bulak-24 thousand tons per year. Unfortunately, they can not reach the planned capacity due to the lack of a stable source of raw materials throughout the year, which implies its storage and preparation under appropriate conditions, since soy with high protein and fat content, as well as increased seed hygroscopic, with unfavorable conditions quickly deteriorates (presence of organic impurities, high humidity). Even dry soy seeds are self-warmed by impurities.

According to the Ministry of Agriculture of the Republic of Kazakhstan, about 2 million tons of grain are stored and processed directly by product producers, i.e. various agricultural formations. At the same time, up to 50% of the volume of this raw material is irrevocable losses. Great danger to the grain is fungi, bacteria, harmful impurity and pathogenic microorganisms carried by pests of cereals - insects, rodents, birds. Toxins formed during the molding process, damaged by insects and mold grains, dirt and odors from pests of grain cause a decrease in its feed value, and animals refuse to eat such grain. Processing and transportation of moldy and damaged grain negatively affect the labor safety and the health of workers. The defeat of the grain by fungi is possible in the field, and during storage. Fighting mycotoxins is a worldwide problem, as in the structure of grain losses, mycotoxins account for 25%. The overwhelming majority of domestic agricultural producers, even in "good" times, did not consider the possibility of building their own elevators. The cost of erecting galvanized silos for storage of grain is estimated at about 150 - 250 dollars per ton. That is, in the equipment for an elevator with a capacity of 20 thousand tons alone it is necessary to invest about 3 to 5 million dollars. And also need to pay for design work, building. The minimum payback period of the elevator is 4-5 years, and this is provided that the agrarian will store on it not only its own grain [4,5,6].

In many areas of the country's climatic conditions predetermine cleaning a large part of the harvest of grain, oilseeds and other crops with high humidity, in which their long-term preservation can not be ensured.

Reduced soy humidity to 12% and bringing crude and wet grain to a stable storage state - the main purpose of drying.

In general, drying is understood as the process of dehydration of materials. This complex process consists of the transfer of heat by heated soy air, the transfer of humidity inside the grain to its

surface, its evaporation in the peripheral layers of each grain, the movement of steam from the peripheral layers of the grain to the surface and into inter granular space, removing it from the mass of the grain. At the same time, a number of physical and biochemical processes that affect soy quality are passing through soya. When drying, the role of air is not limited to the functions of the heat deliverer and humidity absorber. Oxygen of air takes part in biochemical processes in the embryo and endosperm, which increase with increasing temperature. At the same time, the processes of physiological ripening of soy are intensified, which is of great importance for improving its quality. Timely and correctly drying increases the stability of soy during storage, improves its grain and food dignity. Drying accelerates the post-harvest ripening of soy, smoothing the grain mass in terms of maturity and humidity, improves the appearance of soy. Drying has a positive effect on output and quality of soy processing products. Drying acts depressingly on pests and soy micro flora, allows in some cases to improve the technological properties of defective grains (damaged by a bug-tortoise, frostbite, sprouted, etc.) Thus, drying allows to bring soy into a stable state for storage and improve its quality.

In the Institute of AIP and NT KazNAU received a patent for invention No. 31913. Method and device for drying the grain. The essence of the invention lies in the fact that the grain is loaded, dried, cured, dried, cooled and unloaded, characterized in that the permissible moisture level at drying and before drying is limited by the value: $\Delta U_d \leq \text{Kimu. Usp, where Kim.d.}$ - Massive exchangeable permissible number of Kirpichev; n is calculated by: $n = (U_n - U_k) - \Delta U_d / \Delta U_d$, where U_n , U_k , ΔU_d - initial, final moisture content and permissible moisture content, kg ow / kg dry. mat. . A device for drying grain containing, above the drying bunker, drying chamber, cooling, fan, furnace, loading and unloading way, characterized in that the capacity of the drying chambers is determined from: $G_d = G - n \cdot G_{ot} / \eta_d + n$, t , where G , G is the capacity of the dryer and the vending chamber, t ; η_d , η_d - the fraction of heat entering the evaporation of moisture during drying and drying, h ; n is the number of restraints, in addition, the number of chambers before drying is equal to the number of vending chambers [7].

However, along with this, we propose a method of active soy ventilation. In this case, the material itself moves in the air stream. As a result, cooling and drying of the unmerged material is achieved in order to prevent or eliminate self-heating during mass harvesting, equalize the temperature and humidity of the material during storage, eliminate clumping and form local rotting zones, etc. Along with this, the re-equipped containers are currently used in urban and temporary architecture, for realizing business ideas and creating residential and workplaces. Of the containers build houses, hotels, shops, build shopping centers and even office buildings. The advantages of container construction are obvious - it's cheap, fast, practical and durable. All these positive characteristics of buildings built on the basis of sea containers, could not fail to appreciate the workers of agriculture, agrofirms and private farmers who have found their application of such a universal design, as a metal container block.

Today standard 20-foot and 40-foot containers are actively used as granaries, as well as universal warehouses for agricultural products. Practice has shown that a minimal re-equipment of the container in accordance with the required conditions allows for a long time to preserve the quality and weight of any type of grain.

Analysis of the mechanism of dehydration of the material during convective drying shows that the temperature of the drying agent can be significantly increased to 70 ° C during brief heating of the material. The limit is the temperature at which the evaporation temperature (the temperature of the wet thermometer of the psychrometer) will be equal to or close to the allowable temperature of the grain heating. Experiments show that, at a high temperature of the drying agent, soy warm up to 55 ° C to an

acceptable temperature, and the evaporation of moisture from its surface takes place within a few seconds (about 10 s). Above 55 ° C, the supply of heat to soy above 55 ° C leads to injury to the embryo of the grain [8].

In this connection, we are proposed the most sparing, less energy-consuming method of storage and drying of soy, acceptable for the conditions of direct commodity producers.

3.The solution of the problem under consideration

As a result of preliminary research it was established that for the drying and storage of soy it is most effective and economically expedient to use active ventilation of the material while the material itself is moving in the air stream. As a result, cooling and drying of the material is achieved. As a result, the soy in the tank is stirred, preventing and eliminating self-warming, equalizing the temperature and humidity of the material during storage, excluding caking and the formation of local decay zones, etc.

At the same time, the modernized agricultural containers, agricultural company and private farmers, who have found their application of such a universal design as a metal container block, could not but evaluate the converted containers.

With this in mind, the advantages outlined above can have a greater effect when combined using them.

We offer a new version of container-modular equipment for drying and storage of grain in farms (Fig. 1).

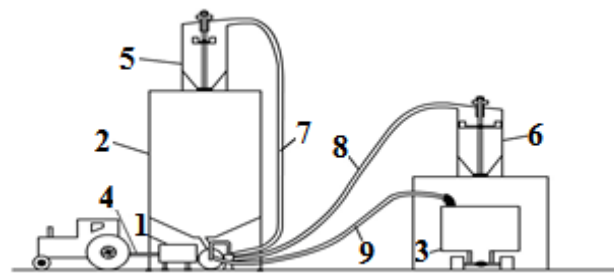


Figure 1- Container-module equipment for drying grain.

1-pneumatic conveyor, 2-equipped container, 3-vehicle for grain storage, 4-VOM tractor, 5,6-cyclone, 7,8,9-hoses for grain loading and unloading

The equipment operates as follows. The process consists of three cycles: loading, venting and unloading.

Loading (Fig. 2) is carried out by means of a pneumatic conveyor (1) from the vehicle (3) through the suction conduit (9), then hoses (7) into the hopper (2), where the grain is stored.

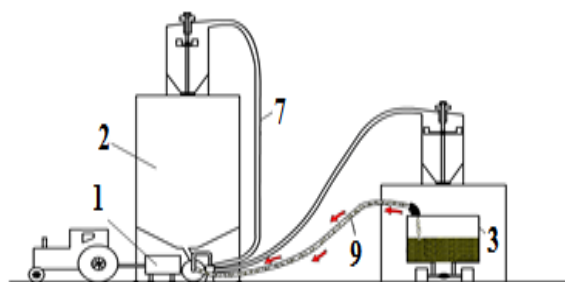


Figure 2-Scheme of grain loading through a pneumatic conveyor

The active ventilation of the grain (Fig. 3) is carried out in a closed circle through the pneumatic conveyor (1) -shoot (7) - cyclone (5) into the storage bin (2).

Ventilation is carried out until the humidity is 12%. At the same time, there is a valve on the pneumatic conveyor to transfer the flow of mass into the corresponding hose.

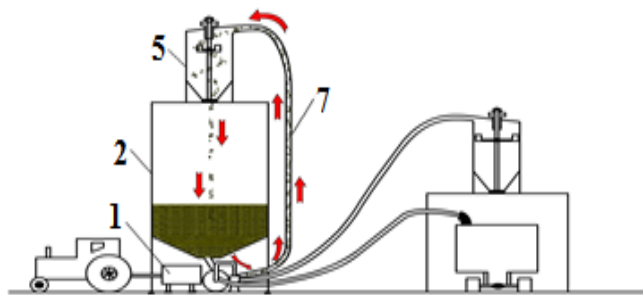


Figure 3- Scheme of ventilation of grain flow in a container

The unloading of grain from the hopper (Fig. 4) comes from the lower part by means of a pneumatic conveyor (1), a hose (8) through a cyclone (6) into a vehicle (3).

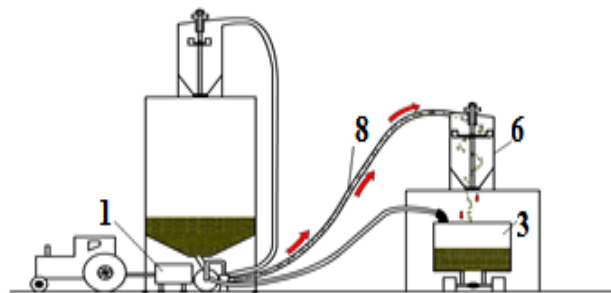


Figure 4. - Grain unloading scheme

Modular equipment of container type are the most advanced devices for rapid cooling, as well as for slow drying of soy and seeds of various crops, intended for the accumulation and temporary conservation of soy, while preserving its sowing and food qualities. The equipment occupies a relatively small space, provides full mechanization of loading and unloading of grain, it is mounted quite quickly. Thanks to the ability to work in any weather, rapid cooling, full mechanization of loading and unloading soy, vented hoppers are suitable for use in combination with inline grain cleaning and drying lines [9].

4. Conclusion

For post-harvest drying of soy, container-modular equipment for pneumatic drying and storage is offered.

The equipment will occupy a relatively small space, provide full mechanization of grain loading and unloading, install quickly enough, and use containers of 20, 40 tons as capacity for storage, which makes it possible to work in any weather, rapid cooling, full mechanization of loading and unloading soya, ventilated bunkers are suitable for use in combination with grain-line drying lines.

The proposed technology of container-modular air drying and storage equipment will allow drying without the use of expensive energy sources (gas, fuel oil, coal). It is necessary to justify the technological constructive scheme of the proposed variant of soy drying, with the conduct of an analytical study. Development of a technical specification for a laboratory sample of a soy drying plant, followed by manufacturing for laboratory testing.

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THEORETICAL INVESTIGATION OF A REAR-MOUNTED LINKAGE FOR WIDE-SPAN TRACTORS

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Abstract: The work is devoted to the investigation of the peculiarities of aggregation of wide-span tractors (vehicles) with agricultural machines and implements. As a result of the conducted studies, it has been established that, from the point of view of the control impact (the turning angle of the driven wheels) and the disturbing impact (the turning angle of the mounted implement in a horizontal plane) exerted by the wide-span tractor, the most desirable is such a variant of configuration of the mounted device in which the instantaneous centre of rotation, formed by the convergence rays of its lower links, is in the centre of the mass of the tractor. When using wide-span tractors (vehicles) with mounted implements of the high 4N and 4 categories in accordance with the ISO 730: 2009, one should consider a possibility to configure them both for a three-point and a two-point scheme.

KEYWORDS: WIDE SPAN TRACTORS (VEHICLES), REAR-MOUNTED LINKAGE, STABILITY AND CONTROLLABILITY, ANGULAR MOBILITY, RESEARCH ON THE PC.

1. Introduction

Wide-span tractors (vehicles) [1, 2] are lately gaining popularity in the world, which allow implementing a controlled traffic farming technology.

Owing to their rather high versatility the wide-span tractors (vehicles) can (and undoubtedly should) be aggregated with mounted, semi-mounted and trailed agricultural machines and implements [1, 2]. At the same time, the wide-span tractor (vehicle), by its layout scheme, is intended for linking of the technological part (with or without a mounted device) in sufficient vicinity to its centre of mass [1]. In such a situation, to ensure that the deviations from the course of the wide-span tractor (vehicle) did not adversely affect the stability of the movement of the mounted aggregated machines and implements, the design of the mounted implement must (to some extent, naturally) be able to independently rotate in a horizontal plane. That is why the issue of justifying the parameters of a wide-span tractor (vehicle) from the standpoint of steady movement of its technological part in a horizontal plane is relevant.

It is known that the three-point adjustment scheme of a rear-mounted mechanism of the conventional tractor can provide sufficient mutual angular turning ability of its framework and the technological part [3]. Considering a possibility to unify the mounted implements of the wide-span tractors (vehicles) with the conventional ones, the parameters of which are determined by the International Standard ISO 730: 2009, it is necessary to establish a correspondence of the sizes and requirements for a three-point mounting, designed for the connection of agricultural machines and implements.

In addition, certain trends have been outlined lately in the improvement of the design of the three-point mounting devices of tractors [4-9]. However, insufficient attention has been paid to the problem of their angular mobility, especially with respect to the wide-span tractors (vehicles) characterised by an untypical layout, the specificity of their use and the operating conditions.

The purpose of the work is to increase the efficiency of operation and use of wide-span tractors (vehicles) by justifying the parameters of their mounted devices.

2. Materials and method

As a physical object of research, we will consider a wide-span vehicle of the authors' design, shown in Fig. 1.



Fig. 1. A design of a wide-span vehicle developed in Ukraine

When making a plane-parallel movement in a horizontal plane, a number of corresponding forces are acting upon the wide-span vehicle and its technological part. For the purpose of mathematical simulation of its plane-parallel movement, we will construct an equivalent calculation scheme for the wide-span vehicle (Fig. 2).

