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SCIENTIFIC RESULTS ON JUSTIFICATION THE PARAMETERS OF A COMBINE U-SHAPED FURROW-OPENER

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Abstract

A combine U-shaped furrow-opener for laying and seeding crops and granules of mineral fertilizers with their multi-level application is presented. The research technique for substantiating the optimal parameters is presented. The results are determined on the basis of laboratory and laboratory field studies. The optimal design parameters of the combined opener with a U-shaped furrow were revealed: the width of the bed compactor is 13.1 mm, the distance between the planes of the outlet holes of the needle guide and the vas deferens is 35.4 mm, the distance from the base of the exit hole of the needle guide to the U-shaped furrow is 48.7 mm. The average traction resistance of the seeder was 13,325 N when the tractor moved in the VI gear. The distribution of seeds along the length of the row with the dual-level opener is 74.2%. The depth of seeding crops with an experimental seeder and a serial corresponding one was 49 ± 3 mm and 51 ± 5 mm. The soil layer between the seeds and fertilizers was 25 ± 3 mm.

Key words*: combined opener, soil layer, multi-level application.*

INTRODUCTION

Grain crops are the main source of food. Confirmation of this fact is the ever-increasing sown area of grain crops. So, in Russia in 2018, grain and leguminous crops occupied an area of 44.8 million ha, of which 26.7 million ha were sown with wheat. Ensuring stable and high yields of grain crops largely depends on the quality of the sowing, including the final operation - laying and planting seeds and fertilizers.

Estimated indicators of the quality of laying and sowing seeds of grain crops and granular mineral fertilizers when they are applied at different levels include: distribution of seeds in a row, depth of sowing seeds and fertilizers, soil layer between seeds and fertilizers. Improvement of these indicators could be achieved by using combined openers in grain seeders for laying and sowing seeds of grain crops and granules of mineral fertilizers when they are applied at different levels. However, seeders with serial openers have disadvantages, which include: the formation of a non-horizontal furrow bottom relative to the soil surface; shedding of the walls of the furrow; uneven soil layer between seeds and fertilizers. At the same time, the laying of seeds of grain crops is carried out on an unconsolidated bed. From this, the yield of agricultural culture is declining. Therefore, it is necessary to develop a combined opener, the design of which ensures optimal placement and sowing seeds of grain crops and granules of mineral fertilizers when they are applied at different levels.

In this regard, studies devoted to improving the quality of laying and sowing grains and granular mineral fertilizers with the development of a combined opener with U-shaped furrow are relevant and have important economic and economic importance for the agricultural sector.

MATERIALS AND METHODS

The theoretical laws are based on the basic laws of classical mechanics, mathematics, and the working processes of sowing and planting machines. Experimental studies were carried out on the basis of comparative laboratory and field studies of estimated indicators for laying and planting seeds of grain crops and granular mineral fertilizers when they were applied at a different level with a seeder equipped with combined openers with a U-shaped furrow.

Experimental studies were performed using standard methods (GOST 31345–2007, STO AIST 5.6–2010). Analysis and processing of research results were carried out using the programs Statistica 6.0 RUS, Microsoft Office etc.

To determine the distribution of seeds along the length of a row of a combined U-shaped furrow-opener for laying and sowing seeds of grain crops and granules of mineral fertilizers with their multilevel application, experiments were carried out with the opener and with the serial opener. As a result, the frequencies of appearance of squares with the number of seeds (seedlings) were obtained. Based on the obtained experimental values, graphs were plotted reflecting the uneven distribution of seeds along the row length by the serial and studied openers.

RESULTS AND DISCUSSIONS

A multi-level method of sowing seeds with the simultaneous application of fertilizers allows to apply part of the fertilizer up to 30% together with the seeds, providing them with nutrients for a powerful start, and part of the fertilizer (the main dose - 70%) is applied under the seed bed with a soil layer to avoid damage seed material. Thus, providing plants with nutrients for the entire time of growth and development, and also allows to reduce the number of technological operations, reduce soil compaction.

In Penza State Agrarian University, a structural and technological scheme and model of a combined U-shaped furrow-opener shorting bar for laying and planting seeds of grain crops and granules of mineral fertilizers at their multi-level application was developed (Patented in the Russian Federation for invention No. 2671704) **(**Figure 1).

