Substantiation of the parameters of the double flat disc seeder for directly sowing repeated crops in the soil after wheat crop harvesting in Uzbekistan

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Abstract. The article presents the results of theoretical studies on the basis of the parameters of a seeder equipped with a double flat disk. This sows directly that repeated crops without tilling the soil of wheat-free fields in the soil-climatic conditions of Uzbekistan. In order to ensure the required quality of work of the seeder with a double flat disc, the diameter of its discs should be at least 21.4 cm. The angle of sharpening is 25°. As for the width of the bottom planting bed formed by the coulter discs, it should be at least 15 mm. The height of the meeting point of the coulter discs is at least 8.6 cm, and it was determined that the angle of deviation of the radius connecting it with the center of rotation of the disks should be 78°47'.

1 Introduction

Currently, in the Republic of Uzbekistan, there are the following methods of preparing and planting fields that have been cleared of previous crops and grain for planting repeated crops [1-3].

According to our observation, the first available technique is as following. Fields cleared of previous crops and grain are plowed to a depth of 25-30 cm. Then, in order to level the surface of the soil, compact it and create a soft soil layer, they are treated with the help of plows and trowels. If large lumps appear on the surface of the soil after plowing, it is given additional treatment with the help of machines (millers) with active working organs that work the soil. Then the seeds are planted with the help of seed drills.

Subsequently the following technique was created. Depending on the condition of the soil, the surface of the field is cultivated at a depth of 12-16 cm using chisel-cultivators, disk harrows or milling machines. Then, the surface is treated with the help of harrows and trowels

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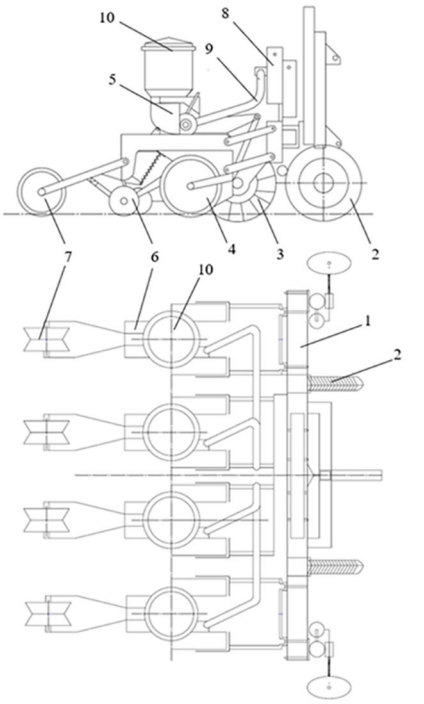
in order to level, compact and create a fine layer of soil. Then the seeds are sown with the help of seed drills.

The third available method is that, fields free from previous crops and grain are tilled only on the tops of the furrows, namely only the part where the seeds are sown, and planting is carried out at the same time.

When the first and second methods mentioned above are used, the technological processes of land preparation and planting for planting repeated crops are carried out using separate machines. This leads to an increase in fuel and lubricants, labor and other costs and a prolongation of the planting period. When the third method is used, it is possible to sow seeds in short periods and collect seedlings evenly. The consumption of fuel and lubricants, labor and other costs is reduced. Based on this, the Scientific-Research Institute of Agricultural Mechanization in cooperation with the Andijan Institute of Agriculture and Agro-Technology developed a seeder that directly sows repeated crops without tilling the soil of wheat-free fields in the soil and climate conditions of Uzbekistan [4]. It is equipped with a frame 1 with a hanging device, a zig-zag disc softener 2, a double flat disc coulter 3, a pneumatic planting device 4, a roller 5 that maintains and adjusts the planting depth, an auger 6 and a compactor 7 that compacts the soil layer above the planted seeds, an exhauster 8, a hose 9, the seed hopper consists of 10 (Figure 1).

2 Materials and methods

In the process of research, the basic laws and rules of higher mathematics, analytical geometry and agricultural mechanics were used.



