

Article

# Justification of The Dimensions of A Small-Sized Disc Opener

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**Abstract:** A study of existing seed drill designs revealed that they cannot be used for sowing grain crops in open ground in multiple rows. Based on this, a new seeder design was made. To ensure that seed drills fully and efficiently perform their intended functions, their parameters must be substantiated. This scientific article is devoted to substantiate the dimensions of the seeder parameters based on the seeder-to-soil ratio.

**Keywords:** sectional seeder, grain seeds, small-sized disc opener, seeder runner, soil density, runner nose, optimal value, physical and mechanical properties of soil.

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## Introduction

Currently, our Republic lags behind foreign countries in the production of modern sectional seed drills for sowing grain seeds in open fields.

Instead of importing seed drills from foreign country to perform a single process, that will be better be manufacture sectional seed drills using seed drills proposed by researchers, on the one hand, increase farmers' income, and on the other hand, lead to the development of factories producing such seed drills.

The main part of the sowing machines is considered to be seed drills. There are many types of seed drills, they are mainly anchor,

coulter and disc. The dimensions of the existing seed drills are large, they are not suitable for our soil and climatic conditions, and they are expensive, so their use in multi-row sowing of seeds is considered more complicated. For these reasons, there is need to create and conduct experiments with small-sized seed drills designed for sowing grain seeds.

The main part. Based on the above, we are conducting experiments on creating a small-sized disc-shaped hopper. The hopper consists of two parts: a slider and a hopper.

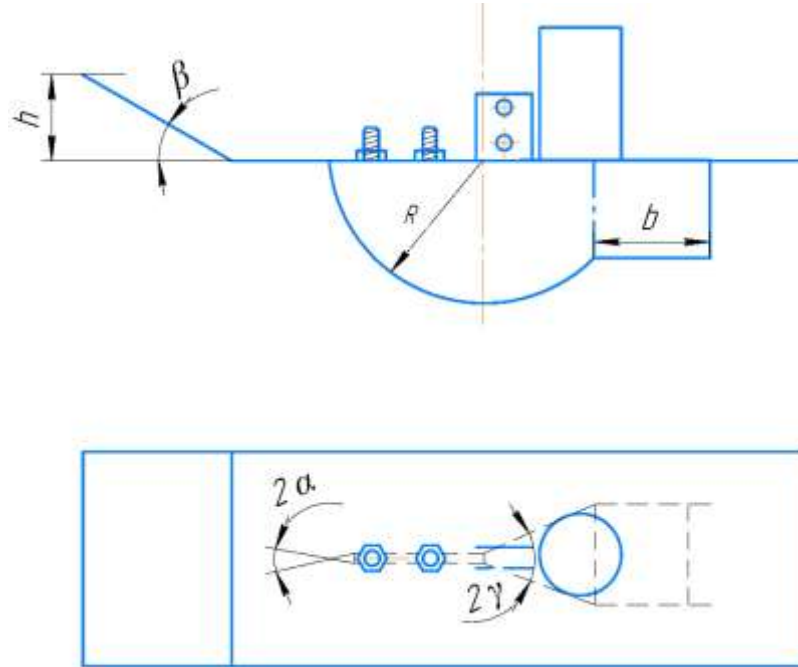


Figure 1. Drawing of a small-sized disc-shaped hopper

Soil compaction by the seed drill. The seed drill must press the soil with its weight for a certain distance in order to reduce the pores caused by the decrease in soil density, compact the soil density to the agrotechnical level required for sowing seeds, crush the clods to a certain extent, and level the surface of the field.