Opener multi-level fertilizer and sowing seeds works as follows. When the opener moves, fertilizers from the hopper (19) through the fertilizer meter (23) enter the fertilizer flow divider (22), where they are divided into the main and starting dose. The main dose of fertilizer through the neck (2) with the funnel (3) of the rack falls into the guide (5). Due to the use of a pipe ellipse-shaped in cross section of the guide 5 and bending its lower part back to the side opposite to the movement of the combined opener along an arc of a circle with a radius of R = 0.3 m, will even out the fertilizer flow of the main and starting doses and seeds, which will significantly improve the uniformity of their distribution along the length and depth of the sowing furrow.

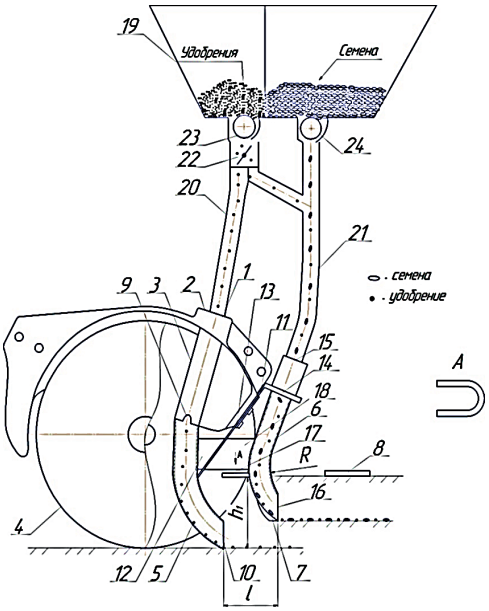

Figure 1. Structural-technological scheme of a combined U-shaped furrow-opener for laying and sowing seeds of grain crops and granules of mineral fertilizers when they are applied at different levels:
1 - stand; 2 - neck; 3 - funnel; 4 - disks; 5 - fertilizer guide; 6, 21 - seeds tube; 7 - bed seal; 8 - closing the working body; 9 - ear; 10 - outlet; 11 - an arm; 12 - stiffener; 13 - scrapers; 14 - shelf; 15 - neck; 16 - outlet; 17 - U-shaped furrow; 18 - level; 19 - hopper; 20 - piping; 22 - fertilizer flow divider; 23 - fertilizer metering device; 24 - sowing apparatus; *l* is the distance between the planes of the outlet openings of the guideway and the vas deferens; *h1* is the distance from the base of the outlet of the guide to the U-shaped furrow; *R* is the bending radius of the lower part of the guide and the vas deferens

Fertilizers from the outlet (10) are evenly distributed along the bottom of the furrow formed by two disks (4) installed at an angle of 10-12°, while not mixing with the soil, due to the location of the holes (10) in the transverse vertical plane directed relative to the longitudinally vertical plane of symmetry the opener, while fertilizer, when leaving the hole (10), are distributed strictly at a given depth, since the base of the output hole (10) is located on a horizontal plane coinciding with the lower part of the cutting edges of the two combination opener discs. To exclude fertilizer spillage into the soil through the cracks, the upper part of the guide (5) has two ears (9), while the end surface of the ears (9) is made parabolic and identical to the end surface of the lower part of the funnel

