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Research Article

JUSTIFICATION OF THE NEED TO CREATE A SPECIAL UNIT FOR SOWING WHEAT SEEDS IN THE INTERROWS OF COTTON AND DETERMINING THE MAIN PARAMETERS OF A HINGED-SKID COULTER

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ABSTRACT

In the general complex of technological operations, sowing wheat seeds between cotton rows is one of the most difficult tasks. The uniformity of seedlings, facilitation of subsequent operations, yield and quality of the final product depend on the quality of seed sowing. The solution to the problem lies in the development and creation of a unit and the installation of small-sized coulters on runners. This article analyzes and defines the parameters of a hinged-skid coulter for sowing wheat seeds between cotton rows.

KEYWORDS

Sowing wheat, cotton rows, hinged-skid coulter, coulter, coulter knife.

INTRODUCTION

Energy-saving technologies and technical means are actively used worldwide to obtain high yields of cereals and other grain crops. Global grain production exceeds 2.796 million tons, which necessitates the introduction of technological solutions to ensure high-quality and efficient work during planting.

In this regard, the development and implementation of energy-saving technologies and sowing machines that meet agrotechnical requirements is an important task.

Currently, scientific research is being conducted to develop new technical solutions for resource-saving

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technologies and equipment in order to efficiently cultivate grain crops. Exceptional attention is given to determining the parameters of a seeder that ensures high-quality seed distribution and efficient resource use in interaction with soil.

Obtaining high yields of winter wheat, which is considered an agricultural crop, depends primarily on the quality of seeds, soil and climatic conditions, timing and norms, method of sowing, modes of fertilization and irrigation.

Currently, in the territory of the Republic of Uzbekistan, winter wheat is grown on irrigated lands in open fields and in rows of cotton. According to data obtained from the Department of Seed Production of the Ministry of Agriculture and Water Resources, today the volume of crops in the rows of cotton is 55-65%.

The positive aspect of sowing winter wheat between cotton rows is that we sow it within the established agricultural terms, before the harvest of cotton is collected. Otherwise, the agricultural terms for sowing wheat would pass. As a result, wheat sprouts would germinate late and could be exposed to cold without entering the growth phase until the time of wintering. [1].

From year to year, the amount of cultivated areas for winter wheat between cotton rows increases. This, in turn, leads to the fact that the technology for sowing wheat between rows has not been developed, and special machines have not been designed to do this. This does not lead to high-quality or stable performance at the level required by agrotechnical standards, and causes a number of other problems.

Due to incorrect machine selection, timing and sowing rates for winter wheat were not adapted to the row spacing used for sowing cotton, and instead of sowing seeds the scattering method was used, leading to excessive seed consumption, as the seeding rate was set at 250-300 kg/ha. [2].

In the irrigated areas of Uzbekistan, cotton is the main agricultural crop. After harvesting cotton, wheat is sown on most vacated fields. The field is then plowed and prepared for the spring sowing of cotton.

At the present time, specialized machine was not created for sowing wheat seeds between cotton rows. Wheat seeds are sowed using various seeding devices and machines that have other functions (granular fertilizer spreaders, cotton row processing). These machines do not fully meet agrotechnical requirements for seeding.

METHODS. The currently used technology for sowing winter wheat and the technical means for its implementation make it possible to plant wheat seeds without burying them to the same depth, evenly distribute them between rows, and prevent them from sprouting evenly due to their accumulation in the center and on one side of the furrow. In addition,

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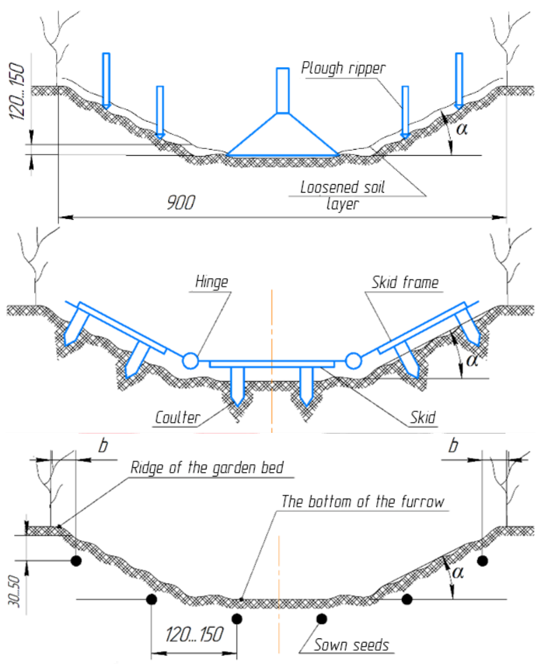
because the seeders are not equipped with special seed distributors, there is an excessive consumption rate of seeds.

