Ridge forming machine for sowing cereals on sloping fields

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Abstract. Traditional technologies and machines for sowing cereals lead to increased water erosion on sloping fields and the washout of crops, respectively, causing a sharp decline in yields. The authors proposed anti-erosion technology and machinery for sowing cereals on sloping fields. The research aims to justify the parameters of the ridge forming machine for sowing cereals on sloping fields. The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. Based on theoretical studies, analytical dependences for determining the parameters of a ridge forming machine in the form of a flat half-disk have been obtained. It was found that the ridge spreader's radius should be 19.5 cm, its height should be 39 cm, and the angle of the disk set to the direction of movement should be within the range of 28-30°.

1 Introduction

In the following years in Uzbekistan, large-scale works on effectively using sloping fields and obtaining high yields of crops are carried out. To date, tillage and sowing of crops on sloping fields are carried out by traditional technical means. Such a situation, in turn, leads to increased water erosion on sloping fields and washing away of crops and, accordingly, a sharp decrease in crop yields [1-2].

Analysis of research has shown that prevention of water erosion during seeding of grain crops on sloping fields and conservation of moisture in the soil, as well as reduction of fuel, labor, and material costs, can be achieved by applying technologies of soil treatment with simultaneous seeding of grain seeds and formation of anti-water erosion ridges and machines for its implementation [3-4].

Based on analysis of the conducted research works and research, the technology of tillage of hillside fields with simultaneous seeding of grain crops and formation of erosion control ridges and design of machines for its implementation have been developed.

In the proposed technology, the following technological processes are carried out simultaneously (Fig.1): deep no-tillage tillage with simultaneous tillage of the surface layer of soil and elimination of weed plants, sowing of grain crops at three different depths, formation of furrows and ridges against water erosion, a sprinkling of seeds sown on the

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field surface with soil from the formed furrows [5-11].

Therefore, in one transition, the development of anti-erosion and grain-sowing machines on sloping fields, as well as the justification of the parameters of the working bodies, is an urgent problem.

The research aims to justify the parameters of the ridge forming machine for sowing cereals on sloping fields.

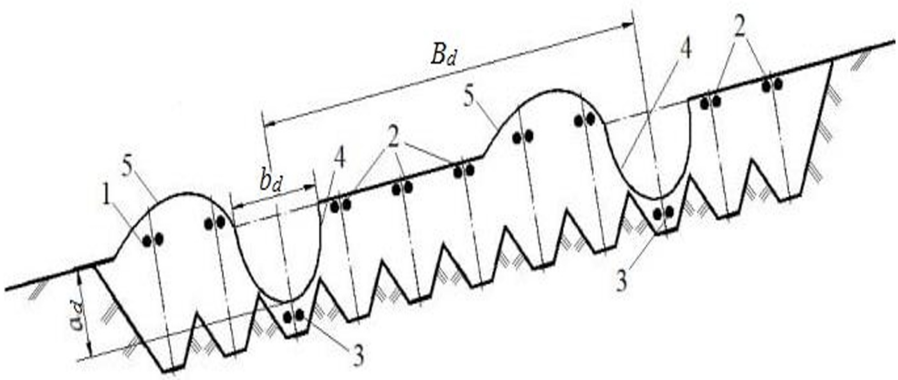


Fig. 1. Scheme of tillage technology with simultaneous sowing of cereals on sloping fields and formation of furrows and ridges against water erosion

2 Methods

The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. In the course of the study, theoretical farming mechanics, laws, and methods were used. As an object of the study, the mower harvest of the combined machine for anti-erosion treatment and grain sowing on the Slope fields was obtained [5, 6]. In order not to increase the metal capacity of the machine through a hyphen, the construction of the mower is simple, and its metal capacity should be small. Due to the above, the sickle-forming was adopted as a semi-flat disc.

Based on the analysis of the conducted research work, the use of slope field processing and grain sowing technologies and technical tools in developed countries, as well as the requirements of agrotechnical for grain planting, a combined machine for processing and sowing grain on sloped Fields was developed [3, 4, 7].

The machine consists of a frame, capacitance, planting, coulters, softeners, and a harvester. In the bodies of work, the first and second lines are arranged in chess order. Harvest formers are installed on the symmetrical axis of the softeners of the second row.

The harvester harvests an apricot at a depth of 10-12 cm in the field and an apricot at a balance of 8-10 cm. The soil overturned with it should cover two rows of grains thrown to the field's surface on the side.