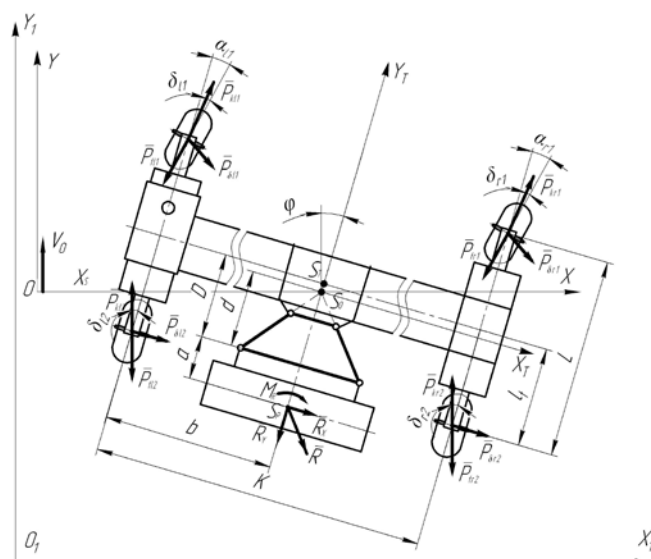


Fig. 2. A scheme of forces acting upon the wide-span vehicle in a horizontal plane with a kinematic method of its control

With respect to the XOY plane the investigated wide-span vehicle with a technological part attached to it has two degrees of

freedom, corresponding to two generalised coordinates: angle φ and abscissa X_S (Fig. 2).

To the number of external forces acting upon the wide-span vehicle in its plane-parallel movement (see Fig. 2) belong:

- the forces of rolling resistance of the frontal (P_{f11}, P_{f11}) and the rear (P_{f12}, P_{f12}) wheels;
- the tangential traction forces $P_{kl1}, P_{kr1}, P_{kl2}, P_{kr2}$, on the frontal and rear wheels;
- lateral forces $P_{\delta l1}, P_{\delta l2}, P_{\delta r1}, P_{\delta r2}$, which lead to the appearance of displacement angles of the frontal δ_{l1}, δ_{r1} and the rear δ_{l2}, δ_{r2} wheels;
- the main vector R (components R_x and R_y , respectively) and the main moment M_R of forces brought to the centre of resistance (point S_0), acting from the side of the agricultural implements.

The value of force R_x and moment M_R will depend on the turning angle β of the lower links of the wide- span vehicle (Fig. 3).

Taking into account the small value of these angles in Fig. 3 we have:

$$\begin{aligned} R_x &= R[\varepsilon \pm (1 - c/l)\beta], \\ M_R &= R(d_0 + D - d)[\varepsilon \pm (1 - c/l)\beta], \end{aligned} \quad (1)$$

where ε – an angle between the direction of the traction force of the tractor and the longitudinal axis of symmetry of its technological part;

β – the turning angle of the lower links of the mounted wide-span vehicle;

d_0 – the distance in a longitudinal direction from the point of application of the hook effort to the instantaneous turning centre of the mounted tractor attachment (Fig. 3);

c, l – the design parameters of the mounted wide- span vehicle (Fig. 3).

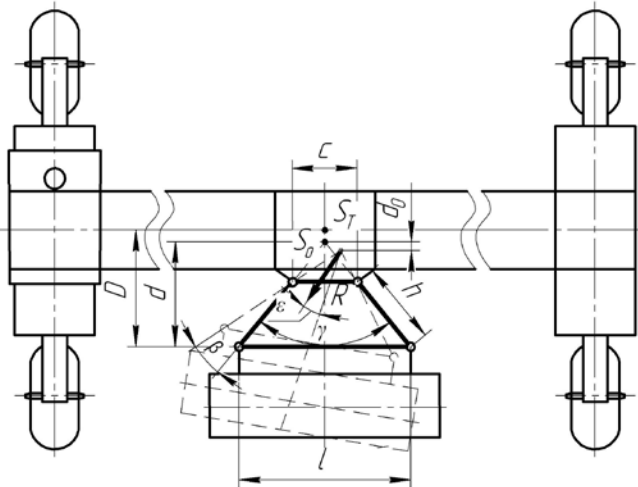


Fig. 3. A scheme of turning of the lower links of the mounted wide-span vehicle attached at angle β

In dependencies (1), the choice of the sign from the proposed record "±" is determined by the correspondence of the direction of angles ε and β . So the "-" sign is accepted when the indicated angles of the agricultural implement change in the process of the work of the wide-span vehicle in antiphase. In case of their in-phase change sign "+" is adopted.

3. Results and discussion

The differential equations of the movement of the wide-span vehicle with respect to plane XOY (see Fig. 2) will look like:

$$\begin{aligned} A_{11}\ddot{X}_S + A_{12}\dot{X}_S + A_{13}\dot{\varphi} + A_{14}\varphi &= f_{11}\alpha + f_{12}\beta + f_{13}; \\ A_{21}\ddot{\varphi} + A_{22}\dot{\varphi} + A_{23}\varphi + A_{24}\dot{X}_S &= f_{21}\alpha + f_{22}\beta + f_{23}, \end{aligned} \quad (2)$$

where $A_{11} = M_T + M_R$;

$$A_{12} = \left(k_{l1} + k_{l2} + k_{r1} + k_{r2} - P_{kl1} + P_{f11} - P_{kr1} + \right. \\ \left. + P_{fr1} - P_{kl2} + P_{f12} - P_{kr2} + P_{fr2} \right) / V_0;$$

$$A_{13} = \left[(k_{l1} + k_{r1} - P_{kl1} + P_{f11} - P_{kr1} + P_{fr1})(L - l_t + D - d) + \right. \\ \left. + (P_{kl2} - P_{f12} + P_{kr2} - P_{fr2} - k_{l2} - k_{r2})(l_t - D + d) \right] / V_0;$$

$$A_{14} = -A_{12}V_0; \quad A_{21} = J_{SO};$$

$$A_{22} = \left[(k_{l1} + k_{r1} - P_{kl1} + P_{f11} - P_{kr1} + P_{fr1})(L - l_t + D - d)^2 + \right. \\ \left. + (P_{kl2} - P_{f12} + P_{kr2} - P_{fr2} - k_{l2} - k_{r2})(l_t - D + d)^2 \right] / V_0;$$

$$A_{23} = -A_{13}V_0; \quad A_{24} = A_{13};$$

$$f_{11} = k_{l1} + k_{r1}; \quad f_{12} = R(1 - c/l); \quad f_{13} = R\varepsilon;$$

$$f_{21} = (k_{l1} + k_{r1} + P_{kl1} - P_{f11} + P_{kr1} - P_{fr1})(L - l_t + D - d);$$

$$f_{22} = R(1 - c/l)(d_0 + D - a - 2d) + (P_{kl1} - P_{f11} + P_{kl2} - P_{f12})b -$$

$$(P_{kr1} - P_{fr1} + P_{kr2} - P_{fr2})(K - b);$$

$$f_{23} = R(d_0 + D - a - 2d)\varepsilon.$$

In the mathematical model (2) the following designations are accepted: M_T, M_P – masses of the tractor and its technological part, respectively; V_0 – the forward speed of the tractor; J_{SO} – the moment of inertia of the tractor with the technological part relative to point S_0 ; k_{l1}, k_{r1} and k_{l2}, k_{r2} – coefficients of the drag resistance of the frontal and rear wheels of the wide- span vehicle, respectively L, l_t, K, a, b, d, D – the design parameters of the wide-span vehicle the nature of which is clear from Fig. 2 and 3; α_{l1}, α_{r1} – the turning angles of the driven wheels of the tractor at its kinematic method of control.

Applying transformation $d/dt = s$, we will obtain a mathematical model of the plane-parallel movement of the wide-span vehicle in a horizontal plane, recorded in an operator form:

$$\begin{cases} K_{11}X_S(s) + K_{12}\varphi(s) = F_{11}\alpha(s) + F_{12}\beta(s) + F_{13}(s); \\ K_{21}X_S(s) + K_{22}\varphi(s) = F_{21}\alpha(s) + F_{22}\beta(s) + F_{23}(s), \end{cases} \quad (3)$$

where $K_{11} = A_{11}s^2 + A_{12}s$; $K_{12} = A_{13}s + A_{14}$; $K_{21} = A_{24}s$; $K_{22} = A_{21}s^2 + A_{22}s + A_{23}$; $F_{11} = f_{11}$; $F_{12} = f_{12}$; $F_{13} = f_{13}$; $F_{21} = f_{21}$; $F_{22} = f_{22}$; $F_{23} = f_{23}$;

$\frac{d}{dt} = s$ – the operator of differentiation.

The nature of the response of the dynamic system to the control and disturbing impacts is determined by the design and technological parameters of the wide- span vehicle, which enter into the coefficients of the right-hand parts of the system (3). In our case the point of interest is the nature of the response of the control and disturbing impacts of the considered dynamic system at various ratios of the design parameters d and D (see Fig. 3). These parameters determine the distance from the axis that passes through the attachment points of the lower links of the mounted device to the instantaneous turning centre (point S_0) and the centre of the mass (point S_T) of the tractor. Therefore, in the process of mathematical simulation, this ratio of parameters was considered for three cases: $d < D$; $d = D$ and $d > D$.

The output values of the mathematical model (3) are transverse displacements X_S of the wide-span vehicle, and its relative bearing φ .

The controllability of the movement of the wide- span vehicle was estimated by analysing the corresponding transfer functions with the help of the constructed amplitude and phase frequency characteristics.

The transfer function $W^\alpha(s)$, which describes variations in

the relative bearing φ of the wide-span vehicle when the turning angle α of its wheels change, can be presented according to the system of equations (3) as:

$$W^\alpha(s) = \frac{C_{1\alpha}s + C_{0\alpha}}{s(B_2s^2 + B_1s + B_0)}, \quad (4)$$

where $C_{1\alpha} = A_{11}f_{21}$; $C_{0\alpha} = A_{12}f_{21} - A_{24}f_{11}$; $B_2 = A_{11}A_{21}$; $B_1 = A_{12}A_{21} + A_{11}A_{22}$; $B_0 = A_{12}A_{22} + A_{11}A_{23} - A_{13}A_{24}$.

Analysis of the conducted theoretical studies showed that the controllability of the wide-span vehicle of the TGATU design at the speed of its movement $2 \text{ m} \cdot \text{s}^{-1}$ depends little on the change in the distance from the axis that passes through the attachment points of the lower links of the mounted device to the instantaneous turning centre (point S_0) with respect to the centre of mass (point S_T). At low fluctuation frequencies (up to $0.8 \dots 0.9 \text{ s}^{-1}$) of the turning angle α of the frontal wheels of the tractor, in possible variants of the ratio of parameters d and D (Figure 2), we have significant overregulation but at high frequencies - underregulation of the control impact by the dynamic system. Besides the desired fluctuation frequency of the turning angle α of the frontal wheels of the tractor is on the level $0.8 \dots 0.9 \text{ s}^{-1}$, where the value of the amplification coefficient of the input control impact is close to one.

The worst amplitude and phase frequency characteristics of the control impact developed by the dynamic system are observed when $d > D$ since in the operating range of frequencies these characteristics are most distant from the desired ones.

The most desirable amplitude and phase frequency characteristics of the control impact developed by the dynamic system are observed when $d < D$. In this case, in the operating range of frequencies, these characteristics are closest to the desired ones.

On the whole, the following trend emerges: in order to ensure satisfactory controllability of the wide-span vehicle of a new design, the fluctuation frequency of the turning angle of its wheels at a speed of $2 \text{ m} \cdot \text{s}^{-1}$ should be equal to $0.8 \dots 0.9 \text{ s}^{-1}$. Otherwise the amplitude and phase frequency characteristics of the control impact developed by the dynamic system are approximated to the desired ones in the case when the instantaneous turning centre of the wide-span vehicle is in the centre of its mass.

Delayed response of the wide-span vehicle to the control action is the less, the less is distance d . It is another matter that the difference between the obtained phase-frequency characteristics is not significant and generally manifests itself only at the frequencies of the control impact, greater than $0.8 \dots 0.9 \text{ s}^{-1}$.

The transfer function $W^\beta(s)$, which reflects a measurement of the change in the relative bearing of the wide-span vehicle from value β , according to the system of equations (3), can be presented as:

$$W^\beta(s) = \frac{C_{1\beta}s + C_{0\beta}}{s(B_2s^2 + B_1s + B_0)}, \quad (5)$$

where $C_{1\beta} = A_{11}f_{22}$; $C_{0\beta} = A_{12}f_{22} - A_{24}f_{12}$.

From the analysis of the development of a disturbing impact by the dynamic system it follows that with an increase in parameter d the amplitude-frequency characteristics undesirably increase. It is true that this process is more or less significant only at low fluctuation frequencies of angle β ($0.5 \dots 1.3 \text{ s}^{-1}$). The most desirable variant of the ratio of the considered parameters is when $d > D$. The latter condition indicates that the instantaneous turning centre of the wide-span vehicle should be in the centre of its mass.

This condition can be ensured by choosing such a convergence angle γ of the lower links of the mounted wide-span vehicle in which the instantaneous turning centre of the first link will be located in the zone of the centre of mass of the second link. In practice this can be achieved by setting the required value of c (Fig. 3). When $d = D$, parameter c in Fig. 3 should be equal to:

$$c = 1 \left(1 - \frac{2h}{\sqrt{1^2 + 4D^2}} \right). \quad (6)$$

And the convergence angle γ of the lower links of the mounted wide-span vehicle is equal to:

$$\gamma = 2\text{ATAN}\left(\frac{1}{2D}\right). \quad (7)$$

Analysis of dependencies (6) and (7) for the mounted devices of high categories 4N and 4, according to ISO 730: 2009, showed that, increasing distance D from the axis that passes through the attachment points of the lower links to its centre of mass, the required increase in length c varies nonproportionally (Fig. 4). As nonproportional is also reduction of the convergence angle γ of the lower links. On the whole, increasing length D from 0.6 to 2.6 m, c increases from 0.02 m, which practically corresponds to full reduction of the lower links of the wide-span vehicle to one point, up to 0.77 m. In this case angle γ decreases from 85 to 24 deg.