Based on the literature analysis and the results of the conducted research [3], a new technology for sowing wheat between cotton rows, as well as a machine and a coulter for its implementation have been developed. To prepare for sowing according to the proposed technology, fields with cotton row spacing of 90 cm are loosened twice with KHU-4 cultivator if necessary, and seeds are then sown in plowed rows (Fig. 2.3).



a) - processing between rows to a depth of 12-15 cm;

b) - sowing wheat in 6 rows using the strip method along the row spacing, 11-12 cm wide, 3-5 cm deep and compacting the surface above the seeds;

c) - the position of sown seeds within the cross-section between rows

Fig. 1. Proposed technology for sowing winter wheat between cotton rows

In this case, the rows are processed to a depth of 12-15 cm (Fig. 1a), wheat is sown in 6-8 rows along the furrow profile using a strip method (Figs. 1b,c) to a depth of 3-5 cm, with intervals of 9-12 cm. Additionally, during one pass of the seeding machine, the soil is compacted according to established agrotechnical standards.

When comparing existing and proposed technologies for sowing winter wheat between cotton rows, it was found that the proposed technology allows not only significant reduction in labor, energy, fuel and lubricant costs, but also a reduction in wheat seed consumption due to sowing at the required level and uniform germination of seedlings.

A design of a seeder has been created, equipped with a hinged coulter that adapts to the complex profile of cotton rows and performs sowing of wheat seeds according to established agrotechnical requirements at low energy costs. Each section has its own bunker,

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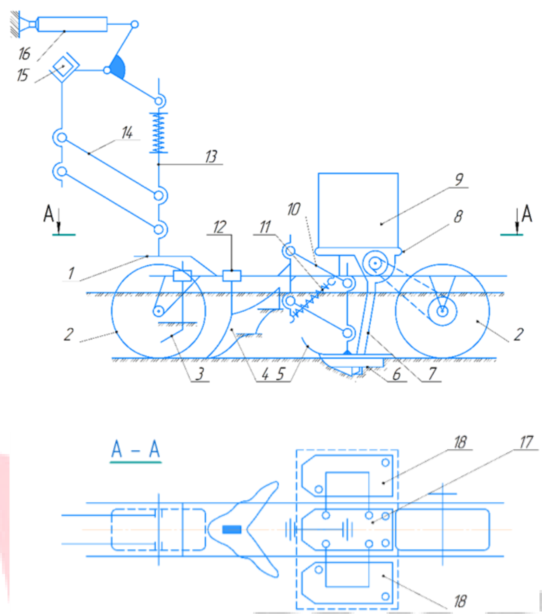
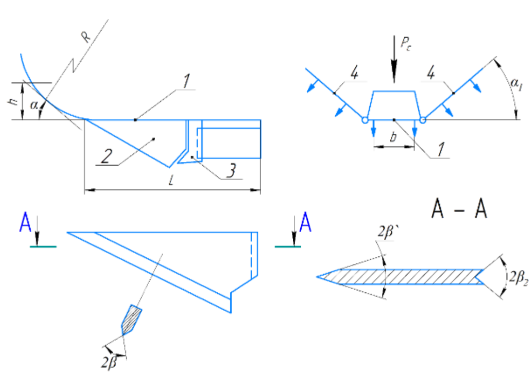
and a seeding unit is selected for it. Skids with central and variable inclinations of the wings have been selected on which coulters are mounted, as shown in Fig. 2.



1-beam, 2-support wheel, 3-ripper, 4-furrow former, 5-coulter runner, 6-coulter, 7-seed tube, 8-seeding unit, 9-hopper, 10, 11-spring parallelogram mechanisms, 12-lock, 13-traction, 14-parallelogram section mechanism, 15-frame, 16-hydraulic cylinder, 17-central runner, 18-right and left coulter wings.

Fig. 2. Scheme of the seeder section for sowing wheat seeds in rows between cotton rows.