The following are the main parameters of the sickle-forming machine (Figure 1): radius R_d – of the flat half disk; sharpening angle of the sickle forming half disk thread – i_d; thickness of the sickle-forming machine t_d and height – H_d; installation angle relative to the direction of movement of the disc – y_d.

Theoretical studies were conducted to substantiate the optimal values of the specified parameters of the harvester.

The sharpening id and thickness td of the sickle-forming thread was adopted according to previous studies [1, 2], mainly 25º and 4 mm, respectively.

In the work process, each disc is scraped to a certain layer depth by forming a tubular rod in the soil and rolling it to the side (Figure 1). As a result, in the place of forty clowns, a plum and a willow with a high level on the surface of the field are formed.

The soil processing quality of the harvest is evaluated according to the height and width of these harvests, that is, the laying of the soil on the side distance. The height of the mower, the width of the mower, the part of the working body in the form of a flat disk radius R_d, the angle of installation concerning the direction of movement of the mower y_d, the depth of operation ad and depends on the speed of movement of the machine.

The working mower harvester must cut the soil in the range of two armies and form the ditch. The width of the upper part of the ditch bd should not be greater than the width of the two rows of the groove, that is, $b_d<2b_p$. Otherwise, the harvester will rub the grains planted on the left and right sides. If we take into account the irradiation of the two upper sides of the arc formed during the working process of the harvest, then according to the above condition:

$$b_d \leq 2b_p - 2\Delta b \tag{1}$$

here Δb is the width of the edge parts of the range, which is not treated with a sickle-forming machine, cm. 1-according to the picture

$$\Delta b_d < \Delta b \tag{2}$$

here Δb is irradiated soil width, cm.

Based on the conducted experiments, Δb_d=3-5 cm. In that case, Δb=5-7cm. (1) according to the expression Δb=5-6 cm when b_d=18-20 cm.

We determine the mounting angle yd relative to the direction of movement of the harvest from the condition of free slip of soil and plant residues on the working surface of the working body [6].

$$\gamma_d \leq \frac{\pi}{4} - \frac{\varphi_{\max}}{2} \tag{3}$$

here φ_{max} is the maximum value of the friction angle of the working surface of the mower harvester.

If we take into account φ_{max}=30-34˚ (3) in the expression, it turns out that the angle of installation of the harvest relative to the direction of motion should be in the range γ_d=28-30°.

Since the cross-section of the mower cut with the mower is in the form of an ellipse (Figure 1), there is a connection between the width of the mower cut with it, the processing depth, and the radius of the flat disc of the mower cut with it

$$\left(\frac{2D_d}{2}\right)^2 = \left(\frac{D_d}{2} - a_d\right)^2 + \left(\frac{C}{2}\right)^2 \tag{4}$$

From this expression

$$R_d \leq \frac{a_d}{2} - \frac{C^2}{8a_d} \qquad (5)$$

1-according to the picture

$$C = \frac{b_\partial}{\sin \gamma_d} \qquad (6)$$

Thus

$$R_d = \frac{a_\partial}{2} + \frac{b_d^2}{8a_d \sin^2 \gamma_d} \qquad (7)$$

Considering that b_d=18 cm, a_d=12 cm, and y_d=30°, (7) the calculations performed on the expression revealed that the flat disc portion of the harvest is R_d 19.5 cm.

To simplify the calculations, we assume that the height of the sickle-maker is equal to the diameter of its flat disc part, that is, $N_d=2n_d=D_d$=39 cm.

Resistance of the harvest to gravity. We determine the resistance of the Harvest to gravity by the following formula, which is simplified:

$$R_{d1} = K_d S_d \qquad (8)$$

here K_d is the comparative resistance of the flat disc part of the sickle maker, kN/m^2; S_d is the cross-sectional surface of the cut-off part of the sickle maker with the flat disc part of the sickle maker, m^2.

