

Determining the Angle of the Teeth of the Driver

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Abstract: As a result of studying the designs of existing seed drills, it was found that they are not suitable for sowing grain seeds in rows between cotton rows. Based on this, a new design of the seeder was selected. In order for the seeder to fully and qualitatively fulfill the tasks set before it, its parameters must be justified. This scientific article is devoted to justifying the parameters of the seeder based on its relationship with the soil.

Keywords: Grain seed, seeder, seeder, multi-row sowing, seeder blade, radius of curvature, sharpening angle.

Introduction. Planters of various designs are known for planting seeds of various plants [1, 2]. They are mainly intended for planting seeds in open fields.

In order to select seeders for planting between cotton rows, seeders for planting vegetable and melon crops were also analyzed [3, 4, 5, 6, 7]. As a result, it was concluded that the design and dimensions of seeders intended for open fields are not suitable for use between cotton rows.

Along with the above, planters designed for use between rows of cotton were also studied [8, 9, 10, 11, 12, 13, 14, 15]. Although the design of these planters is adapted to work between rows, they have some shortcomings in performing the tasks assigned to the planters. Taking into account the above data, the design of a planter that sows grain seeds in multiple rows between rows of cotton and performs the task assigned to them qualitatively was selected, Figure 1. Because of the high maneuverability of this planter, it was called a “squirrel”-shaped planter.

This is different from others in that the sharpening angle of the coulter blade is the same as the sharpening angle of the knife, so the knife is understood together with the blade, and since the width of the blade base is the same as the width of the coulter, the soil (including weed residues) is pushed (pushed) in both directions, clearing the way for the coulter.

The purpose of the work. To justify the optimal values of the parameters and overall dimensions of the selected "squirrel"-shaped seeder in order to fully fulfill the tasks set for the seeder, improve the quality of sowing, and reduce the drag resistance of the seeder.

Solution to the problem. To justify the optimal parameters of the planters, their relationship with the soil is carried out taking into account the physical and mechanical properties of the soil, namely their density, resistance to volumetric compaction, resistance to crushing of the soil surface under pressure, and frictional resistance angles.

The parameters of the "Suyri" type of cultivator are as follows: the angle of immersion of the cultivator blade into the soil - α , the radius of curvature of the cultivator blade - R , the angle of sharpening of the nose blade - $2\beta^1$, the constructive sharpening angle of the cultivator - 2β , the resistance of the cultivator to drag. Cultivators with correctly selected parameters perform the tasks assigned to them qualitatively. This also leads to an increase in productivity [16, 17, 18, 19, 20].

The "Suyri" shape is used to determine the angle of penetration of the seeder into the soil and its radius of curvature. The blade of this seeder differs from the blade of other seeder blades. In this case, the width of the blade base is equal to the width of the seeder.

During the movement, weeds, first of all, their roots meet the cultivator blade at a height h above the planting depth, that is, at the surface of the soil. Since the width of the base of the sharpening angle of the blade in the "shovel" type cultivator is equal to the width of the cultivator base, it not only cuts the weed residues, but also pushes them to both sides, opening the way for the movement of the cultivator. If it does not have time to cut, the cultivator pushes them down and passes over them. In other cultivators, the plant residues are only cut with the help of the blade or pushed down, but not pushed in both directions.

Therefore, we divide the normal force N acting on the part of the cultivator blade that meets the soil surface, whether it is weeds or soil particles, into two components, namely the force T and the force R acting along the blade, Figure 1.

$$\text{He is in a state of } T = \frac{N}{\sin \alpha}; P = N \operatorname{tg} \left(\alpha - \frac{\pi}{2} \right) \quad (1)$$

Here α - the angle of immersion of the cultivator blade into the soil, grad.