In theoretical studies, the parameters of the skid, coulter and knife were determined. (UZ FAP 01846) [4] General parameters of the skid and knife are shown in Fig. 3.



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h - height of the skid nose, cm, α - set angle of inclination of the skid beak, grad, R - radius of curvature of the skid nose, cm, α1 - angle of adaptation of the skid wing to the slope of the furrow, grad, β - angle of constructive sharpening of the knife, grad, β1 - angle of sharpening of the knife, grad, β2 - angle of opening of the strips of the base of the knife, grad. 1 - skid, 2 - knife, 3 - anchor-type coulter, 4 - skid wings

Fig. 3. Main parameters of the skid and the coulter knife

Skid parameters

To determine the height of a toe, the soil collected in front of it when immersed at a distance of [ho] on a level surface is not greater than its height. A certain distance is then set in the longitudinal direction of the slide and the distance between the highest and lowest points is measured. Fig. 4 shows this process.

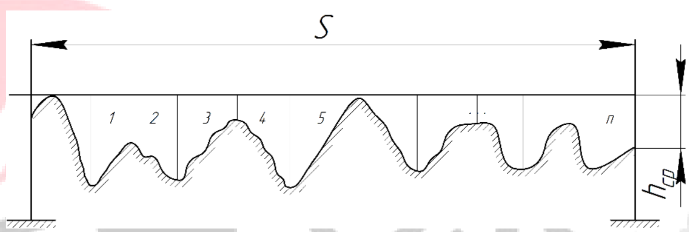

Fig. 4. Methodology for determining the unevenness of row spacing

Average value of unevenness.

$$h_{cp} = \frac{\sum h_n}{n}$$

h_n - sum of the measured values;

n-number of measurements.

In order for the skid's movement to be stable, it must be lowered from the greatest height hcp to the depth ho located below (Fig. 5). The soil collected by the skid must not exceed the height of its toe, which is determined by the condition.

$$h = K_c(h_{cp} + h_o) \quad (1)$$

K_c - a coefficient that takes into account soil compaction (K_c=1,8).

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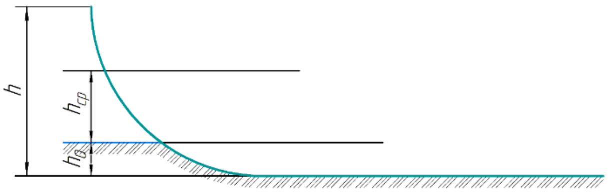

Fig. 5. Scheme for determining the height of the skid **toe**

RESULTS

Determination of the unevenness of the row spacing using special rulers was h_{cp} = 8,7 cm. At the same time, the height of the skid nose (h_o = 0,5 cm) was h = 15,66 cm. In subsequent calculations and during the manufacturing of the skids, h = 16 cm was used.

Determination of the angle of installation of the toe of the skid relative to the longitudinal plane. The installation angle of this angle (Fig. 2) is determined based on the condition of uniform sliding of soil particles along its surface and the absence of accumulation of soil in front of it., [5]

$$\alpha = \frac{\pi}{4} - \frac{\varphi_1}{2} \quad (2)$$

φ_1 - the friction angle of the soil on the metal, grad.

Substituting the values φ_1=20°...30° into equation (2), we determine that the angle of installation of the skid nose relative to the longitudinal plane is approximately α=30°...35°.

Determining the width of the skid. The width of the skid is determined by the number of sown rows and the distance ΔX between them. Wheat seeds are planned to be sown in 6 or 8 rows along the cotton row width, excluding the protective strip. The distances between these rows are 11.8 and 8.75 cm, respectively. Therefore, there is enough space for plant nutrients. The width of a skid in such a case is calculated as follows.

$$B = \Delta X\left(\frac{n-2}{2}\right) \quad (3)$$

ΔX - the distance between rows, cm;

n - number of rows.

Putting the above values into equation (3), we obtain that, when sowing wheat in 6 rows, B=23.6 cm and for 8 rows, B=26.25 cm. When making these assumptions, it was assumed that B=24 cm for 6 rows and B=27 cm for 8 rows.