The surface of the cross-section of the cut with the flat disc part of the mower of the mower:

$$S_\partial = \frac{1}{2} R_\partial^2 \left[\frac{\pi}{2} \arcsin\left(1 - \frac{a_\partial}{R_\partial}\right) - \left(1 - \frac{a_\partial}{R_\partial}\right) \right] \sqrt{1 - \left(1 - \frac{a_\partial}{R_\partial}\right)^2}, \qquad (9)$$

We put the value (9) of S_d in terms of expression (8) in the expression [10]:

$$S_d = \frac{1}{2} R_d^2 \left[\frac{\pi}{2} \arcsin\left(1 - \frac{a_d}{R_d}\right) - \left(1 - \frac{a_d}{R_d}\right) \right] \sqrt{1 - \left(1 - \frac{a_d}{R_d}\right)^2} \qquad (10)$$

$$R_{d1} = \frac{1}{2} K_d R_d^2 \left[\frac{\pi}{2} \arcsin\left(1 - \frac{a_d}{R_d}\right) - \left(1 - \frac{a_d}{R_d}\right) \right] \frac{(2b_p - 2\Delta b)\sin \lambda_d}{R_d} \qquad (11)$$

Mowing in the cross-direction of the soil fragments falling from the mower masofasi affects the height and width of the mower being harvested.

In the process of work, the mower harvester cuts off the clay pellet, which is in the form of a cross-sectional ellipse at a certain depth of ad, and throws it to the side (Fig. 2). In the cross-sectional surface of cuttings and overturned soils are equal to each other, that is

$$F = S_d \tag{12}$$

According to the results of the previously conducted research work, the natural slope φ_{tc} and the angle of collapse φ_c are considered equal to each other since the values are close to each other, that is,

$$\varphi_c = \varphi_{tc} = \varphi_o$$

Without it 2-according to the picture:

$$F_1 = F_2,\ F = F_1 + F_2, \tag{13}$$

$$F = \frac{1}{4} L_i h_1 \tag{14}$$

$$L_u = 2h_1 ctg\varphi_o \tag{15}$$

Let's put the value of φ_o (15) in the expression (14) in the expression

$$F = h_1^2 ctg\varphi_o. \tag{16}$$

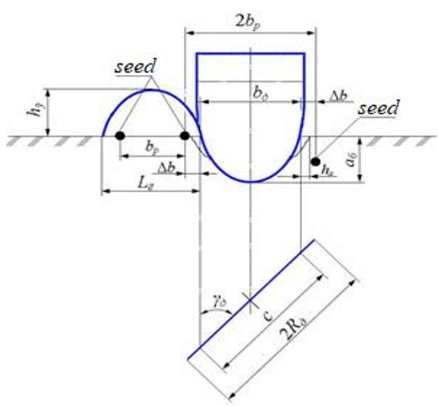


Fig. 2. Scheme for determining parameters of harvest

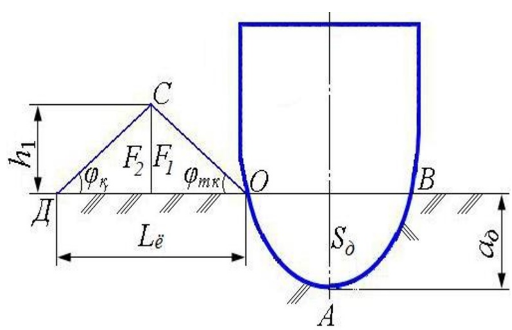


Fig. 3. Scheme for determining height of mower and cross-throw distance of soil fragments falling from mower

We get after a certain change by putting the values of S_d and F in the expression (9) and (16) according to the expression (12)

$$h_1 = 2\sqrt{\frac{ctg\varphi_o}{2} R_d^2 \left[\frac{\pi}{2} \arcsin\left(1 - \frac{a_d}{R_d}\right) - \left(1 - \frac{a_d}{R_d}\right)\right] \sqrt{1 - \left(1 - \frac{a_d}{R_d}\right)^2}} \tag{17}$$