(3) of the neck (2) of the rack (1), while their end surfaces fit snugly to friend. To increase the reliability of the opener, the guide (5) in the upper part is additionally fixed motionless with the aid of an arm (11) reinforced with a stiffener (12) at the attachment point of the internal coulters (13) of the coulter. The starting dose of fertilizers together with the seeds sown by the sowing apparatus (24) through the seeds tube (21) enters the neck (15) of the tubular seeds tube (6). To equalize the flow of seeds and fertilizers in the tubular seeds tube and for their uniform distribution along the length of the sowing furrow, the tubular seeds tube (6) is made of a transverse ellipsoidal tube sections, while the lower part of the tubular seeds tube (6) is bent backward, in the direction opposite to the movement of the combined opener, along a circular arc of radius R = 0.3 m to exclude mixing of fertilizers and seeds with soil at their exit from the tubular vas deferens (6), which contributes to the seeding of fertilizers and seeds in accordance with the requirements, as well as evenly distribute seeds and fertilizers along the length of the sowing furrow, at the bottom of the tubular seeds tube there is an outlet (16) located in transverse vertical plane directed relative to the longitudinally vertical plane of the opener. In order to lay seeds and fertilizers on a compacted bed, to obtain friendly seedlings of plants and better digestibility of fertilizers by the roots of plants in the initial period of their vegetation, under the outlet (16) on the tubular seeds tube (6) a seed bed (7) sealer (7) is installed, made in the form of a curved wedge with two side the working faces made with an inclination equal to the inclination of the walls of the furrow cut by the opener discs (4) and the supporting working face *ab* made with a width equal to the width of the bottom of the furrow 14 mm, while the supporting working face *ab* curved wedge is located horizontally. For the final embedment of the furrow behind the opener, followed by the tubular seeds tube (6), at the level of the U-shaped furrow (8), a sealing body (17) U-shaped is made of a round bar with a diameter of 0.012-0.014 m, while the furrow (8) has a working width of 0.15 m (Kalabushev et al., 2018).

For laboratory and field studies, the SZ-5.4-0.6 seeder was used, equipped with combined U-shaped furrow-opener. The seeder consists of a frame, grain box, openers, seeds tubes. The seeder is available in three versions. The technical and economic characteristics of various modifications of the seeder are shown (Table 1). The studies had been conducted during 2017-2018 on the farm "ANTONOVO" of the Penza region, Russia (Figures 2 and 3).

When conducting research to create natural conditions is almost impossible. Therefore, an approximate technological scheme of the experimental opener was used. When conducting field trials of the SZ-5.4-0.6 seeder with combined U-shaped furrow-opener, a flat area was selected. The soil was ordinary chernozem of medium loamy granulometric composition. During field studies, Arkhat spring wheat seeds with a seeding rate of 200 kg/ha were taken.

Figure 2. A seeder with combined coulters on the fields of Antonovo farm

Figure 3. Combined opener with U-shaped clipper

Moisture and soil hardness were determined according to Interstate Standard (IS) 28168-89, IS 28268-89 on the day of the experiments at a depth of 0-15 cm along the diagonal of the plot with a tenfold repetition. To determine the humidity, we chose the thermal weight method.

When determining the influence of the design parameters of a combined opener with a U-shaped furrow-opener on the quality of placement and sowing of grain seeds and granular mineral fertilizers when they are applied at different levels, the root-mean-square deviation of the soil layer between seeds and fertilizers was taken as an optimization criterion and a multivariate experiment of the D-optimal design was carried out.

According to the results of the sifting experiment, the most significant factors were determined: the distance from the base of the outlet of the guide to the U-shaped furrow (*h1*); the distance between the planes of the outlet openings of the guide and the seeds tubes (*l*); bed seal width (b) (Kalabushev, 2019).

In accordance with the methodology of the multifactor experiment, the parameters of the combined U-shaped furrow-opener are refined. After processing the experimental data, graphs were built and correlation relationships between the soil layer between the seeds and fertilizers and the studied parameters were determined (Larushin et. al, 2018).

The optimal value for the bed seal width indicator can be considered as 13.1 mm, while the coefficient of variation of the soil layer between seeds and fertilizers would be 27.0%. The test results are presented in graph form Figure 4.

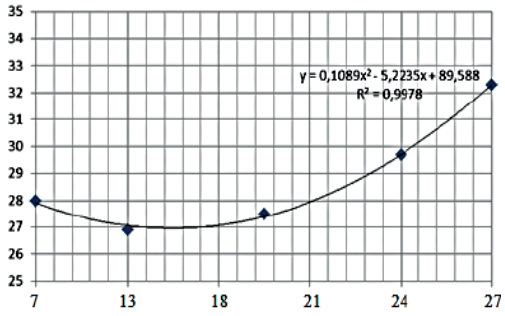

Figure 4. The effect of the width of the bed compactor on the coefficient of variation of the soil layer between seeds and fertilizers

According to the research data, the value of 35.4 mm could be considered the optimal value of the distance between the planes of the outlet openings of the needle guide and the seeds tubes. The coefficient of variation of the soil layer between seeds and fertilizers is 28.9%. The test results are presented in graph form Figure 5.