Determination of the vertical force required to immerse the skid into the longitudinal direction and the coulter attached to it to working depth. To simplify the work, 4 cm high coulters were installed under the skid. When the skid rests against the moving surface, the coulters are buried to the sowing depth. However, in order for the skid to move steadily, it must be buried in the soil by ho=0.5 cm. When this condition is met, the depth of sowing wheat seeds is 4.5

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cm. According to agrotechnical requirements, the depth for sowing wheat should be within 3…6 cm [6]. This means that this method meets agrotechnical requirements.

The vertical force on the skid is created by a parallelogram mechanism installed on the seeder section. The force of vertical pressure is determined by the condition of immersion of the coulter to a given depth, and is determined by the following equation [7].

$$P_c = S_c \cdot h_o \cdot q_M \qquad (4)$$

P_c - the vertical pressure force acting on the coulter (N);

q_M - the coefficient of soil resistance to volumetric compression (N/cm³).

The supporting surface of the skid is determined as follows:

$$S_c = b_c \cdot l \qquad (5)$$

b_c - the width of the supporting surface, cm;

l - the length of the supporting surface that accepts the pressure, cm.

Taking into account the design dimensions of the skid, as well as the values of the quantities involved in the equations, i.e., b_c=24 cm, l=6 cm, ho =0.5 cm and q_M=4.5 N/cm³, it was determined that the vertical pressure force was equal to P_c=324 N.

The value of the force required to immerse the skid to a given sowing depth should be about [Pc] = 400 - 550 N. If we take into account the weight of the parallelogram mechanism falling on the skid, then it can be Pc ≈ [Pc]. The change in vertical pressure relative to the supporting surface of the skid is shown in Fig. 6.

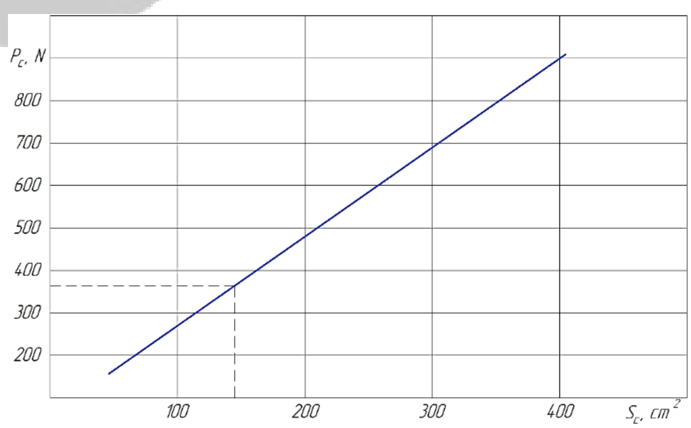

Fig. 6. Change in vertical pressure depending on the supporting surface of the skid

Using this graph, the required vertical pressure can be determined based on the parameters of the new skid.

Parameters of the coulter knife

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To determine the angle of entry of the knife into the soil, it is necessary that, when the coulter is working, the remains of weeds remain inside the furrow and their roots slip under the coulter without accumulating in front of it. The forces acting on the knife are shown in Fig. 7.

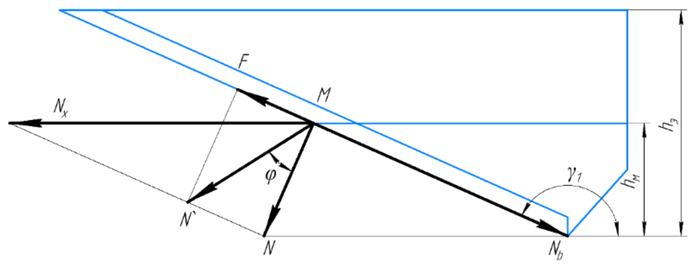

Fig. 7. Scheme of knife forces acting on a soil particle

Determining the size of the coulter knife

Determining the angle of entry of the knife into the soil. Let us consider the condition under which, during the operation of a coulter in a furrow, the remains of weeds and their roots will slide underneath the coulter and not accumulate in front of it.

DISCUSSIONS

When the coulter moves in the soil, its knife, at a height of h_M from the bottom of the furrow, acts with a force N on a particle of soil M. Friction F = Ntgφ_1 (φ_1 - the coefficient of friction of soil on the surface of the knife), occurs when a particle of soil slides along the edge of a knife. The resultant N` of forces N and F can be divided into components: horizontal N_x and along the tip N_b (Fig. 7). The force N_x shifts the soil in the direction of the coulter movement and is added to the shear resistance forces. The N_b force pushes plant remains and soil down, helping to cut them.