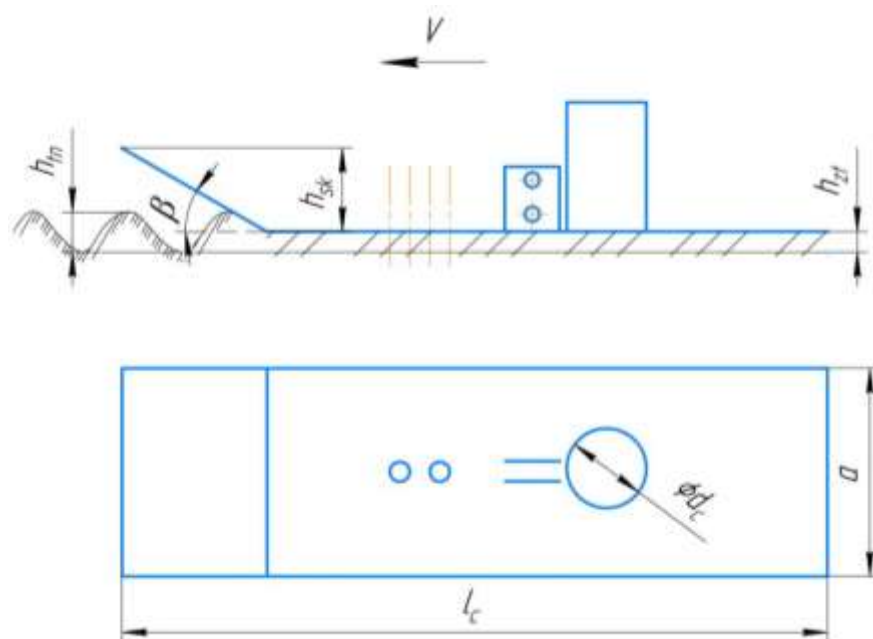


Figure 2. Two-way slider

Based on the results of researchers' work , we show the density of the soil in the field before and after the impact of the seeder with the plowshare.

$$h_{zt} = \frac{h_{on}(p_2 - p_1)}{p_2}$$

in this  $h_{st}$  - height of compacted soil;

$h_{ten}$  - average unevenness;

$P_1$  - Density of uneven soil in front of the plow, gr/cm<sup>3</sup>;

$P_2$  - Soil density after two- stage slip, gr/cm<sup>3</sup>.

Based on the recommendations of scientists and researchers, it shows that the density of the seeded soil layer should be at the agrotechnical level,  $R_2 = 1.20-1.25 \text{ g/cm}^3$  , and the average density of the soil taken from the furrow and spread freely on the ridge should be  $R_2 = 1.05-1.10 \text{ g/cm}^3$  and the average value of the height of the soil unevenness ( $h_{on} = 3.3 \text{ cm}$ ) (1) The result of expression (1) is that the soil compaction of the seedbed should be between  $h_{zt} = 0.40-0.45 \text{ cm}$  [1].

If the results of theoretical studies are considered optimal, it can be concluded that uniform seed germination is ensured if the seeder compacts the soil in which the seeds are sown to the agrotechnical requirements.

The height of the breast of the slipper . The height of the breast of the slipper (see Figure 2) is determined by the scientific conclusions of scientists , based on the condition that the breast of the slipper pushes the soil forward and the soil does not fall beyond the breast [2] and is determined by the following expression

$$h_{sk} \geq (h_{on} + h_{zt}) \cdot (mm),$$

where  $h_{sk}$  is the height of the sliding chest, mm;

$h_{ten}$  -The average value of the height of the soil unevenness ( $h_{tn}$ ), mm;

$h_{zt}$  - Soil compacted under the influence of Ekkich slip.

We combine expression 1 with expression 2 to get the following form. [3]

$$h_{sk} \geq \left[ h_{on} + h_{on} \left( 1 - \frac{P_1}{P_2} \right) \right] \cdot 1, (cm),$$

From expressions (2) and (3) it can be seen that the height of the plowshare for leveling and compacting the soil accumulated in front of the plowshare depends on the height of the soil pile accumulated in front of the working body and its compaction under the plowshare. Taking about account the values ( $R_1 = 1.08-1.1 \text{ g/cm}^3$  ;  $P_2 = 1.2-1.3 \text{ g/cm}^3$  ;  $h_{zt} = 2.0-2.5$ ;  $h_{on} = 3.5 \text{ cm}$ ) determined in the conducted research and analysis, it follows from expression (3) that the height of the plowshare chest is equal or greater than  $h_{sk} = 4 \text{ cm}$ . [3]