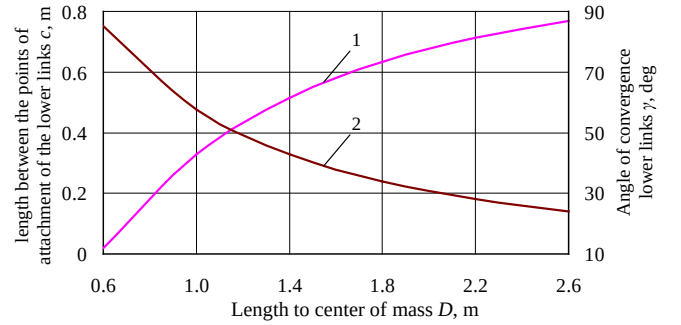


Fig. 4. Dependence of the distance between the points of attachment of the lower links of the mounted wide-span vehicle (1) and the convergence angle of its lower links (2) upon the distance to its centre of mass

The conducted investigations showed that, in order to ensure sufficient angular mobility of the technological part of the wide-span vehicle in relation to its framework, the required distance between the attachment points of the lower links of the mounted device is substantially determined by the distance to its centre of mass. Besides, the proximity of the location of the mounted device to the centre of the mass of the wide-span vehicle is determined by the fact that the required distance between the attachment points of the lower links of the mounted device should be so small that it corresponds to their complete reduction to one point. Therefore, from a position of designing a mounted multi-purpose device for the wide-span tractors (vehicles), one should consider a possibility to configure it, both according to a three-point and a two-point scheme.

4. Conclusion

1. It has been established during the research that the most desirable is such a variant of configuration of the mounted device of the wide-span tractor (vehicle) in which the instantaneous turning centre, formed by convergent rays of its lower links, is in the centre of the mass of the tractor.

2. To ensure sufficient angular mobility of the technological part of the wide-span tractor (vehicle) relative to its framework, the required distance between the attachment points and the convergence angle of the lower links of the mounted device is substantially determined by the distance to its centre of mass. When the latter is reduced, the required distance between the attachment points of the lower links of the mounted device can be so small that it corresponds to their complete reduction to one point.

3. From the position of designing a multi-purpose mounted device for wide-span tractors (vehicles), one should consider a possibility to configure it, both according to a three-point and a two-point scheme.

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VACUUM CONTROL OF MILKING MACHINES BY USING THE FREQUENCY CONVERTER AND THE REDUCING VALVE

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Abstract: The article deals with the milking machine vacuum system which is designed for the vacuum level control with a special reducing valve. Vacuum Milking machines with the vacuum pumps without frequency converter have the constant rotation speed and vacuum level is controlled by the control valve. By using the frequency converter for controlling electric motor of vacuum pump the electric energy consumption significantly decreases but the vacuum fluctuation is higher. The vacuum pump of the designed vacuum system is connected to the air container. The vacuum level of the air container is controlled by the frequency converter on a higher level than the level of the milking vacuum. Newly designed reducing valve is placed between the air container and the vacuum pipeline system of the milking machine. The reducing valve controls the air which flows through it and the vacuum is reduced on the required level and is stabilized. But the energy consumption is a little bit higher.

KEY WORDS: MILKING MACHINES, VACUUM PUMP, VACUUM LEVEL CONTROL, FREQUENCY CONVERTER

1. Introduction

If a constant vacuum is to be obtained by applying a standard regulation method of vacuum magnitude, the control valve must suck so much atmospheric air into the vacuum system that the sum of the air amount sucked in by the milking machine and the control valve within a time interval is constant. The vacuum pump works at a full efficiency irrespective of the actual consumption by the milking machine. For this presently, frequency converters are commonly used to drive the vacuum pumps of milking machines as this result in major electricity consumption reduction. Their frequent using is encouraged by their relatively low price and the resulting short payback periods. Rasmussen states that the payback period is approx. 4.8 years [RASMUSSEN, 2005]. Olejník later gave a payback period of 2 years [OLEJNÍK et al., 2008]. Since then, the prices of frequency converters have dropped even further and their payback period is currently even less than one year. Kudělka features already only about 200 days [KUDĚLKA et al., 2012]. The use of frequency converters results in power consumption reduction ranging around 50 %. Olejník gives a cost reduction value of 50 - 58 % [OLEJNÍK et al., 2008], Kudělka features 57 % [KUDĚLKA 2016]. To a certain extent, the reduction percentage is affected by the vacuum pump delivery given the size of the milking plant. If an unnecessarily high capacity vacuum pump is selected, the reduction appears to be high, too. Rasmussen measured the absolute reduction and states that the automatic milking system DeLaval VMS showed a saving of 20 kWh of electric power over 24 hrs of frequency converter-driven vacuum pumps being in use [RASMUSSEN, 2005]. The vacuum pump revolution control has been dealt with for a relatively long time [DUNN, 1996] and research in the field of milking has focused on vacuum control in the individual teat cups. [STRÖBEL et al., 2012, STRÖBEL et al., 2013] In practice, certain problems are still encountered when using the frequency converters.

2. Prerequisites and means for solving the problem

Vacuum control by changing the revolutions entails certain deterioration in the vacuum stability. Vacuum fluctuation is reflected in the deformation curve of the teat liner. The teat liner deformation curve in dependence on vacuum was described by Karas [KARAS et al., 2003]. Greater vacuum fluctuation is determined by the fact that air flow rate changes, i.e. during the teat cup application, occur very fast and changes in the electric motor and vacuum pump revolutions take place at a slower pace, which is

caused by the rotating part inertia. Therefore, milking machines with frequency converters are also fitted with a conventional control valve, which is set to a value that is by ca. 1 kPa higher than the vacuum level set for the frequency converter control. If the air flow rapidly drops, the vacuum would be increasing for a short period of time. The control valve prevents from the increase exceeding 1 kPa. Contrariwise, when the flow rate increases, no system preventing from the vacuum drop is available and the vacuum changes depend on the time over which the vacuum pump revolutions reach the desired value.

To validate the proper functioning of the stabilisation device, vacuum fluctuation was measured in a tandem milking parlour 2x3 with very good results [FRYČ et al., 2016]. The same device was tested in large herringbone milking parlour 2x13, but results was not satisfactory [FRYČ et al., 2015]. Therefore, was made other newly designed reducing valve. The objective of this study is to validate the applicability of the manufactured stabilisation device prototype in laboratory.

3. Solution of the examined problem

One of the basic demands for milking machines is to maintain a constant vacuum level if air consumption by milking machine is changed. The reduce valve prototype was manufactured by Utility model 14020 [FRYČ, 2004], but was modified for higher air flow rate. To validate the proper functioning of the stabilisation device with reduce valve, vacuum fluctuation was measured in laboratory, where was installed milking machine by Fig. 1.

The vacuum pump of the designed vacuum system is connected to the air container AC1. The vacuum level of the air container AC1 is controlled by the frequency converter on a higher level than the level of the milking vacuum. Newly designed reducing valve is placed between the air container AC1 and the vacuum pipeline system of the milking machine (air container AC2 at experimental device). The reducing valve controls the air which flows through it and the vacuum is reduced on the required level and is stabilized. The experiment milking plant is equipped with oil lubricated rotary vane vacuum pump with an actual delivery of 1564 l.min^{-1} at a 50 kPa vacuum. Working vacuum in experiments was 45 kPa.

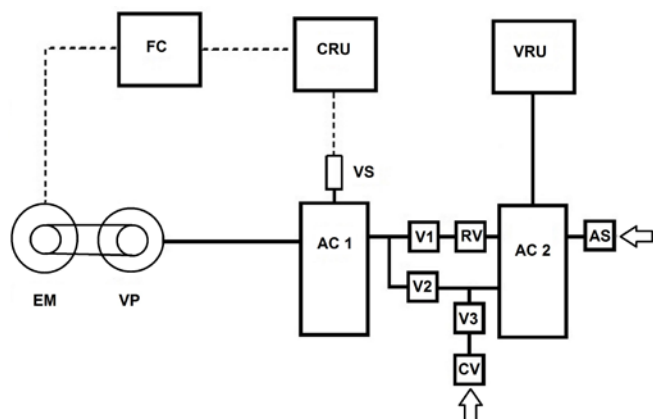


Fig. 1 Scheme of experimental device

FC – frequency converter, CRU – control and record unit, VRU – vacuum record unit, EM – electric motor, VP – vacuum pump, VS – vacuum sensor, AC1, AC2 air container, V1, V2, V3 – closing valve, RV – reducing valve, CV – control valve, AS – air sucking control device

The milking machine vacuum system capacity (pipe lines, air containers) totals 254 l. Three vacuum control alternatives were measured:

1. Control valve
(valve V1 closed, valve V2 open, valve V3 open)
2. Frequency converter
(valve V1 closed, valve V2 open, valve V3 closed)
3. Frequency converter complete with the stabilisation device (reducing valve prototype)
(valve V1 open, valve V2 closed, valve V3 closed)

The vacuum fluctuation measurement was conducted by means of the Pulsatortester PT IV instrument measuring the vacuum for a period of 60 s and over this time interval we determined the maximum, average and minimum vacuum values. The vacuum fluctuation was then calculated as a difference between the maximum and minimum value.

To conduct the measurements in objectively identical conditions, measurement was carried out with the air consumption by a precisely defined variable flow rate (Q_1 , Q_2 , Q_3) see Fig.2. An electromagnetic valve connected instead of the collector to the central suction piece provided for the variable flow. The operation of the electromagnetic valve was controlled by a time relay. 15 s opening intervals alternated with 15 s closing intervals. Once in the open position, the valve sucked 100 l min^{-1} . The total air flow was then gradually increased by sucking in air via three different calibrated openings. More air got into the milking machine vacuum system through the leaking spots. The calibrated openings sucked in 400 l min^{-1} , 600 l min^{-1} and 800 l min^{-1} . The measurement determined that leakage sucked in 22 l min^{-1} .

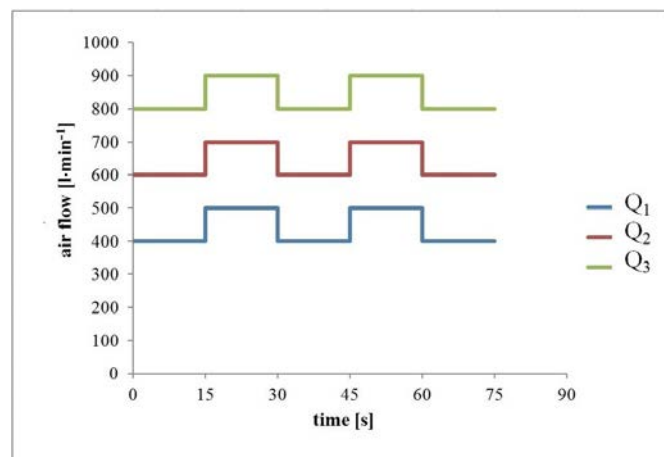


Fig. 2 Variable flow rate of air sucked in by the milking machine

Pressure difference is necessary for reduce valve using. The vacuum level of the air container AC1 is controlled by the frequency converter on a higher level than the level of the working vacuum. Three different levels of vacuum were tested 48 kPa, 51 kPa and 54 kPa. Electric energy consumption was recorded during all experiments.

Each measurement was repeated ten times and the measured values were statistically processed. To process the data, a use was made of the dispersion analysis which was employed to determine the statistical significance of the difference between the measured values determined by the individual vacuum control methods. The method of subsequent testing using the Tukey range test assessed the statistical significance of differences between all the measurement combinations.

4. Results and discussion

When the vacuum fluctuation measurement was carried out under a precisely defined variable air flow rate, the lowest values were achieved when the control valve was used. The average difference between the maximum and minimum vacuum value was 1.1 kPa.

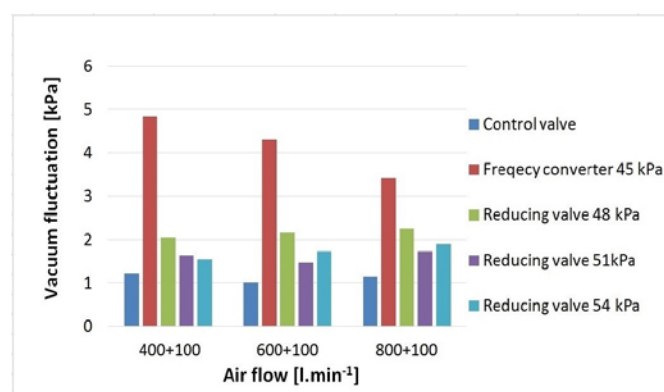


Fig. 3 Vacuum fluctuation at measurement

During frequency converter control the first measurement (flow rate Q_1) was fluctuation 4,8 kPa. With the increasing flow rate, it decreased to values 4.3 kPa (flow rate Q_2) and 3.4 kPa (flow rate Q_3). By connecting the prototype of the stabilisation device with reducing valve was indicated that the vacuum fluctuation is independent on air flow rate, but depends on the vacuum level at air container AC 1. When the vacuum level in the air container AC 1 is

48 kPa the average fluctuation is 2.1 kPa. When the vacuum level in the air container AC 1 is 51 kPa the average fluctuation is 1.6 kPa. When the vacuum level in the air container AC 1 is 54 kPa the average fluctuation is 1.7 kPa. Olejník and Pavelková and other authors state that the vacuum fluctuation during the frequency converter control goes up to 2 kPa when being used on farms [OLEJNÍK et al., 2008]. The comparison of our results with the experiments on farms isn't appropriate. The resembling measurements like ours were carried out by Kudělka and his results are similar [KUDĚLKA 2016].

To process the data, we employed the dispersion analysis based on which we determined that differences in the measured values between the individual vacuum control methods are statistically significant. We obtain following results: We determined the statistically highly significant difference in the measured values between the individual vacuum control methods. Difference between individual measurements with reducing valve are statistically significant only between vacuum levels 48 kPa and 51 kPa. Between other vacuum levels there are not statistically significant differences.

Comparison of electric energy consumption was carried out between vacuum control by frequency converter and vacuum control by reducing valve variations. The results of the electric energy consumption measurements are shown in Fig. 4. When the vacuum level increases the electric energy consumption increases as well. With the increasing flow rate, the differences between values of electric energy consumption increase. The use of frequency converters on farms results in power consumption reduction 50 % or more. [OLEJNÍK et al., 2008], [KUDĚLKA 2016]. We calculated the expected saving of the energy consumption. We supposed that the energy saving is 50 % in case the frequency converter is used for a vacuum control. The calculated energy saving is 46.5 % when vacuum level at air container AC1 is 48 kPa. The calculated energy saving is 42.7 % when the vacuum level at air container AC1 is 51 kPa. The calculated energy saving is 38.2 % when vacuum level at air container AC1 is 54 kPa.