It is known that when particles slide, the cutting resistance is the smallest [3]. From the scheme in Fig. 7, we obtain

$$N_B = \frac{N \sin\left[\gamma_1 - \left(\frac{\pi}{2} + \varphi_1\right)\right]}{\cos\varphi_1} \qquad (6)$$

γ_1 - angle of knife entry into soil;

φ_1 - angle of soil friction on metal, grad, (20°-30°)

According to this equation, for a vertical force to appear, the value of the angle [γ_1-(90°+φ_1)] must be positive. Therefore, the condition for the sliding of soil particles along the knife edge is as follows [7]:

$$N_B = N\mathrm{ctg}(\pi - \gamma_1) > F = N\mathrm{tg}\varphi_1 \qquad (7)$$

or

$$\gamma_1 > \frac{1}{2}\pi + \varphi_1 \qquad (8)$$

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If this condition is not met, soil particles accumulate in front of the knife, which affects the quality of sowing. Plant residues are more slippery than soil due to their physical properties; condition (7) must be met to ensure that they slide along the edge of a knife.

$$\gamma_1 > \frac{1}{2}\pi + \varphi_2 \qquad (9)$$

φ_2 - friction angle of plant residues on the surface of the knife.

Equations (8) and (9) allow us to determine the condition under which soil particles and plant residues slide along the edge of a knife, but do not allow us to determine the angle at which the knife enters the soil. For this, using the diagram in Fig. 7, we find the time t of interaction of a soil particle with the tip of a knife [8].

$$t = -\frac{h_э}{V_n(\cos\gamma_1 + \sin\gamma_1 \cdot tg\varphi_1)\sin\gamma_1} \qquad (10)$$

$h_э$ - sowing depth, m;

V_n - unit speed, m/s.

In accordance with previously conducted studies and requirements for sowing, substituting the obtained values into equation (10): at a sowing depth of $h_э$=0.05 m, unit speed V_n=1.5; 2.0 and 2.5 m/s, and also taking φ_1=φ_2=20, 25 and 30°, a graph was constructed using the equation t to γ_1 (Fig. 8). These graphs show that, for all values of V_n and φ_1, the time t varies in a concave parabola depending on the angle γ_1, which means that, for certain values of the angle γ_1, time will have a minimum value.

Analysis of the graphs shows that at angles of entry of the knife into the soil within the range of 140-155° t is minimal, at smaller angles the friction force F will be greater than the force of movement of soil and plant residues along the knife edge, at larger angles it leads to an increase in the time of movement of soil and plant residues along the knife edge.

Substituting the previously given values of φ_1 into (10), we find that in the range γ_1=147-153° t has a minimum value. Therefore, for soil particles and plant debris to slide along the knife edge, the value must be in the range of γ_1=147-153.

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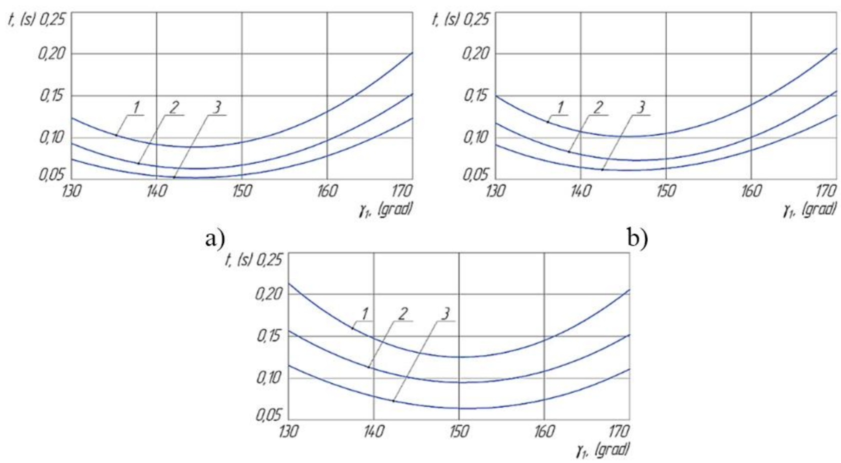

at a, b, c equal φ_1=20°; 25° and 30°, respectively

at 1, 2, 3 equal V_n=1.5; 2.0 and 2.5 m/s, respectively

Fig. 8. The influence of the angle of entry of the knife into the soil on the change in the time of sliding of soil particles and plant residues along the tip

Determining the sharpening angle of a knife tip. The knife edge has a constructive β and an actual β\` sharpening angle (Fig. 9), and to determine β it is necessary to determine the actual sharpening angle. To do this, we will use the condition that the soil in front of it does not stick or accumulate.