During movement, $P > F$ must be present to allow the cutting of plant debris by sliding along the blade. In this case

$$P = N \operatorname{tg} \left(\alpha - \frac{\pi}{2} \right) > F = N \operatorname{tg} \varphi \quad (2)$$

Here φ is the angle of friction of the sowing material on the plant residues, degrees. In this case, from inequality (2) we obtain

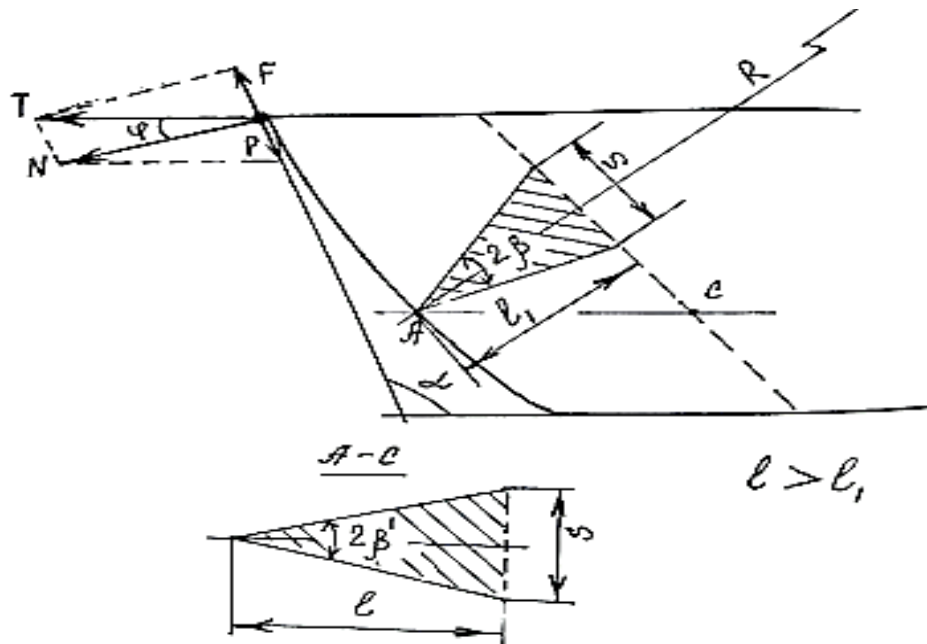


Figure 1. Schemes for determining the constructive and cutting angles of the chisel blade

$$\alpha > \frac{\pi}{2} + \varphi(3)$$

Assuming that in practice $\varphi - 30^\circ \dots 35^\circ$ is between, we get $\alpha > 120^\circ$ greater than. The force T acting in the direction of the two can later be included in the resistance forces.

The radius of curvature of the blade is . This radius is equal to the following according to the shape in Figure 2 [11]

$$R > \frac{N}{1 - \sin \alpha} (4)$$

According to agrotechnical requirements, it is recommended to sow grain seeds to a depth of 3...8 cm [12]. Taking this value as $h_0 = 4$ cm, and assuming that the angle of immersion of the seeder into the soil is $\alpha = 120^\circ$, we determine the value of R using the above expression as $R = 28.5$ cm.

The angle of sharpening of the breast blade $2\beta^1$. This angle is usually determined based on the condition that there is no soil pile in front of the coulter blade and that the soil is scattered to a certain extent in both directions [13, 14]. The sharpening angle determined in this case is called the standard (optimal) angle and is denoted by $2\beta^1_{opt}$.

But the "squirrel" shape is determined by the condition that the angle of sharpening of the coulter blade does not scatter the soil in two directions, but rather gently slides along the side edges of the coulter. In this case, only the deformation of the soil on both sides of the coulter occurs. In this condition, the sharpening angle $2\beta^1_{opt}$ is less than the angle $2\beta^1_{opt}$, i.e.

$$2\beta^1 < 2\beta^1_{opt}$$

Therefore, to determine $2\beta^1_{opt}$, it is necessary to determine the value of . For this, the soil particles acting on the side of the acute angle move at a speed V_a along the direction of the equal action of the friction force and the normal forces [15]. The component of this speed V_k determines that the soil in front of the sides of the acute angle is scattered in both directions so that it does not accumulate and stick. Its expression is defined as follows.

$$V_k = V \frac{\sin \beta_{onm}^1}{\cos \varphi} \cos(\beta_{onm}^1 + \varphi) \quad (5)$$

Here φ is the friction angle, degrees.

To determine the optimal value of the sharpening angle, we take the derivative of the expression with respect to β_{opt}^1 , set the result to zero, and determine the optimal value of β_{opt}^1 for the practical values of the friction coefficients ($\varphi=25^\circ$ and $\varphi=35^\circ$) [9], i.e. . Therefore, the sharpening angle $\beta_{onm}^1 = 54^\circ \dots 66^\circ$ of the “squid” shape can be taken in the range $\beta^1 = 17^\circ \dots 25^\circ$ ($2\beta^1 = 34^\circ \dots 50^\circ$), taking into account that the optimal value of this angle is less than β_{opt}^1 .