To process the data, we employed the dispersion analysis based on which we determined the statistically significant difference in the measured values between the individual vacuum control methods. After that we tested the differences between the specific control methods at the identical flow rate. The testing method – Tukey test – revealed statistically significant differences between all measurements combinations at all the set flow rates.

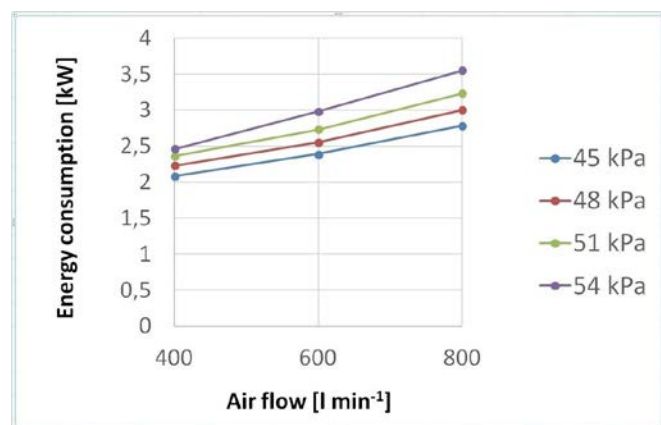


Fig. 4 Energy consumption of vacuum pump electric motor

5. Conclusion

The measurement we performed confirms that if a frequency converter is used, the vacuum fluctuation is at higher level as in case a control valve is used. Likewise it has been demonstrated that the proposed prototype of the stabilisation device can reduce the fluctuation. The achieved results are not as good as in case the control valve is used. On the other hand the vacuum fluctuation reduction nearly by 50 % is satisfactory. Higher energy consumption is the disadvantage of the vacuum control device with reducing valve. Saving of the energy consumption decreases from 50 % to 46.5 % in the best case. We have to choose a convenient variant with optimum vacuum fluctuation and energy consumption saving.

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LIVESTOCK FARMS SERVICING PERIMETER OPTIMIZATION

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Abstract: The system of the servicing of the machines in the livestock farms has been analyzed and the necessity of optimizing the spare parts services and the scope of the workshops for maintaining the equipment in the livestock breeding.

Relations have been developed to optimize the area to be serviced by the workshop and its spare parts warehouse, as well as the optimal average distance to be found from where machines work.

KEY WORDS: MACHINERY, LIVESTOCK FARMS, SERVICE, SPARE PARTS, STOCK MAINTENANCE COSTS, OPTIMIZATION, AREA.

In the process of operation, the machines interact with the environment, and their elements interact with each other. As a result of the influence of numerous and largely unmanageable factors in the process of operation, the mutual arrangement of the parts, gaps, electrical and other dimensions changes. In livestock breeding the equipment operates in aggressive work environments and most often without an approved service system. This results in malfunctions (defects, failures and faults) that translate the machine into a malfunction, inactivity or borderline condition [1,2,3]. Given the specifics of animal breeding, it is necessary to remove them within a short time.

In this aspect, it is necessary to optimize the spare parts service and the scope of the workshops to maintain the required stand-by factor [4,5].

To determine the service maintenance perimeter, the average cost per unit time criterion is used, expressed in the following way:

$$\Phi = C_{np} + C_3 + C_{tp}, \text{ ЛВ./h},$$

Where: C_{np} is losses due to downtime of machines waiting for spare parts BGN/h;

C_3 – costs of maintaining a stock of spare parts BGN/h;

C_{tp} – transport costs related to the supply of spare parts, BGN/h.

In determining the impact of individual elements (C_{np} , C_3 и C_{tp}) on the cost value of the average costs, the relationship between the average distance from the workshop with a spare parts store to the farm and the area of the service area S_0 is expressed by the formula

$$L = k\varepsilon \sqrt{S_0},$$

Where: ε is the coefficient expressing the relationship between the shape of the section of land and the location of the workshop ($\varepsilon=0,4-0,8$);

k – the coefficient representing the distortion of the road network ($k=1,3-1,5$).

There has been a detailed research on the change of the coefficient according to the geometric shape of the earth section (circle, hexagon, square and rectangle) and the location of the workshop with the spare parts warehouse (in the center of the geometry, half of the diagonal of the square and the rectangle, in the middle of the radius of the circle, of the circle itself or of a square and a rectangle). It was found to be in the range of 0,4 to 0,8 [6]. The lower limit refers to cases where it is in the center of the geometric figure, and the upper limit - when it is on one of the vertices of the square or rectangle.

Given the administrative and territorial division of our country, the value ranges from 0,4 to 0,6.

The average time for delivery of spare parts to the farm t_g to the machines is determined by the dependence

$$t_g = (k\varepsilon \sqrt{S_0})/v,$$

Where v is the average speed of the vehicle, km/h.

Hence losses due to downtime of machines waiting for spare parts

$$C_{np} = [(2\varepsilon k \sqrt{S_0})/v] n \lambda C_{np},$$

Where λ is the average number of requests of a certain element, h^{-1} ;
 n - the number of uniform details of a given type in the machine, num.;

C_{np} are losses due to machine downtime, BGN/h.

For a full and consistent description of the flow of requests is necessary to know what is the probability that in a given time interval to eliminate the failure to do 1, 2, 3 requests.

It is assumed that the flow of failures (requests) is custom, ie. the conditions are met: the flow is ordinal, stationary and without consequences. This assumption is confirmed in [6].

The average number of requests for a spare part Λ entering the warehouse serving the area S_0 , is:

$$\Lambda = S_0 \lambda n g T_n,$$

where: g is the average number of machines that are located on a unit served by the warehouse area (density), pc/km²;

T_n - the period of replenishment of spare parts or the period of time for which the machinery will be provided with spare parts, h.

The required stock of X_3 spare parts in the warehouse, which will compensate for random fluctuations in the request flow, is

$$X_3 = U_\alpha \sqrt{\lambda n g S_0 T_n},$$

Or related to a machine unit,

$$X_3/gS_0 = U_\alpha \sqrt{\lambda n T_n / g S_0},$$

Where U_α is the quantile of normal distribution with different confidence α and for $\alpha=0,85-0,99$, $U_\alpha=1,0-2,6$.

Then the cost of maintaining the reserve of C_3 is expressed by the dependence

$$C_3 = C_n E_n U_\alpha \sqrt{\lambda n T_n / g S_0},$$

Where C_n is the cost of the element;

E_n - normative coefficient of efficiency of capital investments ($E_n = 0,15$).

Transportation costs related to the supply of spare parts C_{tp} are:

$$C_{tp} = 2a\varepsilon k(1-\eta)n\lambda \sqrt{S_0},$$

Where a is the value for freight transport per unit distance, BGN/km;

η - the ratio accounting for the reduction of transport costs in relation to the transport of payload ($\eta=0-0,5$).

Hence, in order to determine the optimum level of spare stock, it is necessary to sum up the costs of maintenance of the C_3 stocks, the transport costs C_{np} and the losses due to the downtime C_{tp} , ie. we find the area of the area where the total costs are minimal. Depending on the optimum area of the area to be served:

$$S_{opt}=C_d E_u U_\alpha v / 2k\varepsilon [C_{np} + (1-\eta)av] \cdot \sqrt{T_n / \lambda n g}, km^2,$$

And the optimal average distance L_{opt} , the place where the spare parts of the machine are to be located to where the machines are working, is

$$L_{opt} = \sqrt{\varepsilon k C_d \delta \partial E v U_\alpha / 2 C_{np} + a v (1 - \eta) \cdot \sqrt{T_b / \lambda g g n}}.$$

If the relationship between the number of machines N_M , their density g and the optimal area of the area served by the S_{opt} warehouse is used, there is a dependency on the optimal number of machines that can be serviced by the warehouse for details of a type

$$N_m^{opt} = C_d E_u v U_\alpha / 2k\varepsilon [C_{np} + a(1-\eta)v] \cdot \sqrt{g T_n / \lambda n}, \text{ бр.}$$

So far it has been accepted that the distribution of machinery in a given area is even. Actual conditions more closely correspond to a poisson field model with randomly spaced points.

What is interesting is the extent to which the average radius of service and delivery of spare parts to machines with a uniform distribution of machinery differs from the average radius obtained by accidentally distributing machines in a given territory.

Therefore, the law on the distribution of distances will be used r_n from any point of the field to the n -th point [6].

The distribution function $F_1(r)$ of the distance r_1 from any point of the field to the nearest adjacent point is written with the equation

$$F_1(r) = 1 - \exp\{-\pi r^2 \gamma\}.$$

The physics meaning of $F_1(r)$ is to determine the probability that a circle with a radius r falls at least one point apart from the one that is the center of the circle. The probability of this event does not depend on whether this point is at the center of the circle or not.

The distribution density function is $f_1(r) = \alpha F_1(r) / (dr) = -\pi r \gamma \exp\{-\pi r^2 \gamma\}$. The mathematical expectation of the average distance between two adjacent points respectively

$$r_1 = \int_0^\infty r \cdot 2\pi r \gamma \exp\{-\pi r^2 \gamma\} dr = 1 / (2 \sqrt{\gamma}).$$

The distribution function $F_2(r) = P(r_2 < r)$ reflects the probability that in a circle with radius r fall not less than two points and $F_2(r) = 1 - \exp\{-\pi r^2 \gamma\} - \pi r^2 \gamma \exp\{-\pi r^2 \gamma\}$.

An analogous function corresponding to the likelihood of falling

n points in the circle is

$$F_n(r) = P(r_n < r) = 1 - \sum_{k=0}^{n-1} (a^k / k!) e^{-a},$$

where $a = \pi r^2 \gamma$.

The density $F_n(r)$ is determined by differentiating the distribution function $F_n(r)$ by r :

$$f_n(r) = dF_n(r) / (da/dr) = \left[- \sum_{k=0}^{n-1} k (a^{k-1} / k!) e^{-a} + \sum_{k=0}^{n-1} (a^k / k!) e^{-a} \right] 2\pi r \gamma = a^{n-1} / (n-1)! e^{-a} \cdot 2\pi r \gamma.$$

The mathematical expectation is:

$$r_n = \int_0^\infty r (\pi r^2 \gamma)^{n-1} / (n-1)! \exp\{-\pi r^2 \gamma\} \cdot 2\pi r \gamma dr.$$

After conversion we get

$$r = \Gamma(n+1/2) / (n-1)! \sqrt{n\gamma},$$

where: $\Gamma(n + 1/2)$ is a gamma function [7].

The average distance of space of dots from the center of the circle is defined as the average value of the mathematical expectation of the radius of distance of a point on:

$$r = \sum_{n=1}^{n_a-1} r_n / n_a.$$

The average radius of service and delivery of spare parts to the machines corresponding to the even distribution, taking into account the road network, is determined by the formula $r_{cp} = kr$.

For the practical use of the theoretical results obtained, it is necessary to introduce a correction coefficient η_c , taking into account the random distribution of the machines in a given area:

$$\eta_c = 2/3 \sum_{n=1}^{n_a-1} r_n / (n_a \sqrt{na / \pi \gamma}).$$

And we get:

$$\eta_c = 3/2 n_a^{-3/2} \sum_{n=1}^{n-1} \Gamma(n+1/2) / (n-1)!.$$

From the formula we can conclude that the random allocation coefficient of the machines is a function of the number of machines and does not depend on the density of their distribution in a given territory (area).

The graphic change of η_c , depending on the number of machines, is given in Figure 1. Therefore, on the basis of a deflection of the correction factor accounting for the random distribution of machinery, it is sufficient for the area to have more than 25 machines of a given type, to assume that the random distribution of machinery can be replaced by a uniform distribution, i.e. this proves that the deduced dependencies are practical.

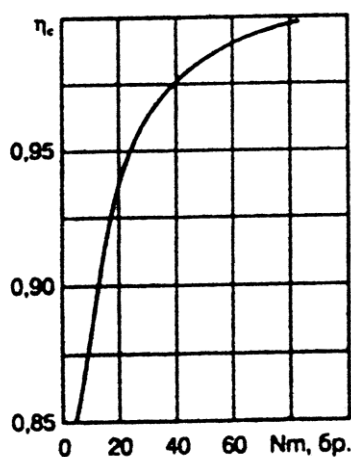


Fig. 1. Change in the coefficient η_c accounting for the random distribution of machinery in the area.

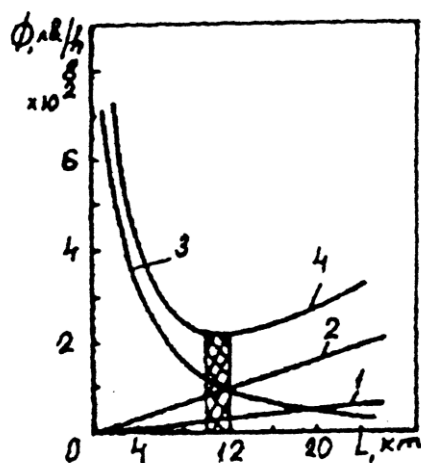


Fig. 2. Modification of total costs Φ , maintenance costs of spare parts C_3 , downtime losses 1 and transport costs 2 depending on the distance between the location of the spare parts of the machinery to the workplace of the machinery.

Fig. 2 shows the change in the total costs Φ , the cost of maintaining the reserve of spare parts C_3 , the transport costs C_{tr} and the losses due to the staying of the machines. When taking management decisions that are often not optimal and close to them, it is better to analyze and take into account the impact of individual factors on the optimum area of the area to be served by the workshop and the spare parts warehouse (S^{opt}_0), the optimal average distance (L_{opt}) where the spare part should be to the place where the machines work, which can be serviced by the spare parts warehouse (N^{opt}_m).

Conclusions:

1. Dependencies have been developed to optimize the area to be serviced by the workshop and the spare parts store, the optimal average distance they need to be located from the machine's location and to optimize the number of machines that can to be served by the spare parts store.
2. It has been found that in order to replace the random distribution of machines in a given area with a uniformity, it is sufficient that the number of machines is more than 25-30 and the analytical dependencies to optimize the perimeter of the maintenance service and that with spare parts are practical.
3. The high cost of spare parts, the periodicity of warehouse stocking and the high speed of transport are factors that allow stocks to be concentrated in a small number of large warehouses.