1-flock; 2-wheel support; 3-zig-zag disc softener; 4-sided flat disk drive; 5-pneumatic planting device; 6-helper; 7-condenser; 8-exhauster; 9-hose; 10-seed bunker

Fig. 1. Seeding constructive diagram.

The working process of the developed seeder is as follows: when the aggregate moves along the field, its zig-zag disk softener softens the part of the fields empty of crops and grain, where the double flat disks pass, and pushes the plant residues and weeds to the sides. The double flat disc planter sows the seeds of repeated crops coming in through the pneumatic seeding device to the specified depth. Then the seeds are buried with the help of a shovel, and the soil layer above the seeds is compacted with a compactor. As a result, it is possible to sow the seeds of repeated crops in a short period of time without tilling the soil, and to collect seedlings uniformly.

This article presents the results of the theoretical research based on the parameters of the double flat disc seeding discs of the seeder, which directly sows repeated crops without tilling the soil of fields free from wheat in the soil-climatic conditions of Uzbekistan (Figure 2).

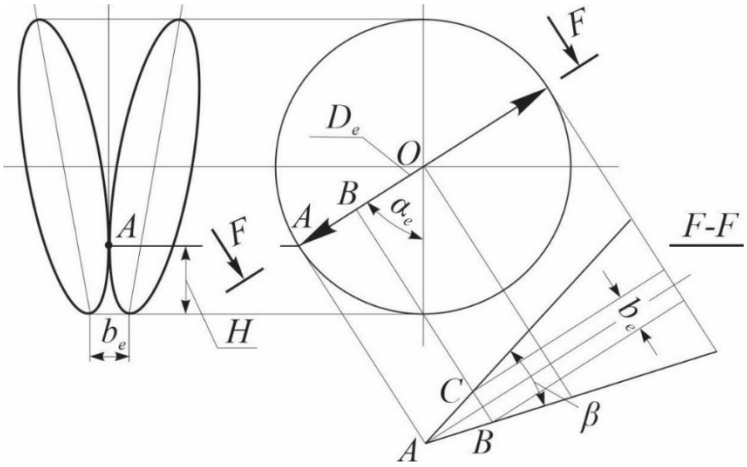


Fig. 2. Parameters of dual flat disk drives: the diameter of two disks with a flat disk D_e, m; Angle of attachment of two flat discs γ_e, °; the angle between the two disks of a flat disk β, °; the width of the seedbed produced by coulter discs b_e, m; the height of the meeting point of two flat disks H, m; the angle of deviation of the radius connecting the meeting point of the double flat disc coulters with their center of rotation relative to the vertical α_e, °.

3 Results and discussion

We determine the diameter of the double flat disc seeding discs, taking into account the angle between them, i.e. the angle of installation relative to the direction of their movement, under the condition that they cut through the remains of plants and the stems and roots of foreign grass encountered in the process of work, according to the following expression [5]

$$D_e \geq \frac{d_{o'}\cdot[1+cos(\varphi_{1o'}+\varphi_{2o'})]+\frac{2h_e}{cos\left(\frac{\beta}{2}\right)}}{1-cos(\varphi_{1o'}+\varphi_{2o'})} \quad (1)$$

where $d_{o'}$ – diameter of plant residues and weed stems and roots, m;

$\varphi_{1o'}$, $\varphi_{2o'}$ – correspondingly, the blade of the flat-disc coulter disc and the friction angle of the plant residues and weed stems and roots on the field surface (soil), °;

h_e – depth of immersion of the coulter with a flat disk, m.

We consider the depth of the double flat disc seed drill to be equal to the sowing depth of the seeds of repeated crops.

We determine the sharpening angle of double flat discs according by the following expression [6]:

$$\gamma_e = \frac{\pi}{4} - \frac{\varphi}{2} \quad (2)$$

where φ – the angle of friction of the soil against the blades (metal) of the disks, °.

Friction angle (2) of the soil on the blades (metal) of the disks, ° when the equation (2) where condition is fulfilled, the soil does not stick to the blades of the two discs, and as a result, the technological process is performed reliably and energy consumption is reduced.