It is known that in order to prevent the soil from sticking and accumulating in front of the knife, the following equation must be satisfied:

$$\beta` = \frac{\pi}{4} - \frac{\varphi_1}{2} \qquad (11)$$

or

$$2\beta` = \frac{\pi}{2} - \varphi_1 \qquad (12)$$

β\` - actual sharpening angle of the knife tip

Substituting the values of φ_1 into equation (12), we determine that 2β\`=55-65°.

Since the angle of entry of the knife into the soil is $\gamma_1 > 90°$, the actual sharpening angle of the knife 2β\` (Fig. 9) differs from its design sharpening angle 2β, that is, there is a shift in the section |UK| to |JK|

According to the scheme in Fig. 9 $\frac{|UK|}{|JK|} = \frac{l}{l`} = \sin\gamma_1$, and also

$$l\,tg\beta = l`tg\beta` \qquad (13)$$

and considering that equalities will be appropriate, we formulate the following resulting relation (14), which shows

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the relationship between actual and design sharpening angles of a knife.

$$\text{tg}\beta` = \text{tg}\beta \sin\gamma_1. \quad (14)$$

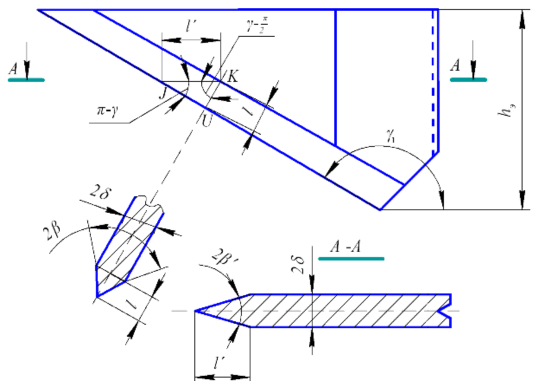
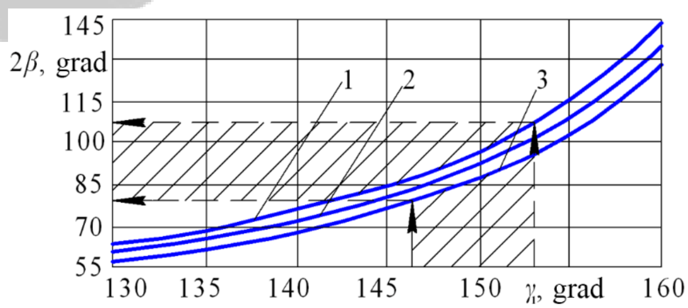


Fig. 9. Scheme for determining the sharpening angle of the knife tip

Solving equation (14) for β, we obtain [8]

$$2\beta = \text{arctg}\frac{\text{tg}\left(\frac{\pi}{2}-\varphi_1\right)}{\sin\gamma_1}. \quad (15)$$

Substituting the values of γ_1 and φ_1 into equation (15), we construct a graph of the change in the sharpening angle of the knife tip, 2β, depending on its angle of entry, γ_1, into the soil (Fig. 10). From the graph, it is established that the angle for constructive sharpening of the knife's tip is within the range of 81-107°.



for a, b, c equal φ1=20°, 25° and 30°, respectively

Fig. 10. Graph of the change in the sharpening angle of the knife tip, depending on its angle of entry into the soil.

CONCLUSIONS

1. A design has been created for a sectional seeder equipped with a hinged-skid coulter that adapts to the complex profile of cotton rows, performing sowing of wheat seeds at the level of established agrotechnical requirements with low energy costs.

2. As a result of theoretical study of the main working element of the skid, the following was established:

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height of toe h = 16 cm; angle of mounting of toe of skid relative to longitudinal plane α=30°...35°; width B=24 cm; vertical pressure force P_c=324N.

3. It was found that the angle of entry of the anchor coulter knife into the soil was γ_1 = 147 °… 153 °, and its sharpening angle was 2β' = 55 ° … 65 °.

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