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CHALLENGES FACING CONTEMPORARY SEED DRILLS FOR REDUCED TILLAGE, REVIEWING VARIOUS TECHNICAL SOLUTIONS AND DISCUSSING A METHOD FOR EVALUATING THEIR EFFICIENCY

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Abstract: *There are significant benefits to be gained from reduced and no-tillage in connection to soil protection policies but the unique requirements of such practices create the need for seed drills capable of matching these requirements. It is necessary to reach a quantitative representation of the effectiveness of different brands of seed drills in order to choose a suitable drill for the task. The seed drill's efficiency can be judged after the biological and economic risks of its usage have been evaluated. This paper shows a method which uses the technical data of the seed drill and reaches a cumulative grade to evaluate the biological risk and also an existing software which compares and evaluates the economic risk for a chosen seed drill compared to Cross Slot seed drill. Combining the two types of risk evaluation lets us choose the best type of seed drill for seeding in reduced tillage.*

Keywords: SEED DRILL, REDUCED AND NO-TILLAGE, EVALUATING EFFICIENCY, BIOLOGICAL RISK, ECONOMIC RISK

1. Introduction

Soil protection has a unique look due to a number of advantages it offers such as improved economy of production; increased organic content and higher quality of the soil; reduced labour costs, assets, machinery and fuel lubricants; improved water balance in soil; reduced erosion processes; increased percentage of plant nutrients; improved environment[1,5,7,8].

The incorrect application of reduced tillage technologies hides potential risks. The risk components with reduced tillage are:

- **Biological risks** – referring to stress situations through disease and pest attacks, toxins and nutrient stress, reduced vitality of the seeds, etc.;
- **Physical risks** – referring to climate changes, preparing appropriate seed bed and efficiency of the whole machine;
- **Chemical risks** – referring to providing sufficient and timely nutrients, particularly hazards of “burning” seeds as a result of incorrect fertilisation, effective application of pesticides, etc.

Properly selected, the seed drill for direct seeding directly reduces the physical risk, and indirectly – all other risks factors. As a final result, the economic risk is reduced[5].

2. Distinctive features of seeding in soil protection agriculture

No-till has answered many of the problems arising from modern agriculture but the main reason it was introduced on a large scale in some regions was to fight soil erosion. Soil in its natural state in nature without human influence is much more resistant to water and wind erosion alike. The development of no-till followed an adaptation of existing in conventional tillage seeding openers to the specific requirements of no-till. Such are the disk openers which make a V-shaped slot and the hoe-type openers that create a U-shaped slot. Only one - a third one - has been specifically developed for no-tillage seeding purposes - the inverted T-shaped slot, achieved with a central vertical disk and two subsurface wings on both its sides[5]. All three types are intended for seeding in the conditions of soil protective agriculture. In our country they are known as seed drills for direct seeding. The similarity of traditional seed drills to those for direct seeding is only superficial since they operate in different conditions. Their distinctive features are:

- **condition of the soil** – there is minimal or zero impact on the soil and its surface is covered by a significant amount of residue or live plants;
- **construction** – the seed drills for direct seeding are mostly of the combined type, which reduces the total number of passages of agricultural aggregates over the soil surface. The seeds are laid in the soil mostly by cross slot seed boots, which provide a greater amplitude of deviations in the vertical plane.

- **energy needs** – attachment to more powerful tractors is required due to the larger technological mass and the higher soil resistance.
- **economic indicators** – the seed drills for direct seeding are more expensive and have higher maintenance costs, but this is compensated by the significantly lower cost of harvested crops.

The choice of a seed drill for direct seeding should start with assessment of the difficulties, arising from the application of soil protection technologies. The ability of the seed drill to overcome these difficulties is the precondition for its efficient use.

- With reduced tilling, the field surface is more uneven and in order for the seed boots to have better coverage, they should have a greater amplitude of deviations in the vertical plane;
- Ability of the seed boots to adapt continuously to the natural change in soil hardness in such a way that they penetrate to the same depth every time
- Incorporating of fertilisers with seeding should be carried out with clear distinction between fertiliser and seed placement, in order to reduce the biological risk of “burning” the seeds.
- The presence of residue on the field surface requires the seed boot not only to prepare an appropriate seed bed, clean of residue, but also to be able to control (to move) the residue in such a way that it will remain close to the planted seeds.

3. Technical solutions for seed drills for direct seeding

Most of the technical solutions, used in the seed drills for direct seeding are known in the traditional seed drills as well, but their abilities should not be exaggerated when it comes to direct seeding[5,7]. The main challenge that the seed drills for direct seeding face is the shape and state of the seed bed, formed by their boots. The most appropriate one turns out to be the inverted T-shape, which is achieved by two types of seed boots:

- **Cross slot seed boot** - it is a straight smooth disc with symmetrically placed cutting wings on both sides (see Fig. 1). The disc cuts the soil vertically and the cutting wings - horizontally. Thus, the cross section of the seed bed takes the shape of a cross (see Fig. 2)[10].



Fig. 1. Sowing section with cross slot seed boot

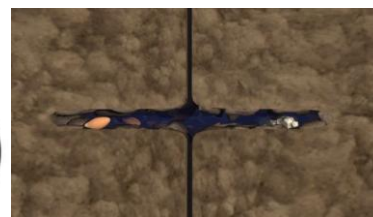


Fig.2. Shape of the seed bed made by cross slot seed boot

The seed bed formed has a wide bottom, longitudinally cut by the disc, with the seeds laid in one half and the fertilizers – in the other. The result is a seed bed clean from residue, with good soil structure around the seeds – dense bottom, a suitable loose top layer and ensured inflow of water and air. The strip planted with seed, remains covered with the plant residue. These seed drills allow seeding at higher operational speed and maintain the set depth of sowing, but have a higher drag.

- **Baker boot** - the shape of the boot resembles universal arrow-like slot with a seed line attached to its end (see Fig.3). It creates favourable environment for seed germination and sprouting, but is subjected to relatively quick wear and tends to collect plant residue on its surface. This kind of boot does not allow separate laying of seeds and fertilisers. Fertiliser is introduced by separate tools at a depth different from that of the seeds (See Fig.4[5,7,11].).



Fig. 3. Seeding section with baker boot and a cutting blade before it

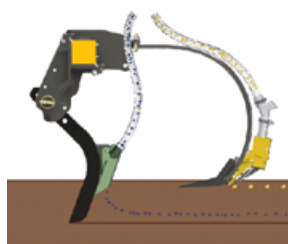


Fig. 4. Laying of fertilisers and seeds

Both types of boots are suitable for both drier and wetter soils of all kinds. The T-shaped form of the seed bed retains the available humidity around the seeds planted when it us scares while keeping the plant residue above the seeds and the soil condition around them activate earth worms at higher humidity (see Fig. 5) [10].

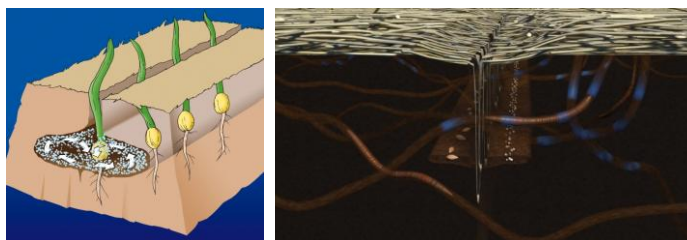


Fig. 5. Strengths of the inverted T-shaped seed bed

An important moment of the operation of all seed drills is their maintaining the set depth of seeding. The most popular way for this is using support wheels.

- **Individual control** – a more precise depth control is achieved when the seeding section is equipped with (a) support wheel(s), close to the seeding boot. This is widely used with seed drills for direct wide-row seeding (see Fig.6) and its popularity is growing also with seed drills for direct row seeding[2,3,4,5,10] (see Fig. 7).



Fig. 6. Seeding section for wide row seeding

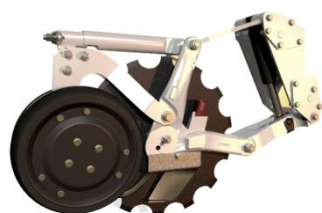


Fig. 7. Seeding section for row seeding

- **Group control** – It facilitates the maintenance of the seed drill, but it can't maintain the depth of each boot in the row(s) of seeding boots

properly (see Fig. 8), especially with large working widths of the seed drills and uneven fields. The support wheels are usually displaced in terms of the seeding boots line[2,3,4,5].



Fig. 8. Group control of seeding depth with seed drills for direct row seeding

Maintaining the seed boots in a fixed position to the field surface is related both with the seeding depth and their drag and balance during operation. Thus the way of attaching the seeding boots to the frame and the means of putting additional pressure on them is important.

Fixed suspension on spring stand – the elastic forces of the spring stand help the digging and maintain the balanced position of the boot, but they can't cover large bumps on uneven fields. (see Fig.9)[11].

Single hinge suspension – the long supporting arm of the seeding section guarantees the proper digging moment of a small mass seeding boot. Once taken out of balance, the boots suspended in this way take longer to return to balance again. That is why single hinge suspension sections need additional mechanical or hydraulic pressure (see Fig.10)[11].



Fig. 9. Fixed suspension on spring stand



Fig. 10. Single hinge suspension

Multiple hinge suspension – suitable for attaching heavy seeding sections and allowing excellent coverage of field surface even where there are bigger bumps. With such suspension, the seeding boot recovers its balance faster when needed. The inclusion of additional devices for monitoring and control of the pressure makes the movement of the section automatic and the operation of the boot even more precise (see Fig.11) [10].

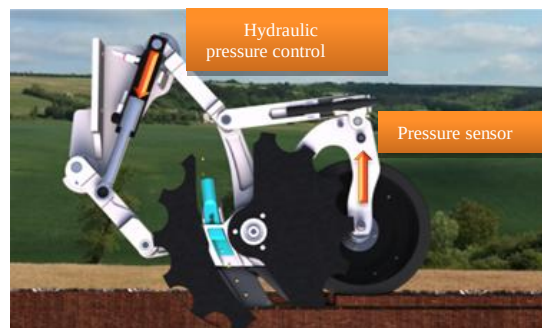


Fig. 11. Multiple hinge suspension

The dense soil, uneven soil surface and plant residue are a challenge for the seed drills for direct seeding in terms of the depth of sowing. Using automated control systems for pressure control contributes to the consistent depth while seeding, no matter what the conditions are (see Fig.12).

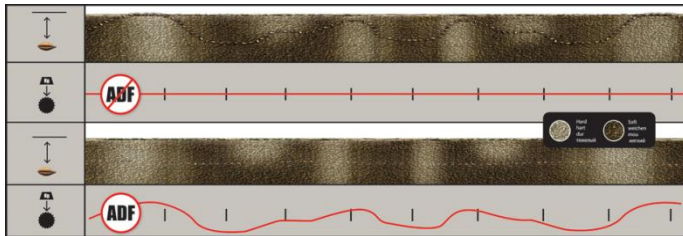


Fig. 12. In-depth seed layout without using the automated pressure control system (above) and with using such a system (below)

An alternative solution for keeping a constant seeding depth is the usage of a cultivator section which tills only the part of the field, where the seeds will be placed (Fig. 13)[6]. This equalizes the soil physical properties in the seeding zone, which benefits the stability of the seeding sections during operation even without the usage of automated pressure control system. This added feature also contributes to the reduction of biological risk when using disk and hoe openers in direct seed drills but increases the seeder weight and thus its drawing resistance. '



Fig.13. A cultivator section with star wheels attached to a direct seed drill

4. Considerations before choosing a seed drill for direct seeding

The choice of a seed drill for direct seeding should start with assessment of the difficulties, arising from the application of soil protection technologies. The ability of the seed drill to overcome these difficulties is the precondition for its efficient use.

- With reduced tilling, the field surface is more uneven and in order for the seed boots to have better coverage, they should have a greater amplitude of deviations in the vertical plane;
- Ability of the seed boots to adapt continuously to the natural change in soil hardness in such a way that they penetrate to the same depth every time
- Incorporating of fertilisers with seeding should be carried out with clear distinction between fertiliser and seed placement, in order to reduce the biological risk of “burning” the seeds.
- The presence of residue on the field surface requires the seed boot not only to prepare an appropriate seed bed, clean of residue, but also to be able to control (to move) the residue in such a way that it will remain close to the planted seeds.

5. Evaluating the effectiveness of the seed drills for direct seeding

The seed drill’s efficiency can be judged after the biological and economic risk of its usage has been evaluated. The technical specifications of the seed drill are crucial in risk evaluation. An

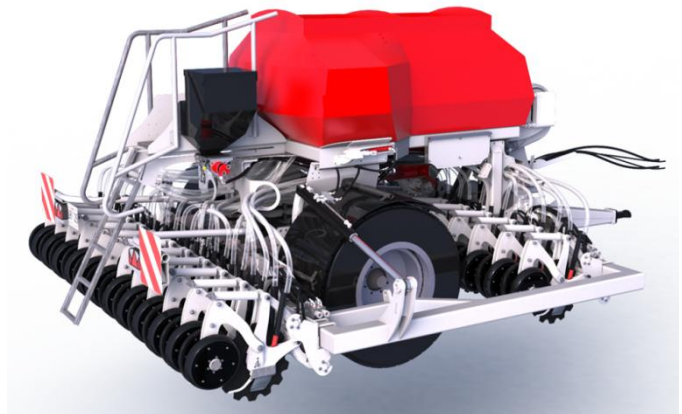


Fig. 14. Seed drill for direct seeding

example estimate is presented for the seed drill for direct seeding shown in Fig. 14.

The economic risk has been calculated by the method presented in section 5.1. below, while evaluating the biological risk is discussed in section 5.2.

5.1. Evaluating the economic risk

The economic risk can be determined by ready-made software. An example for evaluating the economic effect of using any brand of a seed drill for direct seeding compared to Cross Slot drill is presented in a table [here](#) [10]. The table takes into account the initial investment cost as well as operational costs and compares them between the two seed drills.

Using seed drills for direct seeding requires higher investments. Evaluating the economic effect by using an electronic calculator allows entering specific values, concerning the seed drill and the production technology. The economic evaluation is presented at the end of the table with three results and a commentary, making it clear where the right decision making should be directed. Often the higher purchasing cost of the direct seeding drills is later more than compensated by the higher yield these machines achieve - which is referred in the table as the yield-cost advantage.

5.2. A convenient methodology to evaluate the biological risk

A convenient way to evaluate the seed drills for direct seeding is the methodology presented in Fig. 15 [7]. It refers to the functional abilities of the seed drill to reduce to a certain extent the biological risk, which can emerge when seeding with reduced tillage. The criteria (abilities) included in the evaluation arise from the above-mentioned preconditions, each criterion changing from 1 to 10 depending on the technical solution, which has been chosen during construction of the seed drill. The smaller the number under which the technical solution stands, the smaller the estimated biological risk is.