We take the angle b between the double flat disc seeding discs as 10° according to the information given in the literature [7].

We determine the width of the bottom of the planting bed formed by the double flat disk coulter discs on the condition that this size is greater than the largest size of the seeds of repeated crops, i.e.

$$b_e \geq l_u + 3\sigma_u \tag{3}$$

where l_u – largest seed size (length) of repeated crops, m;

σ_u – mean square deviation of the largest seed size (length) of repeated crops, m.

According to (3) when the condition is met, the seeds will fall to the bottom of the seedbed and it will be evenly distributed.

The height of the meeting point of the double flat disc coulters and the angle of deviation of the radius from the vertical, connecting it with the center of rotation of the discs The condition (3) mentioned above, that is, the width of the seedbed opened by the cultivator is at the required level, is mainly the location height of the meeting point A of the double flat disc cultivator discs (see Figure 2) relative to the bottom of the cultivator (hereafter, the height of the meeting point of the cultivator discs) H and so $OA = R$, which connects point A with the center of rotation of the disk, is provided due to the correct selection $\alpha_e$of the angle of deviation of the radius relative to the vertical.

Let the discs of a double flat disc sower meet at point A. Then, from the scheme presented in Figure 2, we have:

$$b_e = 2Htg\frac{\beta}{2} \tag{4}$$

$$H = AB\cos\frac{\beta}{2}; \tag{5}$$

$$b_e = 2AB\sin\frac{\beta}{2}; \tag{6}$$

$$AB = OA - OB = R_e - R_e\cos\alpha_e = R_e(1 - \cos\alpha_e); \tag{7}$$

$$b_e = 2R_e(1 - \cos\alpha_e)\sin\frac{\beta}{2}, \tag{8}$$

where R_e – radius of double-flat disc seeding discs, m.

From (4) and (8) we get:

$$H = 0{,}5b_e ctg\frac{\beta}{2}; \tag{9}$$

$$\alpha_e = arccos\left(1 - \frac{b_e}{D_e\sin\frac{\beta}{2}}\right). \tag{10}$$

In (3) taking into account the expression, these expressions have the following form:

$$H \geq 0{,}5(l_u + 3\sigma_u)ctg\frac{\beta}{2} \tag{11}$$

and

$$\alpha_e = arccos\left(1 - \frac{l_u + 3\sigma_u}{D_e\sin\frac{\beta}{2}}\right). \tag{12}$$

According to the expressions (11) and (12), the height H of the meeting point of the sowing discs and the angle of deviation of the radius connecting the meeting point of the discs with the center of their rotation relative to the vertical are determined, which ensure that the width of the bottom of the sowing field opened by the discs is at the required level.

4 Conclusions

In conclusion, the paper provides valuable insights into the optimization of a double flat disc seeder for sowing repeated crops in Uzbekistan's agricultural conditions. The findings have practical implications for agricultural practitioners and policymakers, highlighting the importance of considering soil type, crop type, and climatic conditions in determining the optimal sowing parameters. The study's rigorous methodology and comprehensive data analysis contribute to the knowledge of precision agriculture, offering a valuable resource for researchers and practitioners in the field.

The calculation parameters are $d_{o'} = 3$ cm, $\varphi_{1o'} = 30°$, $\varphi_{2o'} = 40°$, $h_e = 5$ cm, $\beta = 10°$, $\varphi = 40°$, $l_u = 1{,}2$ cm, $\sigma_u = \pm 0{,}05$ cm. The calculations made according to the expressions (1), (2), (3), (11) and (12). The diameter of the double flat disc coulter discs is at least 21.4 cm, the sharpening angle is 25°. It shows that the width of the bottom of the planting bed formed by the sowing discs should be at least 15 mm, the height of the meeting point of the sowing discs should be at least 8.6 cm, and the angle of deviation of the radius connecting it with the center of rotation of the discs should be 78°47'.

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