The constructive sharpening angle 2β of the cutting edge is determined by the following expression [16, 17].

$$tg\beta = tg\beta^1 \cdot \sin \alpha \quad (6)$$

If we solve this expression with respect to β , we get the following, that is,

$$2\beta = arctg \frac{tg\left(\frac{\pi}{2} - \varphi\right)}{\sin \alpha} \cdot (7)$$

$\alpha=120^\circ$ and $\varphi=35^\circ$ into the resulting expression, we find that the constructive sharpening angle of the blade is $2\beta=54^\circ$.

the seeder *to the planting depth under its own weight* . It is desirable that the seeder sinks to the planting depth under its own weight. If this does not happen, an external force will have to act on it. This will complicate the design to some extent. In previous studies, the vertical pressure force R_s required to sink the seeder to the planting depth was determined, that is, its value is $R_s=25 N$.

If it is possible to lower the seeder to the planting depth by its own weight, then the following condition must be met:

$$Q_e \geq R_s \quad (8)$$

Here Q_e is the weight of the object, N;

Based on this condition, the amount of Q_e is also determined by the condition that the slider sticks to the surface of motion along the surface S_c . In this case, Q_e is determined by the following expression.

$$Q_s = g \cdot \rho_m \cdot S_c \cdot \delta \quad (9)$$

Here ρ_m is the density of the “squirrel” shaped planting material, kg/m^3 ;

g – acceleration of free fall, m/s^2 ;

δ - thickness of the lining material, m.

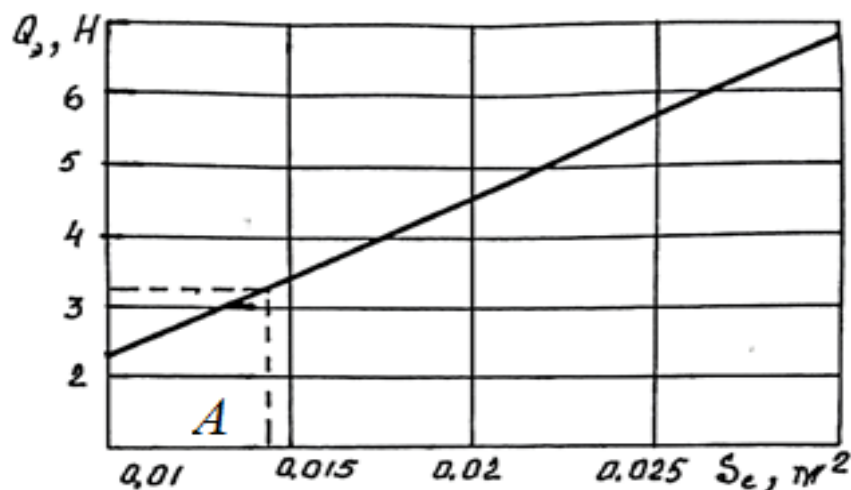


Figure 2. Variation of seeder planting depth relative to the surface of the slipway.

the constructive and physical quantities, namely $\delta=0.03$ m, $g=9.8$ m/s² and $\rho_m=7850$ kg/m³, into the expression, we obtain an expression relating Q_e to S_c .

$$Q_e = 230,8 \cdot S_c \quad (10)$$

expression (10) for the assumed $h_o=0.04$ m is presented in Figure 3 a.

It is clear that as the surface of the slide increases, the weight of the seeder increases. If we consider that the surface area of the selected “squirrel”-shaped seeder slide in contact with the soil surface is $S_c=0.2 \cdot 0.07=0.014$ m², $Q_e=3.2$ N is equal to a value close to (point A). When this is compared with the vertical pressure force R_s determined above and required, it is found that it is less than R_s when the planting depth is $h_o=0.04$ m, i.e. condition (8) is not met. Because when $S_c=0.014$ m², the vertical pressure force required to immerse the seeder to $h_o=0.04$ m is $R_s=25$ N.

Therefore, in order to lower the seeder to the planting depth, it is necessary to use, in addition to its own weight, the weight of the working section between the rows where they are stacked, or the spring force of the parallelogram mechanism.

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