A METHOD FOR RANKING NO-TILLAGE SEED DRILLS

DRILL/OPENER FEATURE	OPTIONS									
	INCREASING			BIOLOGICAL			RISK			
	10	9	8	7	6	5	4	3	2	1
Slot micro-environment (examples)	Inverted T-shaped seed slot (Cross Slot)			U-shaped seed slot (Hoe, Angled Disc)			V-shaped seed slot (Double/Triple Disc)		Broadcasting (no seed slot)	
Seed slot covering	Integral seed covering (press wheels)			Separate seed covering (towed harrows)					No seed covering	
Fertiliser placement	Separate horizontal placement			Separate vertical placement			Mixed with seed		No fertiliser	
Seed depth control	Adjustable depth/press wheels at seed release point			Adjustable depth/press wheels behind opener		Spring loaded press wheels			No depth/press wheels	
Surface following	Fully automated down-force and load sensing		Hydraulic down-force with gas-cushioning and load sensing			Hydraulically adjustable coil springs			Spring tynes on a fixed toolbar	
Residue handling and micro-management	Integral disc and tyne			Disc(s) only		Separate disc and tyne			Tyne only	
	10	9	8	7	6	5	4	3	2	1

How to use this chart: Assess each of the six drill/opener features listed down the left-hand side of the chart. Assign the score from the colour bars that relates to the option the drill or opener exhibits. A low total score indicates a higher level of risk. (Example: a hypothetical drill may have inverted-T openers (8), require towed harrows (5), have no fertiliser capacity (1), no press/depth wheels (1), hydraulically adjustable coil springs (5) and separate disc and tyne (5) = Total 25/60.

Fig. 15. Method for classifying the seed drills for direct seeding

The biological risk has been assessed in the following way, using the methodology mentioned:

The official data for the assessed seeding machine is considered. As an example of how the evaluation chart works, we take the data for the T-Force© Series of the company NOVAG SAS [9]. In engineering and execution it meets some of the criteria described in Fig.15. If the seed drill machine meets the requirements in columns 1,2 and 3 (green), then for each row from Fig. 14 we get the following values:

- With seed bed shape – inverted T-shaped after using cross slot boot (Grade 2).
- Burying the seeds – immediately with a pair of V-shaped depth/press wheels (Grade 2).
- Introducing fertilisers at the same time as sowing – the type of seed boot used allows horizontal introduction of fertiliser separately from the seeds (Grade 2).
- Sowing depth control – carried out by a pair of depth/press wheels, mounted close to the boot (Grade 2).
- Covering of the terrain– fully automated control of pressure and drag (Grade 1).
- Moving the plant residue – by the disc and tine of the boot (Grade 4).

The cumulative grade from the six criteria is equal to 13. The higher this grade is, the bigger the biological risk. The maximum risk is 60 points. It the sum total is divided by the maximum risk, we get – $13/60=0.216$, i.e. about 22% is the probability of disturbing the biological productivity of plants, just from applying the selected seed drill. This risk varies for the different constructions of seed drills from 10 to 90 %.

6. Conclusion

The unique requirements of reduced and no-tillage create the need for seed drills capable of matching these requirements. Evaluating the effectiveness of a seed drill can be accomplished only after evaluating separately the biological and economical risks connected with the usage of the seed drill. The biological risk can be evaluated using a method taking into consideration the construction of the machine and giving each technical solution a numeric equivalent. These are then combined and transformed into a single number

which represents the overall risk of disturbing the biological productivity of the plant by using the selected drill in percentage. The economic risk can be evaluated by using a developed software to make a comparison between the cost of two machines and the yield-cost advantage of one of them. Combining the evaluation of the biological and economic risks makes it possible to choose the most suitable and efficient seed drill to answer the unique requirements of seeding in conservation agriculture.

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PRACTICAL ADVICES TO CHOOSING APPROPRIATE SOIL TILLAGE MACHINES

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Abstract: The main physical soil properties are considered highly important for soil fertility. Measuring soil moisture, in-depth soil hardness and soil density can help in choosing an appropriate soil tillage method. The paper shows a practical handbook, which can be used with addition to soil moisture meter and a hardness meter to reach these conclusions. The selection of the tillage method is done by using a paper disk, provided in the handbook, showing good tillage practices.

Keywords: SOIL MOISTURE, SOIL IN-DEPTH HARDNESS, SOIL DENSITY, RECOMMENDED TILLAGE TYPES

1. Introduction

The main stage of crop cultivation is the mechanical treatment of the soil, which changes physical properties of the latter in such a way that they will be favourable for the development of the crops.

2. Main physical soil properties

The general physical properties of the soil are: density, relative bulk density, porosity, water permeability and aeration. Soil bulk density (mass) is considered to be one of the most important factors for fertility. It affects not only the development of the plant root system, but also their water, air and nutrition regime. It has been found that for different type of plants and soils there exists optimal density and any deviation from it could lead to complete depletion of organic matter, and hence, lack of fertility.[1,4] The farmers get a realistic idea about the physical properties of the soil usually when they are investigated in specialised laboratories, which takes time and resources. Due to various reasons they often do not pay attention to soil's physical properties, relying too much on available equipment to keep them within certain limits. Equipment, inappropriately chosen and used, can have subsequent adverse effects on the yield [2,3].

Well-structured soil predetermines good indexes of its physical properties (see Fig.1).

In this sense a good practice in agriculture is the one that

considers soil's physical properties when selecting the type of tillage.

A solution is provided by the handbook with guidelines for good practices in soil treatment (see Fig. 2) [5]. It has been developed by the project team and is designed for use by farmers directly in the field. The Handbook consists of instructional disk for measuring the bulk density of the soil in a user-friendly way and a table with recommended types of tillage.



Fig. 2. Handbook with instruction for good practices in tilling

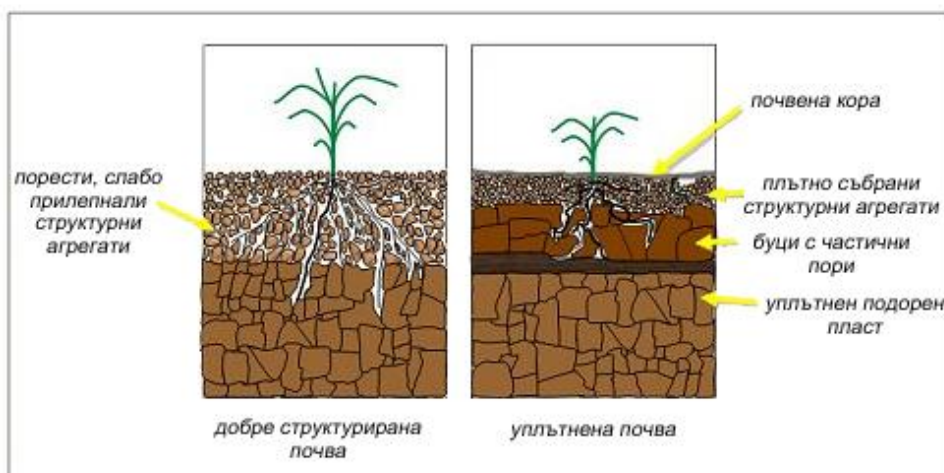
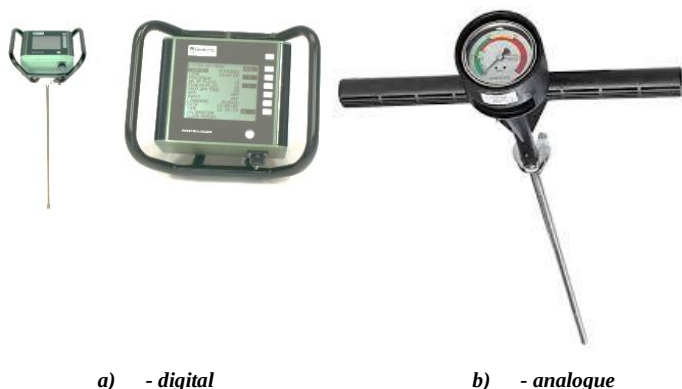


Fig.1. Well-structured and compacted soil

The Handbook can be used before and/or after tillage. In both cases it is recommended the soil to be “mature”. The measurement before tilling helps to select the appropriate way for its implementation while the measurement after can be used, for example, for devising the irrigation regime.

The use of the Handbook requires two measuring devices: moisture meter and hardness meter for the soil. The meters can be digital or analogue, but for practical needs it is recommended that they be of the first type (see Fig.3 a).



a) - digital b) - analogue
Fig.3. Soil hardness meters

On the inside of the Handbook you will find the instructional disk and the table with recommended types of tillage (see Fig.4). The disk consists of a moveable and a stationary part. The stationary part is divided into semicircles, each of which has 9 sectors with a colour scale. The rotating part has two opposed open sectors and belts, representing the layers of soil.

3. Four steps in determining recommended tillage method

Working with the Handbook before tilling takes four consecutive steps.

3.1. Evaluating soil moisture

With the first step the absolute soil moisture is measured, which

is one of the indicators on the disk. Using the moisture meter (see Fig.5), the reading is done in the field and the value displayed will be used for adjusting the disk.



Fig. 5. Analogue soil moisture meter

3.2. Measuring soil in-depth hardness

The second step is related to measuring the soil hardness in-depth. With the devices shown this depth could be 0.80 m. The analogue hardness meter has a colour scale divided into three sectors - green, yellow and red. The scale in the upper part of the disk is arranged in the same way, where the soil hardness is the next indicator. The scale is read in the following way: green sector – good condition; yellow – satisfactory; red – deteriorated condition of the soil.



Fig. 6. Hardness meter scales

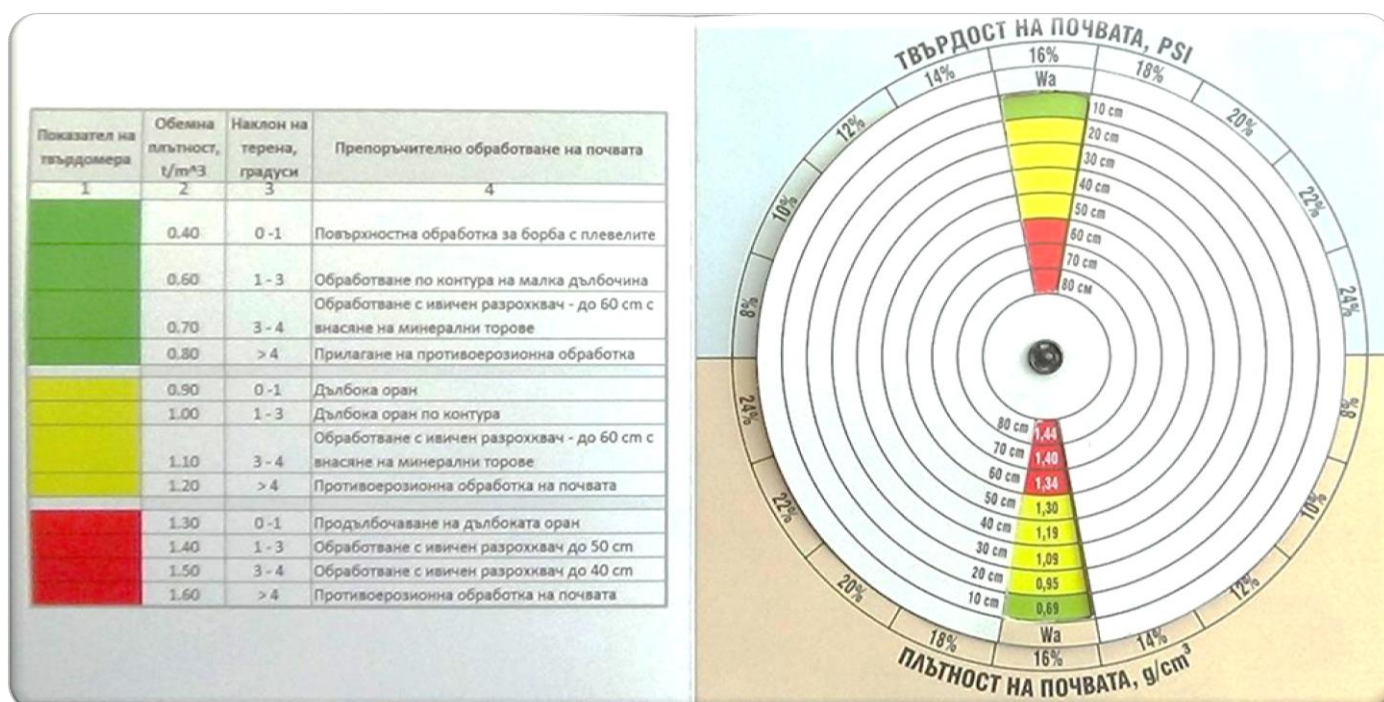


Fig. 4. The inside of the Handbook with instructions for good practices in tilling

3.3. Measuring soil density

Measuring the soil density is done with the third step. For this purpose it is necessary to fix the indicators on the disk first, according to the data from the devices. The adjustment is done in the upper part of the disk, which refers to soil hardness. On the outer belt of the rotating part an indicator for the absolute soil humidity is placed, which is coloured in blue. It has to be set against the moisture sector, which corresponds to the moisture measured by the respective meter. Thus we get a colour scale for soil hardness to open, and there we find the colour indication, measured by the hardness meter at the depth of penetration of the device (see Fig.7). At this setting of the disk, from the scale in the lower semi-circle, the soil density at the specific depth of penetration is indicated. Here, besides colours, the scale has numeric indication, with the colours corresponding to the indications in the upper part and the numbers assumed to be the mean value of soil density in the specific layer.