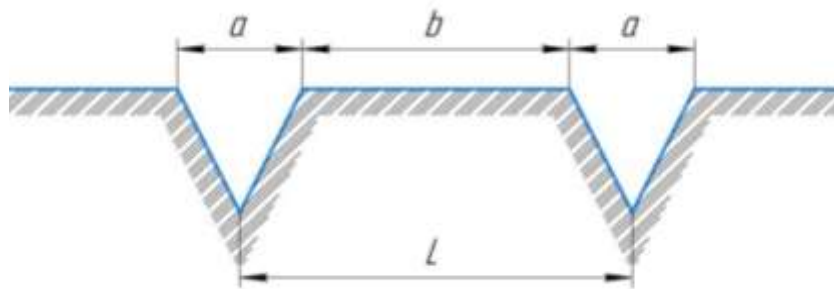
The angle of installation of the plowshare relative to the horizon. The angle of deviation ( $\beta$ ) in the direction of movement of the plowshare (see Fig. 2) should satisfy the condition that uneven soils do not accumulate in front of the plowshare and pass with minimal friction on the working surface, [4]

$$\beta = \frac{\pi}{2} - \varphi$$

where  $\varphi$  is the angle of external friction of the soil, and degrees.

The angle of external friction of the soil depends on the flatness of the surface of the material from which the plow is made, which rubs against the soil.

In the field of irrigated agriculture, the physical and mechanical properties of irrigated soil were studied by Klyonin NI, Sakun VA, GMRudakov, VASergienko, RIBaymetov, FMMamatov, A.Tokhtakoziev, I.Tergashev, M.Muradov and others. The results of the research and the analysis of the results obtained by scientists show that, taking into account the fact that the angle of external friction of the soil, that is, the angle of friction of the soil with the surface of the steel, is on average equal to 43 0 . The result of expression 2.4 is that the angle of deviation in the direction of movement relative to the two-way slide is equal to  $\beta-47 0$  sowing slide. When calculating the width of the sowing slide, it is calculated taking into account the dimensions of the furrow and the furrow when sowing grain[5]. In this case, if we take into account the combination of a 76 cm furrow and furrow, which is currently considered optimal, and taking into account the furrow of 23-26 cm and 50 cm, and taking into account the placement of seeds in the furrow according to the agrotechnical requirements of grain sowing, and taking into account the placement of seeds in the furrow, and if 5 rows of seeders are placed when the rows are 10 cm apart, we will need to make the maximum width of each seeder equal or less than 10 cm.



L – total width between rows; b – width of the ridge; a – width of the plot;

**Figure 3.** Dimensions of the egat and the pushta

$$L = b + \frac{a}{2} + \frac{a}{2} = b + 2\frac{a}{2} = b + a$$

From this we will find the width of the furrow. According to agrotechnical requirements, the width of the field is known, as, 25-26 cm.

$$b = L - a$$

From expression (6), we will determine b and how many pairs can be placed on the board in total, that is it, (pieces)

$$E_{\text{СОИИ}} = \frac{b}{d}$$

From expression (7) will be clear that there are 5 pairs in the pile, if we put the result into the following expression.

$$E_{\text{ЭИИ}} = \frac{b}{E_{\text{СОИИ}}}$$

The width of the two-way slide is derived.

The width of the two-way slide should be 10 cm or less, assuming that the working bodies do not touch each other during operation and not damage the technological process.

$$E_{\text{эп}} \leq 10\text{cm}$$

In this case, it can be concluded that the seeding slides do not touch each other and the soil layer where the seeds are sown is compacted to the full agrotechnical level.

the seeding slide. The length of the seeding slide should be equal to or greater than the length of the seeder. Because the seeder, when performing the technological process, works by loosening the soil around it, and the seeding slide should press the soil and create a density around the seed at the agrotechnical level. Based on the conclusions of scientists who conducted research on leveling-compacting working bodies, we have accepted that the width of the seeding slide should be 10 cm longer than the seeder [6].

Based on theoretical studies and the adopted parameters, they are once again justified by conducting experiments in Chapter 3.

