WEB ISSN 2535-0242
PRINT ISSN 2535--0234

EXPERIMENTAL STUDY OF TWIN ROWS DRILLING MACHINE

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

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

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

Introduction

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

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

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

Exposition

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

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

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

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

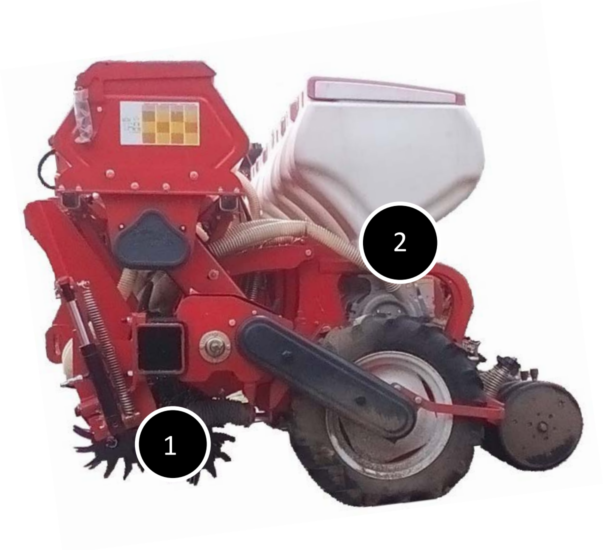


Fig. 1. *Drilling machine, sowing seeds in twin rows*
1-cultivator section with needle disks; 2-drilling section

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

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

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

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

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

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

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

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

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

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

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

$$E[Y/x]=\eta(x), \tag{1}$$

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

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

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

$$y=\eta(b_0,b_1,...,b_m,x), \tag{2}$$

where: $b_0,b_i,....b_m$ are the experimental coefficients of regression.

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

To determine the optimal operating mode of the sowing machine, optimization methods are used by a desirable function [6]. For this purpose, the assigned functions of Y_1, Y_2 and Y_3 are represented by a generic desirable function, which is of the type:

$$D=\sqrt[3]{d_1.d_2.d_3}\ , \tag{3}$$

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

$$d=\exp[-\exp(-Y_i^{`})] \tag{4}$$

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

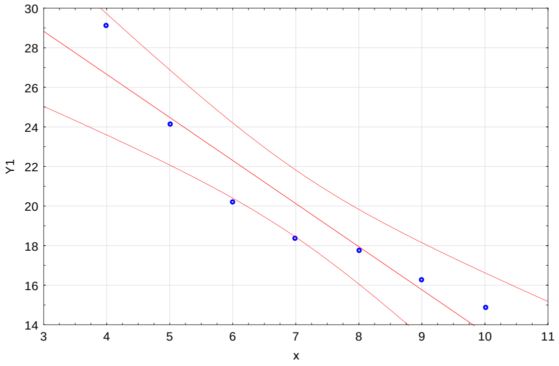
The processing of all the results of the experiments carried out, as well as the determination of the necessary numerical characteristics of the studied parameters, was performed with the help of the specialized software "Statistics" 13.

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

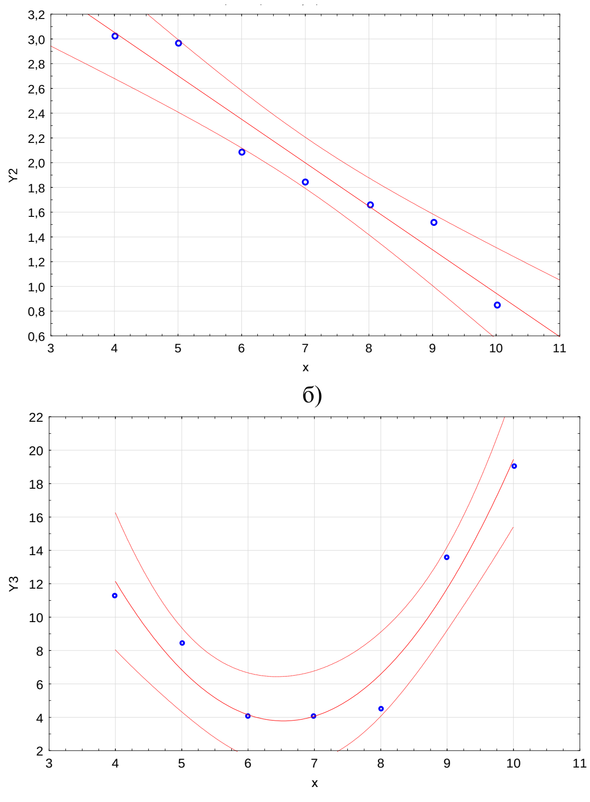
Table 1. *Results from the modified seed drill experiments*

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

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



a)



б)

в)

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

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

$$Y_1 = 35{,}364 - 2{,}177.x$$
$$Y_2 = 4{,}459 - 0{,}351.x$$
$$Y_3 = 59{,}379 - 17{,}021.x + 1{,}303.x^2 \qquad (5)$$

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

$$p_1 = 0{,}0012$$
$$\alpha = 0{,}05 > p_2 = 0{,}0003 \qquad (6)$$
$$p_3 = 0.0035$$

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

$$D = -1{,}144 + 0{,}486.x - 0{,}032.x^2 \qquad (7)$$

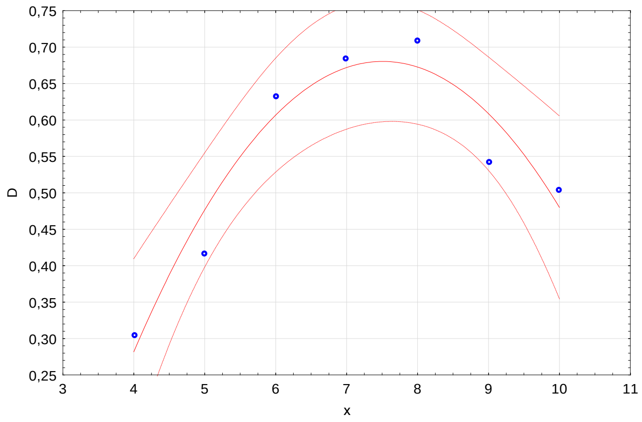


Fig. 3. *Line of regression for the generalized function of desirability*

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

Conclusion

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

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