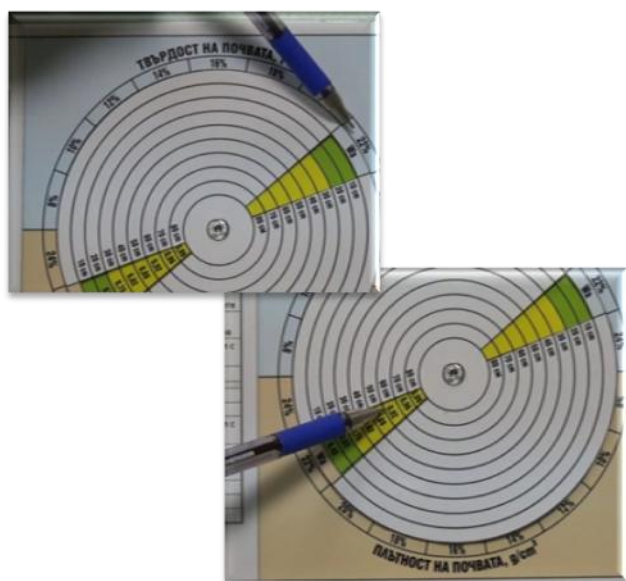


Fig. 7. Indicators on the disk

3.4. Recommending the suitable tillage type

In the example reviewed, the final step is related to recommendations for types of tillage, consistent with the results obtained. The recommended types of tillage are shown in the last column of the table in the Handbook, where, depending on the reported hardness and density of the soil, as well as the inclination of the slope, the most appropriate type of tillage is given, which will ensure both the necessary physical properties of the soil and its resistance in the presence of erosion processes.

4. Conclusion

A practical handbook has been developed to help determine an appropriate method of soil tillage with only the usage of two simple inexpensive tools - soil moisture meter and a hardness meter. The received data is then interpreted and via a provided in the handbook paper disk is determined which tillage type will suit most the condition in which the soil is in and will help prevent erosion processes.

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EFFECTS OF TILLAGE METHODS ON WEEDS POPULATION IN SECOND CROP SOYBEAN (*GLYCINE MAX. MERIL L.*)

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Abstract: The aim of this study was to determine the effects of different tillage methods on weeds population in second crop soybean production. The experiment was conducted at the experimental area of Agricultural Faculty at Dicle University in 2014. The treatment was lay out at the randomized complete blocks design with three times replication. In this study, different six tillage method were applied (one conventional tillage (CT) – four conservation tillage (RT) and direct sowing (NT)). There were observed more density the species of *Xanthium strumarium* subsp., *Solanum nigrum* L., *Euphorbia helioscopia* L., *Convolvulus arvensis* L. and *Sorghum halepense* (L.) Pers in experimental area than other weed species. According to results, there were found significant difference between treatments. The lowest values of weeds were recorded in the conventional tillage methods (CT), while the highest values of weeds were noted in RT4 Tillage methods and NT. Therefore, conventional tillage method was beneficial and useful in reducing of weeds population on soybean crop.

Keywords: SOYBEAN, TILLAGE, WEED, CONVENTIONAL TILLAGE

1. Introduction

Soybean (*Glycine max* L.) is among the most important arable crop and the major sources of food in worldwide and it plays an important role in healthy nutrition because of its valuable composition. It contains 36-40% protein, 18-24% oil, 26% carbohydrates and 18% mineral substances. Because of these valuable nutrients, it is known as the wonderful plant of the century (Arioğlu, 2007). In soybean oil, there were a lot of vitamin such as, Ca, Fe, Zn mineral and A, B1, B2, C, D, E, K vitamin, therefore it is so important for human and animal food.

To increase production and reduce production cost in soil tillage operations, reduced tillage and direct seeding system is of great importance. Appropriate tillage and sowing technique can reduce factors that impede seedling emergence reduce energy and labor cost, and weed control during the growing period. However, tillage systems are location specific; their success depends on soil, climate and local practices (Bayhan et al. 2006; Ozpinar and Cay, 2006; Sessiz et al., 2009). Especially weed control in agricultural cultural practices is so expensive among applications. Weeds have an adverse effect on crop yields as a result of competition with cultivated plants. The highest yield on soybean was found in CT method and the lowest yield was found in NT method (Sessiz et al., 2009). The best result for silage yield was found in tillage combination. The lowest yield was found in the heavy-duty disc harrow tillage method (Bayhan et al. 2006). In addition, crop loss caused by weeds are 33.8% while soil erosion is 13.16%, disease and damage are 35.8% (Rangasamy ve ark., 1993). The crop yields have been loosed between 20-100% that due to weeds population (Özer, 1993). About fifty percent of production cost in agricultural activities are used for weed control. In a study conducted with the sorghum plant (Rangasamy ve ark., 1993), it was determined that were required for all maintenance grubber about 560 hours on the weed struggle, while 1536 workers working hours per hectare. In single hand weeding, the labor requirement can reach from 300 to 1200 man h ha⁻¹ (De Datta et al.1974).

The weed control in soybean is done mostly by hand and cultivator. Because the manual weed struggle is a tedious, time-consuming and expensive process that's why the mechanicals struggle are so importance in weed control processes. The mechanically weed struggle does not only destroy weeds but also increases the aeration of the soil and the water conservation. Özasan and Gürsoy (2015) reported that the effects of the tillage treatments on weed density differed among the weed species. *Sorghum halepense* had the highest density under the reduced tillage method, while the *S. arvensis* density increased under the conventional tillage treatment.

The germination of weed seeds or the application of the vegetative propagation organs varies depending on the soil temperature, light, light soil handling patterns and processing depth. As the chemical struggle leads to environmental pollution that's why the mechanical struggle is important as alternative method of struggle. In this study, the effects of soil treatment methods on weeds in soybean crop.

In recent years in Turkey, especially due to introduction of agricultural irrigation in Southeastern Anatolian region has lead to a dramatic increase in irrigating farming and thus second crop farming have gained importance. Conventional tillage methods using by all farmers in this region result in physical degradation of soil and increased soil erosion, labour, time, energy and production costs (Sessiz et al., 2009).

The main objective of this work was to evaluate the effects of different tillage methods on weed control in field conditions for second crop soybean in southeastern part of Turkey.

2. Material and Methods

The field experiment was conducted during the summer of 2014 at the experimental area of Agricultural Faculty at Dicle University, Diyarbakır Province (latitude 37°53'N and longitude 40°16'E, 680 m altitude), Turkey. In this study, SA-88 soybean variety was used as second crop. The analysis of soil in experimental area were determined as 71.1% (clayey), 1.25% (organic matter), 1.63kg da⁻¹ (phosphorus), 13.02%(calcareous), saltless and mid-alkali (pH 7.73) in laboratory of GAPUTAEM (GAP International Agricultural Research and Training Center, Diyarbakır). The average weather conditions such as annual temperatures, relative humidity, and rainfall are summarized in Table 1.

The average temperature in June-December period was conducted 26.28°C, average moisture was 33.98% and average rainfall 16.72 mm. Tillage treatments in 2014 consisted of six tillage methods that are described in Table 2. The specification of the tools used in the experiments are given in Table 3.

Table 1. Monthly means of temperature, humidity and rainfall

	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Avrg. Humidity(%)	82.1	53.6	68.3	63	53.7	29.6	22.4	21.5	35.5	60.9	70.2	87.9
Max. Temp.(°C)	9.2	16.8	22	19.6	26.3	31.6	42	42.1	31.3	30	19.7	16
Min. Temp.(°C)	-1	4.9	6.9	6.4	16.3	18	26.4	25.8	16.5	10.5	4.7	-3.6
Avrg. Temp (°C)	3.4	5.4	10.8	14.7	19.7	26.5	31.5	31.1	24.8	17.5	8.5	6.6
Tot. Rainfal.(mm)	43	17	60.6	39.9	48.8	21.4	0.6	0.0	27.4	34.2	97.6	73.4

Source: Diyarbakır Meteorology Bulletin (2014)

Table 2. Soil tillage methods utilized in experiments

I. Conventional Tillage (CT)	Plough + Disk harrow + Float + Direct seeding machine
II. Reduced Tillage (RT1)	Disc harrow + Float + Direct seeding machine
III. Reduced Tillage (RT2)	Stripe tiller by rotary + Float + Direct seeding machine
IV. Reduced Tillage (RT3)	Cultivator + Float + Ridge tillage + Direct seeding machine
V. Reduced Tillage (RT4)	Cultivator + Float + Direct seeding machine
VI. No-Till (NT)	Seeding by direct drill

Table 3. The specification of the tools used in experiment

Tool	Type	Working depth (cm)	Working width (m)	Working speed (m/s)
Moldboard plough	Four bottom	30-35	1.42	0.50
Heavy disk harrow	24 disk - tandem	15	2.5	0.45
Cultivator	11 sweeps	15	3.10	0.45
Rotary tillage	Four row	12	2.8	0.45
Ridge tool	-	-	0.7	0.40
Float	-	-	2.9	0.60
Direct planter	Four row	4-6	2.8	0.40

Experimental areas were design as 18 plots with each measuring 12 m x 6 m. Before sowing, the experiment area was irrigated eight hours with sprinkler irrigation system. After irrigation, soil tillage operations were made and after soil tillage applications, seed planting was performed by pneumatic planter with an inter row spacing of 0.7 m distance on 23 June 2014. Massey Ferguson tractor was used in the experiments. Travel speed of tractor was changed depend on tools (Table 4).

**Fig. 1.** The view of experimental area during the growing.**Fig. 2.** The view of experimental area during the growing.

After emergence of weeds, two times weed counted, the first weed count was made 30 days after sowing. Just the first count of weeds, all of the weeds in plots was manually removed by worker (Figure 1 and Figure 2). The second count of weeds was made after 30 days of the first count. Weed count each plot of 3 replicates 1 m² frame randomly discarded and the according to weed species have been counted in the remaining frame. No herbicide was applied to the field both before and after tillage. The treatment was lay out at the randomized complete blocks design with three times replication. Data was subjected to an analysis of variance (ANOVA) using a statistical software package (JMP version 5.0.1a). Least significant difference (Tukey's HSD test) was used to compare treatment means at P=0.05.

3. Results and Discussion

The average values of variance analysis and Duncun's test results are given in Table 4 and 5. There was observed more density the species of *Xanthium strumarium* subsp., *Solanum nigrum* L., *Euphorbia helioscopia* L., *Convolvulus arvensis* L. and *Sorghum halepense* (L.) Pers in field during growing season than others weed species.

Table 4. Analysis of variance (mean square) for weeds population

VK	DF	First Count	Second Count
		F Ration	F Ration
Practies	5	5.30*	7.80*
Replication	2	2.12	0.52
CV		23.6	13

* 0.05

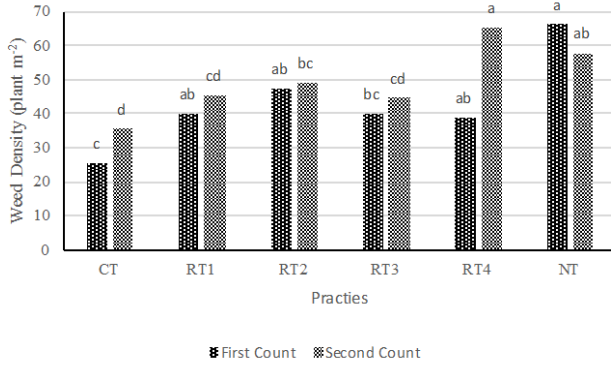
As it can be seen from Table 4, statistically significant differences were found among the tillage methods on weeds population.

Weed density was found between 25.6-66.3 plant m⁻² at the first count. The highest values of weed density was found in RT4 tillage methods as 66.3 plant m⁻² other hand the lowest values was determinate in CT tillage methods as 25.6 plant m⁻² at first count (Table 4). Weed density of the second count was found highest values in V. Tillage methods (65.3 plant m⁻²) than CT tillage methods (35.6 plant m⁻²). Similar result were reported by Çoruh and Boydaş (2007), according theirs results the lowest weed density were found in CT methods and deep tillage methods. Also similar result was determined by Güncan (1975).

Table 4. Tillage treatment and weeds population

Practies	Weed Population	
	First Count	Second Count
CT	25.6 c	35.6 d
RT1	40 ab	45.6 cd
RT2	47.6 ab	49.3 bc
RT3	40 bc	44.6 cd
RT4	59 ab	65.3 a
NT	66.3 a	58 ab
LSD	20	11.8

CT: Conventional Tillage RT: Reduce Tillage NT: No-Tillage

**Fig. 2. Weed population (plant m⁻²)**

The higher weed density values were found in second count than the first count in this study. However, both the first count and the second count, the highest values were observed in NT treatment. The lowest values were obtained CT tillage methods (Figure 1). According to second count of weed density was obtained highest values in reduce tillage and no tillage than conventional tillage methods. *Xanthium strumarium* L. is one of the most prevalent and competitive weeds in the Southeastern United States (Snipes et al. 1982) and is listed among the most common and troublesome weeds in peanut, cotton (*Gossypium hirsutum* L.), and soybean (*Glycine max* (L.) Merr.) grown in the region (Dowler 1995; Royal et al. 1997). *Xanthium strumarium* subsp. that can continue to grow after soybeans have flowered may be more competitive with soybeans. Barrentine (1974) reported that Mississippi common cocklebur achieved a maximum height of 200 cm in 96 cm tall soybeans. Soybean plants reached maximum height 10 week after emergence, whereas common cocklebur reached maximum height 16 week after emergence. Royal et al. (1997) reported that a Florida common cocklebur had maximum dry weight yield of 17,000 kg ha⁻¹ when harvested 20 weeks after emergence. The reduction in soybean seed yield was less than 10% when common cocklebur was removed 6 weeks after soybean emergence. *Xanthium strumarium* subsp. may grow to heights of 150 cm and have a root depth and radius of 2.9 and 4.3 m, respectively (Bloomberg et al. 1982). Çelik and Altıkat (2006) reported that weed population is higher about % 30-40 in conventional tillage system than reduced tillage system.

4. Conclusion

Significant differences were found between Conventional tillage (CT) and no-tillage (NT) methods. The weeds are so problem for yield and yield component for soybean. Generally, weed rates were found to be high for no-tillage methods in treatment. As a results, it can also be concluded that conventional tillage method was beneficial and useful in reducing of weeds population in second crop soybean.

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RATIONALE OF AGRO-TECHNICAL PERIOD HARVESTING WALNUT

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Abstract: Reveals the scientific and methodological principles of definition agro-technical period for harvesting of walnuts depending on intensity fall fruit and the quality nut kernel.

KEYWORDS: WALNUT, PARAMETERS, QUALITY, PERFORMANCE, AGRO-TECHNICAL PERIOD, HARVESTING

1. Introduction

One of the problems with the production of walnuts is precisely indefinite agro-technical harvesting period. It known that delayed harvesting walnuts reduces the quality and yield losses, because there is a direct relationship between the period of harvesting walnut and quality [1]. Today timing of harvest in the agricultural sector engaged a number of scientists [2-4, 7, 9-11]. In relation to harvesting of walnuts, research study related to early ripening of fruits and signs of maturity, but clear boundaries defined harvest season was not. According to research results, can be argued that there is a direct relationship between the period of harvesting walnut and its quality [1].