The optimal value of the distance from the base of the outlet of the guide to the U-shaped furrow could be considered a value of 48.7 mm. The coefficient of variation of the soil layer between seeds and fertilizers was 28.7%. The test results are presented in graph form Figure 6.

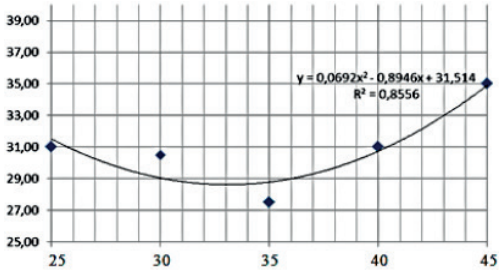

Figure 5. The effect of the distance between the planes of the outlets of the fertilizer guide and the vas deferens on the coefficient of variation of the soil layer between the seeds and fertilizers

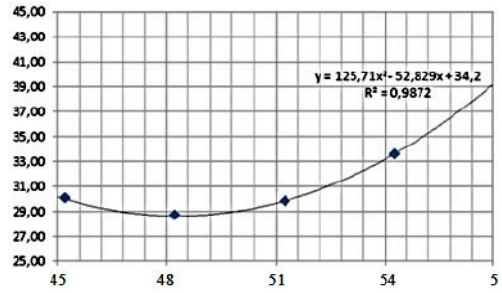

Figure 6. The effect of the distance from the base of the outlet of the fertilizer guide to the U-shaped shortener on the coefficient of variation of the soil layer between the seeds and fertilizers

Next, the results were compared. As it could be seen from the graph of dependencies, the seeder with experimental openers placed the seeds at a given depth better than the serial seeder.

As a result of the analysis of the obtained values, it was found that the number of seeds planted in a given layer (84.5-84.9%) is higher than the serial seeder (65.7-68.4%).

The number of spring wheat seeds planted to a predetermined depth, as well as the hardness and moisture of the soil, affects the dynamics of the appearance of wheat seedlings and field germination.

As a result of observations of spring crops of the Arkhat variety carried out by a seeder with experimental openers and a seeder with serial openers, we note that the seedling emergence rate in the first case is somewhat better.

After the passage of the experimental seeder, seedlings appeared one day earlier due to the multi-level fertilizer application than after the passage of the serial seeder. On the ninth day, the maximum difference in the number of seedlings per day was noted - 9%. This is due to the fact that with a more uniform distribution of seeds along the depth of planting and row length, the plants are in more favorable conditions for growth and development than seeds that are planted with serial openers of the SZ-5.4-0.6 seeder.

The soil layer between spring wheat seeds and fertilizer granules during sowing was determined for each individual opener. After studying the data obtained, it follows that the number of seeds out of contact with the granules of the fertilizer (interval of more than 10 mm) is 95.5% and this amount is within acceptable limits.

During laboratory and field studies, the distribution of seeds along the length of the row with a combined U-shaped furrow-opener is 74.2% (serial - 61.5%). The depth of sowing of seeds of grain crops with an experimental seeder and a serial corresponding one was 49 ± 3 mm and 51 ± 5 mm. The distance of the soil layer between seeds and fertilizers was stable 25 ± 3 mm.

To determine the traction resistance of the SZ-5.4-0.6 seeder, equipped with combined U-shaped furrow-opener, a dynamometer of the VISKHOM design was used, electrically connected to the IP 238 MR information-measuring system. As a result of processing the experimental data, the average value of the traction resistance of the seeder was 13,325 N when moving in the VI gear.

To change the depth of embedding during the transition to different crops, it is recommended to use track rollers of a combined U-shaped furrow-opener, which allows to change the position of the fertilizer guide and the seeds tube in the soil, thereby setting the necessary depth for laying and seeding the seeds of grain crops and granular fertilizers.

CONCLUSIONS

As a result of laboratory and field studies of the seeder equipped with combined U-shaped furrow-opener, the design parameters obtained as a result of theoretical and laboratory tests are refined. The data obtained fully comply with the requirements for grain seeders with openers.

To improve the quality of sowing seeds of grain crops with seeders of the SZ-5.4-0.6 type, it is recommended to use combined U-shaped

furrow-opener for laying and seeding grain seeds and granules of mineral fertilizers when they are applied at different levels.

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