It is known that according to agrotechnical requirements, winter wheat sowing is recommended to be sown to a depth of 3-8 cm, depending on the physical and mechanical properties of the soil and the state of the environment. Based on agrotechnical requirements, we set a planting depth of 4-6 cm. As a result, the seed planting depth  $h_u$  will be maximum 6 cm, and we should adopt a sowing radius  $R$  of 8 cm, adding 2 cm to prevent the seeds from slipping and not being cut off, creating a soft base and retaining moisture. [7].

The main dimensions of small-sized disc type grinders are:

$R_d$  - radius of curvature of a small- sized disk-shaped plate, cm;

$l_t$  - the width of the seed blade, cm;

$2\beta_d$  - constructive sharpening angle of a small-sized disc-shaped cutter, degrees;

$2\beta_e$  - sharpening angle of a small-sized disc-shaped chisel, degrees;

$2b$ -thickness of the seeding blade, cm;

$2\beta$ - opening angle of a small-sized disc-shaped nozzle, degrees;

$\alpha_b$  - the angle of immersion of the seeder into the soil, degrees;

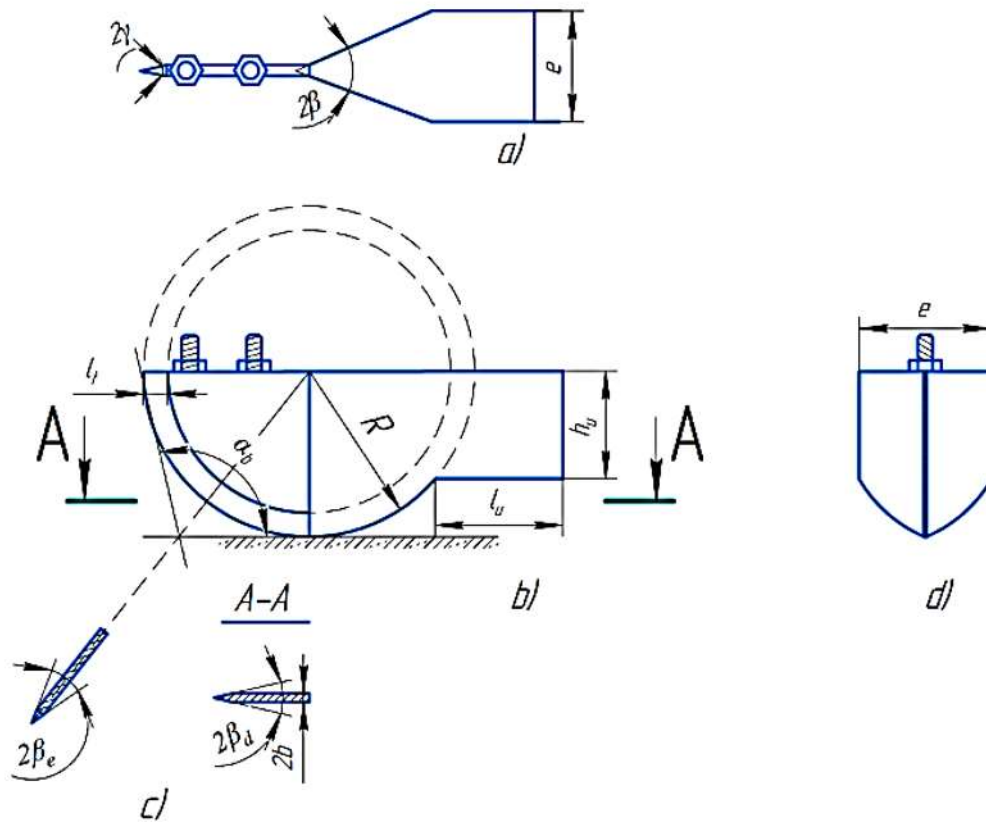
$l_u$ -length of the soil barrier, cm;

$h_u$  - depth of the soil barrier and seeding depth, cm;

$e$ - is the width of the soil barrier, cm.

The dimensions that need to be determined are the depth of seeding, the spacing between rows where the seeds are planted, and the movement of the seeder in the soil, as well as the resistance that occurs.