2. Preconditions and means for resolving the problem

To substantiate the agro-technical period of harvesting walnuts and the choice of the method of harvesting, it is necessary to determine the beginning ripening and fallow of nuts, the distribution of the intensity of precipitation during the harvesting season, and as well as its duration, depending on the natural and climatic conditions.

The reason for beginning harvesting season of walnut is complete maturation of fruits, to achieve their better storage [2]. To date, research done features of the maturation of walnut [5]:

- 1) the flowering period (if flowering occurs in spring, then ripening occurs in late August and mid-September, when they bloom in June, then begin to ripen from the third decade of September);
- 2) the cracking of the green pericarp around the fruits;
- 3) the beginning of yellowing of leaves on a tree;
- 4) formed outer pericarp layer hard shell that protects the core of halves.

3. Results and Discussion

To determine the beginning of the onset and fallowing of nuts, a research was carried out in the conditions of the western region of Ukraine on basis of the Department of horticulture and vegetable growing of Lviv National Agrarian University.

To study the agrotechnical-harvesting season, were selected trees aged from 20 to 40 years old in the middle varieties. The start of observation began on September 15th (on basis of flowering of walnut) before the start of the forecast season. Every day, until 10:00 am, the fruits of nuts were harvested, with a crown area of 15m², counted the number, weight, and determined the quality of the fruit. At the beginning of September experiment, cracking outer pericarp layer was not observed. The first cracking outer pericarp layer was recorded on September 18, but nuts from trees did not fall (Fig. 1).



Fig. 1. Cracking outer pericarp layer at the beginning of the harvest season

To test the ripeness and quality halves that hung on the tree, with auxiliary equipment shaken several fruits in dark green outer pericarp layer that hard separated.



Fig. 2. Fruit and halves of walnut at the beginning of the harvesting season

In Figure 2 shows the state of walnuts at the beginning of the harvest season. The outer pericarp layer was hardly separated, halves of nut is ripe.

The first fallen of nuts were recorded on September 22, which accounted for 6.3-9.2% of the total number of walnuts. On the skeletal branches of walnut trees (Fig. 3), fruits of varying degrees of ripeness were recorded:

- fruits of full ripeness in fully exposed outer pericarp layer;
- fruits at different stages of cracking outer pericarp layer;
- the fruits of outer pericarp layer whose color varied from light green to dark shade.

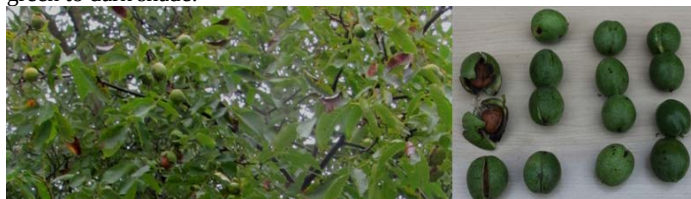


Fig. 3 Skeletal branches of walnut tree and nuts of different degree of ripeness

The outer pericarp layer of light green color was easily removed from all nuts. The outer pericarp layer of dark green color are removed by applying considerable effort and need specialized cleaning equipment.

In the period from September 21 to 24, there was dampness and rainy weather, which prompted, outer pericarp layer until the intensive opening and falling of nuts. During this period, about 40% to 55% of the harvested harvest was obtained from the trees under study. On September 23, windy and humid weather was observed, which increased the intensity of falling fruit and amounted to 18-23% of the total harvest.

September 25 was a dry and warm weather. The intensity of cracking of outer pericarp layer and falling nuts stopped. The harvesting period ended on October 15th.

In Figure 4 shows the dependence of the intensity of fall nuts per day. The first day corresponds to September 22.

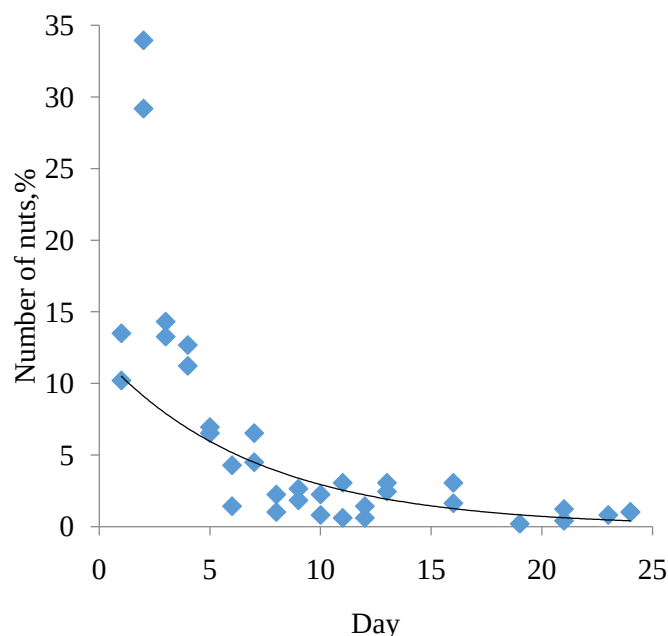


Fig. 4 Intensity of fall walnut

After processing the obtained research data, the regression equation, which is described by the exponential law, is derived:

$$I = 12.09e^{-0.142n},$$

where I - intensity of fall of the fruits during the harvest season, %/day;

n - number of days relative to the beginning of the harvesting season.

Also, for the establishment of the agrotechnical term, the quality of the collected nuts was analyzed (Fig. 5). In accordance with GOST-16833-71, the quality of core halves a walnut is divided into four groups [6] (Fig. 6).



Fig.5 Quality of core halves a walnut

A) September 15;
B) September 25;
C) September 26th.



Fig. 6 Standardization of the quality of the nuts

A) higher grade;
B) first grade;
C) second grade;
D) third grade.

As can be seen from the figure, nuts according to standardized requirements can be attributed to a higher grade that corresponds to the beginning of harvesting season.

Observation of the fallen walnuts showed that the length of stay on the inter-row surface negatively affects their quality. On the 25th of September the quality of their of halves was already in line with the first grade, and on September 26, the darkening of core halves to the second and third varieties was recorded. After September 26, due to contact with the intermediate row, nuts lose qualitative characteristics (Fig. 7). As of October 5, 25% of halves that falling in earth during the period from 15 to 22 September were spoiled (Fig. 7).

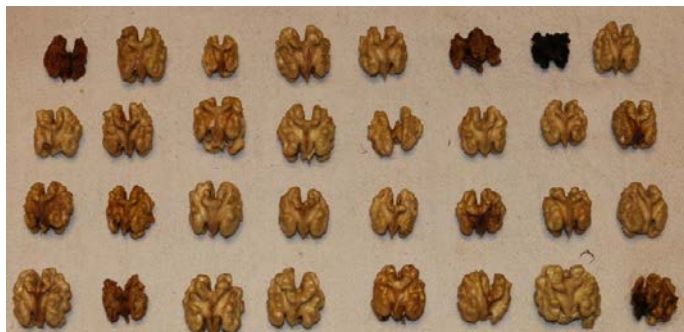


Fig. 6 Quality of halves walnut as of October 5

Having analyzed the obtained results, it was determined that the agro-technical harvesting period of walnut is 10 days for the conditions of the western region of Ukraine.

4. Conclusions

The beginning of harvesting season and its duration depend on the agro-technical terms of achievement, which is characterized by the formation of shells and core of halves.

The falling of nuts begins a week after discovering the first signs of maturation.

Throughout the harvesting season, the intensity of falling nuts decreases, on average, from 10 to 20% in the beginning to 0.4 - 0.8% at its completion.

The core halves nuts from contact with the intermediate row surface lose their quality and after ten days they begin to spoil.

From the observations made it was determined that the agro-technical term for walnut harvesting is 10 days.

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MODEL OF FINANCIAL ANALYSIS OF AN ORGANIZATIONAL BIODIVERSITY ENTERPRISE ¹

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Summary: Bulgaria is the EU's leader in increasing the number of organic producers over the last five years. The types of crops with the largest share in the structure of organic areas of all areas in our country are respectively $\frac{3}{4}$ of the areas including permanent crops, Technical crops, meadows and pastures. The remaining $\frac{1}{4}$ occupy grain, vegetable, essential oil and fodder crops. In relative terms, however, the most widespread is the production of leafy vegetables and grazing, and the areas occupied by these crops are almost entirely grown in this way. More than half of the areas with berry crops (except strawberries) are certified as organic or in transition. Areas planted with some perennial plantations and essential oil and healing crops also occupy a larger share. An important requirement for the objectivity of the financial analysis is the reporting of the comparability of the source information for the reporting period with the relevant data from the financial analysis entities. It is imperative to take into account the distortive influence of all the factors in order to achieve correct and sustainable conclusions: agrotechnical; natural and climatic; socio-economic.

KEYWORDS: ORGANIC FARMING, FINANCIAL ANALYSIS, SPECIFICATION OF ORGANIC FARMING, OPERATORS

Introduction

In the world as of 31.12.2016 organic farming in the world is practiced in over 170 countries and 57816759 ha of agricultural land is organically cultivated by approximately 2726615 farmers. In 2016, retail sales of organic food and beverages reached 84698 million. €¹.

The results of the latest survey of certified organic farming worldwide (end of 2016) indicate that, in addition to the growth in organic agricultural land, there has been an increase in the number of organic producers, exports and retail sales of this type of product.

Organic market in the EU also continues to grow ascendant. It has increased more than twice in 2016 compared to 2007 and has reached € 30682 million against € 14499 million (in the base year)

Exposition

The severely narrow national market is the main problem and obstacle to the development of organic farming in Bulgaria. According to Eurostat official data, the value of sales of organic food and drink in the country amounts to 1 euro per person per year or to a total market value of 7 million. €.

Table 1 Organic production areas in Bulgaria and the EU (2007-2016)

Types of areas	2007		2016	
	Bulgaria	EU	Bulgaria	EU
Biological agricultural land (ha)	13 646	7171537	160620	12047878
Share of organic areas in common agricultural land (%)	0,45	3,99	3,45	6,74

Table 2 Operators² of organic production in Bulgaria

Bio Operators	2012	2016	%
producers	2754	6964	2,53
processors	81	175	2,16
importers	1	13	1300,00
exporters	14	9	-0,64

Source: FiBL Research Institute of Organic Agriculture

Table 3 Number of organic producers in Bulgaria and the EU

Region	2007	2012	2016
Bulgaria	240	2754	3546
EU	186281	253381	295123

Source: FiBL Research Institute of Organic Agriculture

Bulgaria is the EU leader in increasing the number of organic producers over the last five years (Table 4). In 2016, compared to 2007 (the year of Bulgaria's accession to the EU), bio-producers in our country have grown nearly 15 times those in the EU. At the beginning of 2016, the number of registered organic producers was almost 7,000, and in the last five years it has increased more than 2,5 times. Certified or undergoing organic conversion in Bulgaria has increased nearly four times between 2007 and 2016.

¹ FiBL, The World of Organic Agriculture 2016

² All producers, processors, exporters and importers of organic produce are included here

Table 4 *Certified Organic Areas in Bulgaria and the EU in ha (2007-2016)*

Region	2007	2012	2016
Bulgaria	13646.00	39136.80	160620.00
EU	7171537.20	9980114.95	12047878.05

The types of crops with the largest share in the structure of organic areas of all areas in our country are respectively $\frac{3}{4}$ of the areas including perennials (34.10%), technical crops (23.85%), permanent meadows and pastures (16,50%). The remaining $\frac{1}{4}$ occupy grain, vegetable, essential oil and fodder crops (Table 5)

Table 5 *Organic farming structure of crops grown biologically 2016*

Type of crops	(ha)	%
Cereal crops	2838	13,05
Technical cultures	5184	23,85
Fresh vegetables, melons, strawberries, (general)	1086	5,00
Perennial crops	7409	34,1
Permanent meadows and pastures	3601	16,5
Forage crops from arable land	1621	7,5
Total	21739	100,0

Sources: Eurostat

However, in relative terms, the production of leafy vegetables and nuts is the most common, and the areas under these crops are almost fully grown in this way. More than half of the areas with berry crops (except strawberries) are certified as organic or in transition. Areas planted with some perennial plantations and essential oil and healing crops also occupy a larger share.

What impresses is that yields of some long-lasting crops, somewhat typical of organic production, are significantly lagging behind those of our geographical region - Turkey and Spain.

Table 6 *Average yields of organically grown perennial crops in Bulgaria, and (MT / ha)*

Agricultural crops	Bulgaria		Turkey		Spain	
	Conventional agriculture	Organic agriculture	Conventional agriculture	Organic agriculture	Conventional agriculture	Organic agriculture
Strawberries		4,7		15,7		28
Cherries	5,322	1,8		7,6		11,1
Plums	5,053	5,3		5,7		11,8
Nuts	0,601	0,3		1,4		0,4

Source: Eurostat

Despite the lower yields of organic production, these crops have the potential for significant distribution in Bulgaria.

In developing a financial analysis algorithm for an organic greenhouse production plant, it is essential to clarify the specifics of this production as the initial stage of the financial analysis.

Results

As a result of the scientific expertise, the following important conclusion has been formulated. In order to conduct an objective financial analysis, mandatory comparability of the information for the reporting period with relevant data from the sites of the benchmarking analysis is necessary. Therefore, it is imperative to take into account and eliminate the distortive influence of all the factors to achieve true and sustained conclusions. More important factors in this aspect are:

- agro-technical factors (changes in assortment policy, seasonality and alternative to fruit growing from permanent crops);
- natural-climatic factors (seasonal temperature variations in time and geographic location of the organic production site);

- ocio-economic factors (ethnic and religious structure of the population, specificity of the consumption of a particular type of production; food habits and peculiarities of consumers by geographic areas; purchasing power, age and sexual composition of consumers; price scissors products from organic and traditional farming; investment risk in the construction and accounting of the costs of creating the tangible fixed assets in the greenhouse production at different stages of the business year; cyclical fluctuations in raw material prices, energy, water and preparations used in greenhouse bio-production);

Sources: 1. Eurostat (<http://ec.europa.eu/eurostat>);

2. Agrostistics department, MAF

3. NSI (<http://www.nsi.bg/>);

4. Faostat (<http://faostat3.fao.org/home/E>);

5. The World of Organic Agriculture 2016 (<http://www.fibl.org>);

6. USDA – Economic Research Service (<http://www.ers.usda.gov>)