or

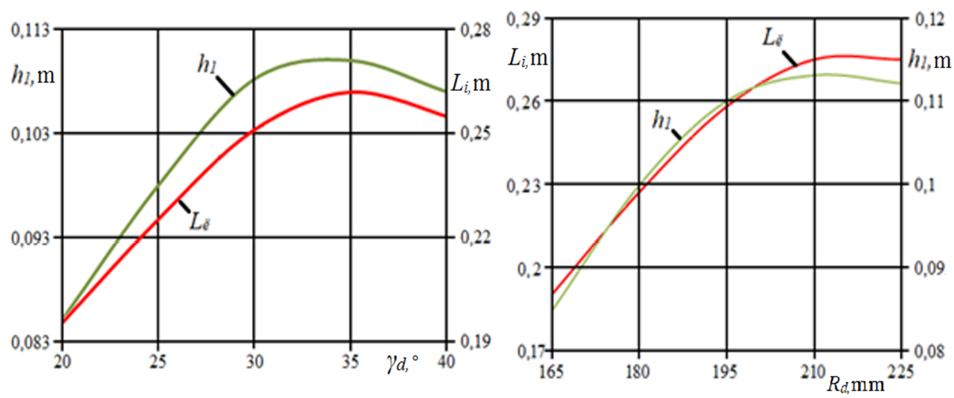
$$h_1 = 2\sqrt{\frac{ctg\varphi_o}{2}R_d^2\left[\frac{\pi}{2}\arcsin\left(1-\frac{a_d}{R_d}\right)-\left(1-\frac{a_d}{R_d}\right)\right]\frac{(2b_p-2\Delta b)\sin\gamma_u}{R_d}} \quad (18)$$

$$L_i = 2\cdot ctg\varphi_o\sqrt{\frac{ctg\varphi_o}{2}R_d^2\left[\frac{\pi}{2}\arcsin\left(1-\frac{a_d}{R_d}\right)-\left(1-\frac{a_d}{R_d}\right)\right]\frac{(2b_p-2\Delta b)\sin\gamma_u}{R_d}} \quad (19)$$

(17) and (19) the cross-throw of the soil piece by the expression masofasi, the height of the φ_o, and the harvest H_1; the change graphs related to the installation angle of the harvest y_d and radius of the harvest are given in Figure 3.

As can be seen from the graph presented in Fig. 3, the cross-throw of the soil fragments masofasi and the height of the mower increased by the bubble parabolas with an increase in the mounting angle relative to the direction of movement of the disc.

Analysis of the graphs showed that in order to form a sickle according to the requirements of agrotechnical, the angle of installation relative to the direction of movement of the sickle maker should be 28–33° and the radius of 190-200 mm.



φ_0=35°; b_p=0.15 m; Δb=0.06 m; a_d=0.12 m

Fig. 4. Cross-throw soil piece masofasi L_i mower height graf change graphs of height h1 concerning direction of movement of mower concerning angle of installation radius R_d

Taking into account that R_d=0.195 m, a_d=0.12 m, b_r=0.15 m, Δb=0.06 m and K_d=35 kN/m^2, (11) the calculations performed on the expression showed that the gravitational resistance of the harvest was R_{d1}=0.148 kN.

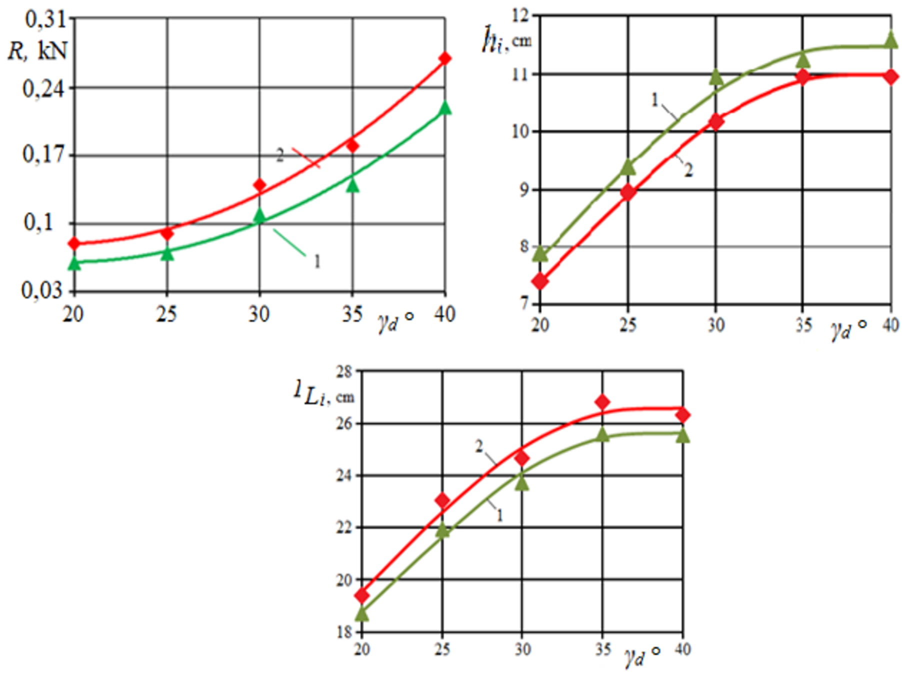
3 Results and discussion

In the experiments conducted to study the effect of the angle of installation of the harvest on its working performance concerning the direction of movement, the harvest was studied, as the resistance of the harvest to its gravity and the height of the harvest on the field surface. The direction of the generator was changed from 5 to 20 degrees relative to the angle of installation according to the motion of the generator. In this case, the slope of the harvest was 195 mm, and the aggregate's movement speed was 6 and 8 km/h (Fig. 4).