The angle of entry into the soil and the radius of curvature of a small -sized disc seeder. To a small-sized disc seeder for easily enter thing soil layer and moving even at the specified seeding depth when moving in the field, the seeder blade must be sharp to cut off the plant residues and weeds that come out of it and the uncrushed clods, and to leave the uncut ones under the soil, the seeder's angle of entry into the soil must be steep ( $\alpha_b$ ).

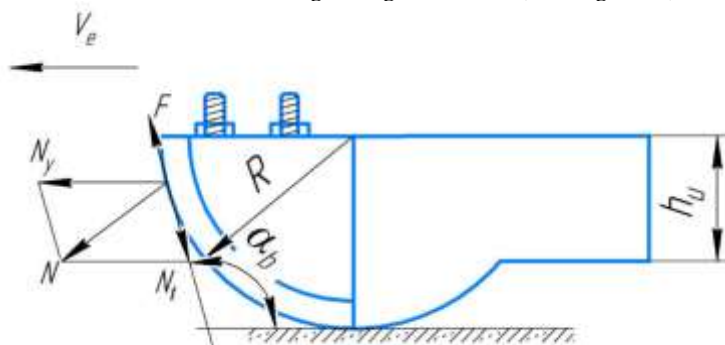


a - top view of the seeding knife; b - side view of the seeding knife; c - actual and design sharpening of the seeding knife; d - front view of the seeder blade;  $h_u$  - seeding depth;  $l_u$  - length of the soil barrier.

**Figure 4:** Main dimensions of a small disc harrow

The angle of entry of a small-sized disc coultter into the soil is the angle between the plane of the plane drawn from the top of the coultter blade to the base along the blade (see Figure 4-b).

When a seed drill blade strikes a solid object (plant root, stump, etc.) other than soil, the upper part of the blade exerts a nominal force  $N$ , and this force is divided into components  $N_o'$  along the direction of the drill and  $N_t$  moving along the blade (see Figure 5).



$V_e$  - direction of seeding;  $F$  - friction force generated on the seed;  $N_y$  - force acting in the direction of seeding;  $N$  - normal force;  $N_T$  - force acting along the seed;  $h_u$  - seeding depth.

**Figure 5.** Scheme of the effect of iodine on the two blades.

$$N_y = \frac{N}{2 \sin \alpha_b}$$

$$N_t = N \operatorname{tg} \left( \alpha_b - \frac{\pi}{2} \right)$$

where  $\alpha_b$  is the angle of entry of the tiller into the soil, degrees.

To ensure that foreign objects that collide with the cutting edge slip and are cut off during the cutting movement,  $N_t$  The friction force generated at the blade must be greater than  $F = N \operatorname{tg} \varphi$ , i.e.

$$N_T = N_{\operatorname{tg}} \left( \alpha_b - \frac{\pi}{2} \right) > F = N_{\operatorname{tg} \varphi}$$

where  $\varphi$  is the angle of friction of the body against the steel, deg.

(12) expression  $\alpha_b$  When we calculate it relative to , it looks like this:

$$\alpha_b > \frac{\pi}{2} + \varphi$$

Fulfilling the condition in expression (13) ensures that the soil is broken and the foreign bodies are cut off by sliding when the two movements are made [8].

$\varphi$  in expression (13) is  $35^\circ$ , which is known in the literature, and substitute it into expression (13), it is determined that the seed drill's soil entry angle  $\alpha_b > 125^\circ$ .

It is known that according to agrotechnical requirements, winter wheat sowing is recommended to be sown to a depth of 3-8 cm, depending on the physical and mechanical properties of the soil and the state of the environment. Based on agrotechnical requirements, we set a planting depth of 4-6 cm. As a result, the seed planting depth  $h_u$  is a maximum of 6 cm, and we have adopted a sowing radius  $R$  of 8 cm, adding 2 cm to prevent the seeds from slipping and not being cut off, creating a soft base and retaining moisture. [9].

As a result, it was determined that  $\varphi$  is equal to  $35^\circ$ ,  $\alpha_b$  is greater than  $125^\circ$ , the seeding depth is up to  $h_u = 6$  cm, and the radius of the small-sized disk-shaped seeder is  $R = 8$  cm g a.