According to the Fig. 5, an increase in the movement of the mower from the 20 direction of the installation of the mower crop is because the height of the mower crop and the distance from the soil to the mower-the distance from the mower to the 20 direction of the installation of the mower crop. An increase in the speed from 6 km/h to 8 km/h led to a decrease in the height of the harvest mower while an increase in the distance of cross-fertilization of the soil.

According to the results of the conducted studies, to ensure low energy consumption of reeds (average height 10,5 cm) and cross-grazing of soil (average grazing masofasi 25 cm), the requirements of the machine should be within the range of 30-3 without the requirements of installation concerning the direction of movement of the harvest.

In the experiments conducted to study the effect of the mower on its working parameters, the movement speed of the aggregate was determined as 6 and 8 km/h, and the installation angle concerning the direction of movement of the mower was accepted as 30º. The radius of the harvest was changed from 170 mm to 245 mm in the range of 25 mm.

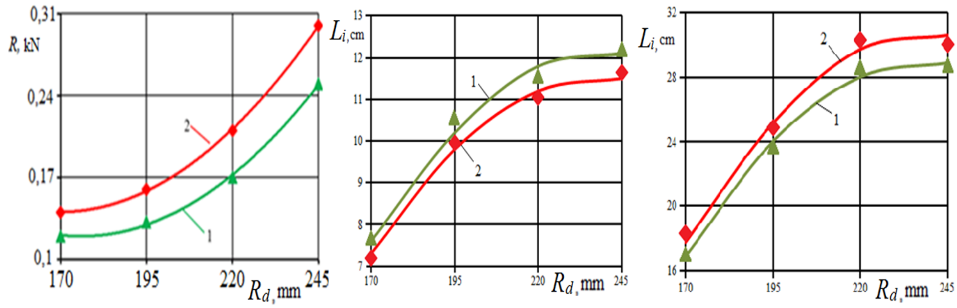


1, 2-aggregate movement speed is 6 and 8 km/h, respectively

Fig. 5. Mower harvester traction resistance (R), mower height (h_i), and soil cross-throw masofasi (L_i) can be changed depending on installation angle (γ_d) relative to movement direction of mower harvester

According to the data obtained, the increase in the yield of the mower from 170 mm to 245 mm led to an increase in the height of the harvested mowers. The reason for this is an increase in the volume of soil in front of the harvester, which is an increase in the volume of soil in front of the harvester. An increase in the speed from 6 km/h to 8 km/h led to a decrease in the height of the harvest mower.

6-from the picture, it can be seen that with the increase of the radius of the mower from 170 mm to 245 mm, the gravity resistance of the mower is increased. With the increase in the yield of the harvest, the increase in its resistance to gravity can be explained by the increase in the volume of soil affected by the harvest (Fig. 6.). The increase in the speed from 6 km/h to 8 km/h led to an increase in the traction resistance of the harvest.



1, 2-aggregate movement speed is 6 and 8 km/h, respectively

Fig. 6. Mower-forming tensile resistance (R), mower height and soil cross-throw distance (L_i) depending on the mower-forming radius (R_d) change

According to the results of the conducted research, the yield of the machine mower should be 190-200 mm in order to ensure the formation of the mower at the level of requirements and cross-fertilization of the soil with low energy consumption.

4 Conclusion

According to the results of the conducted theoretical studies, while low energy consumption according to the requirements of agrotechnical, the radius of the harvest is between 19-20 cm, the height of 39 cm, the angle of installation concerning the direction of movement is between 28-30°, the sharpening and thickness of the harvest crochet need respectively 250 and 0.4 cm.

The traction resistance of the archer to the pull-up was determined by the relative resistance of its flat disc part, its parameters, as well as the depth of processing, and The conducted calculations showed that the traction resistance should be in the range of 0.145-0.151 kN.

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