The resistance to pulling a small disc seeder In determining the weight, we found it convenient to divide the seeder into two parts, because both parts have different dimensions. These are the blade part of the seeder that cuts the soil and the barrier part that blocks the seed-carrying part. The sum of these two parts gives the resistance of the seeder to traction.

$$R_e = R_p + R_t$$

where  $R_e$  is the resistance to pulling a small disk-shaped object, N;

$R_e$  - small disc seeder blade resistance, N;

$R_T$  - resistance of a small- sized disc-shaped spring, N;

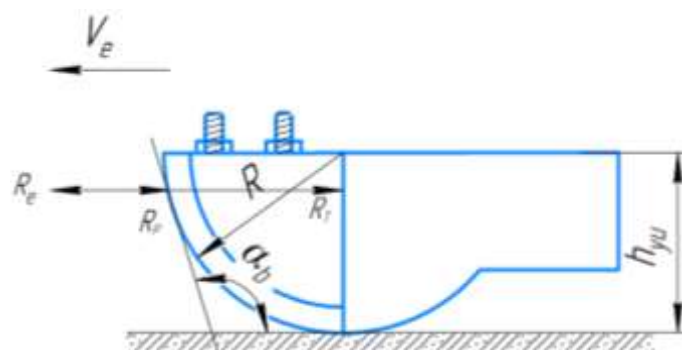


Figure 6. Scheme for determining the resistance to traction of a small-sized disc type drill

When calculating the resistance to pulling a plow blade, we assume that its pulling resistance is directly proportional to the soil compression deformation, and calculate the resistance as follows.

$$R_p = K_p \frac{b^2 h_{yu} (\cos \varphi + \sin \varphi \operatorname{ctg} \beta_e)}{\cos(\beta_e + \varphi)}$$

where  $K_p$  is the coefficient of proportionality, N/m<sup>3</sup> ;

$h_{yu}$  – depth of plowing in the soil, cm;

$\beta_e$  – half the sharpening angle of the blade, degrees.

$$\beta_e = \operatorname{arctg}(\operatorname{tg} \beta_e \sin(\arccos \frac{R - 0,5h_{yu}}{R}))$$

The main part of the drag resistance of a small disc seeder is due to the seeding chamber. It can be determined as following (see figure 6)

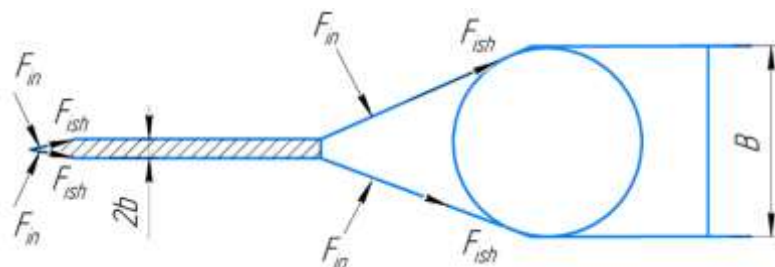


Figure 7. Diagram of forces acting on the blade and the guard of a small-sized disc harrow

$$R_T = F_k + F_{ish} + F_{in}$$

where  $F_k$  is the resistance force of the barrier, N;

$F$  is the friction force, N;

$F_{in}$  – The resistance force, N, resulting from the inertial force resulting from the interaction with the soil.

We determine the resistance force arising from the lateral force acting on the soil seeder barrier as follows

$$F_k = Ph_{yu} (B - 2b) \cos(\frac{\pi}{4} + \frac{1}{2} \arcsin \frac{2b}{B})$$

where  $R$  is the stress resulting from soil crushing, Pa;

$V$  - width of the soil barrier, cm.

We determine the resistance force resulting from soil friction on the seeding pipe barrier as follows:

$$F_{ish} = fPh_{yu} (B - 2b) \cos(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B})$$

where  $f$  is the coefficient of friction between soil and steel.

We define the resistance force arising from the inertia force resulting from the impact of the soil tiller as follows

$$F_{in} = 2Bh_{yu} \sigma V^2 \sin(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B}) \operatorname{tg}(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B} + \omega)$$

where  $\sigma$  is the soil density, kg/m<sup>3</sup> ;

$V$  – speed of movement of the two, m/s;

$\omega$  is the coefficient of soil friction.

( 18), (19) and (20) into expression (14), we get the following expression.

$$R_T = P - h_{yu} (B - 2b) \left[ \cos\left(\frac{\pi}{4} + \frac{1}{2} \arcsin \frac{2b}{B}\right) + f \cos\left(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B}\right) \right] + 2Bh_{yu} \sigma V^2 \sin\left(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B}\right) \operatorname{tg}\left(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B} + \omega\right)$$

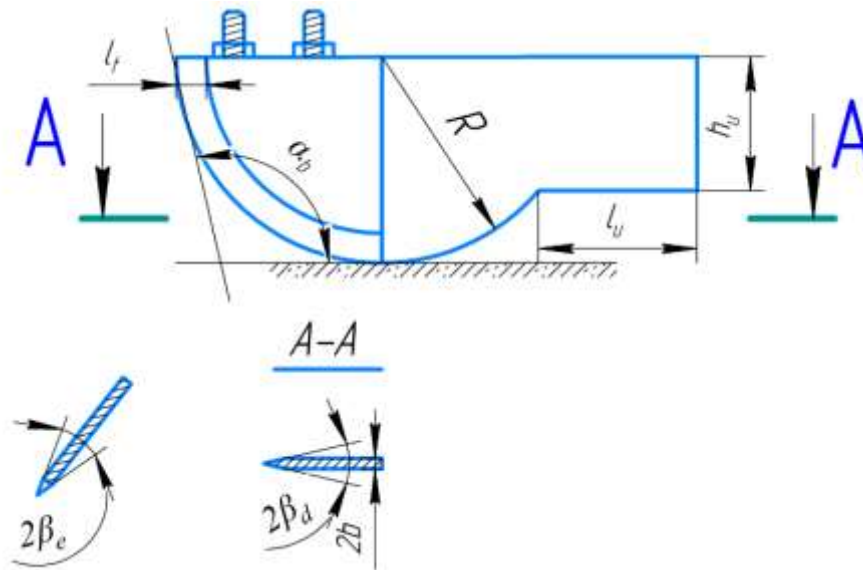
above expressions ( 15) and (21) into expression (14), we find the resistance to the pull of the two wires, R e

$$R_e = \left\{ K_p \frac{b^2 (\cos \varphi + \sin \varphi \operatorname{tg} \beta_e)}{\cos(\beta_e + \varphi)} + P(B - 2b) \left[ \cos\left(\frac{\pi}{4} + \frac{1}{2} \arcsin \frac{2b}{B}\right) + f \cos\left(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B}\right) \right] + 2B\sigma V^2 \sin\left(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B}\right) \operatorname{tg}\left(\frac{\pi}{4} - \frac{1}{2} \arcsin \frac{2b}{B} + \omega\right) \right\} h_{yu}$$

Substituting the corresponding values into this expression,  $K_p = 2 \cdot 10^6 \text{ N/m}^3$ ;  $h = 0.04 \div 0.06$ ;  $\varphi = 35^\circ$ ;  $2b = 0.005 \text{ m}$ ;  $f = 0.4$ ;  $B = 0.03$ ;  $P = 2 \cdot 10^4 \text{ N}$ ;  $R = 0.08 \text{ m}$ ;  $V = 1.1 \div 2.5 \text{ m/s}$ , we find that  $R_e$  is in the range of  $28.64 \div 47.39 \text{ N}$ . This is the resistance to traction of one pair of shoes, and considering that there are five shoes in one section and four sections in the machine, we can also find the total resistance of the shoes.

angles of a small-sized disc-shaped coulter . The coulter blade should encounter little resistance when moving through the soil layer, cut as much as possible the objects that come in its way, and cut the stubble and move it to two sides.

To sharpe angle of a small-sized disc-shaped chisel as  $\beta_e$  and the angle of the disc blade as  $\beta_d$ , and in the construction of this chisel, we can introduce the designations  $2\beta_e$  and  $2\beta_d$ , respectively, since the angles that are on both sides of the workpiece (see figure 8).



$\beta_e$  - the sharpening angle of the drill ;  $\beta_d$  - the sharpening angle of the disk blade.  
Figure 8. Small-sized disc cutter sharpening angles

The following conditions must be met to prevent soil from accumulating in front of a small-sized disc seeder and increasing resistance, and to ensure that the disc blade moves without soil sticking to it.

$$2\beta_e = \frac{\pi}{2} - \varphi$$

(23) from the expression  $\varphi$  We will find the angle of sharpening by setting the value of  $\varphi = 35^\circ$  known from above. As a result, this angle ( $2\beta_e$ ) is equal to  $55^\circ$ .

In the process of cutting the soil of a small-sized disk-shaped coulter, the blade is not perpendicular to the horizon, that is, the angle of entry of the coulter into the soil is not perpendicular to the horizon, and since the part of the coulter structure that is affected by it during the cutting of the soil is disk-shaped, the angle of sharpening of the coulter ( $\beta_e$ ) is different from the angle of the disk blade, that is it,

$$\text{tg}\beta_c = \text{tg}\beta_d \sin \alpha_b$$

from expression (24), ( $\beta_d$ ) it takes the following form

$$\text{tg}\beta_d = \frac{\text{tg}\beta_e}{\sin \alpha_b}$$

Substituting the values of expression (25) into expression (23), we obtain the following expression:

$$2\beta_d = 2\text{arctg} \frac{\text{tg}\left(\frac{\pi - 2\varphi}{4}\right)}{\sin \alpha_b}$$

or by taking into account the values in expression (23), we obtain the following expression:

$$2\beta_d = 2\text{arctg} \frac{\text{tg}\left(\frac{\pi - 2\varphi}{4}\right)}{\cos \varphi}$$

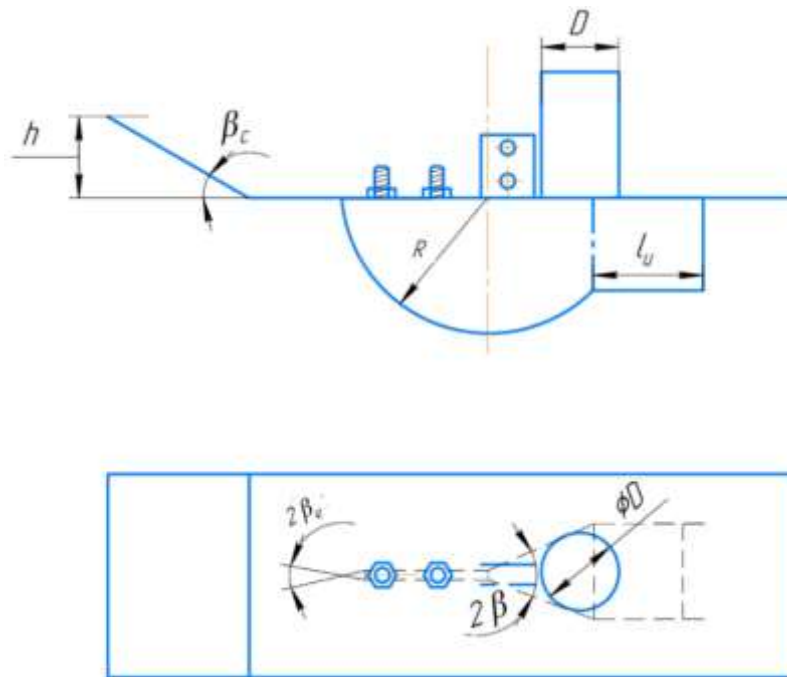
to the above expression  $\varphi$  Assuming the value of, the angle of the disk blade is  $2\beta_d = 65^\circ$  It follows that is equal to.

When determining the size of the soil contact area (2b) of a small-sized disc seeder, the dimensions of other similar types of seeder were analyzed and, taking into account the resistance of the soil during operation,  $2b=5$  mm was assumed.

As a result, it turned out that the optimal values for a small-sized disk-shaped seeder are the sharpening angle  $2\beta_e = 65^\circ$ , the angle of the disk blade  $2\beta_d = 55^\circ$ , and the width of the part of the seeder that interacts with the soil  $2b = 5$ mm.

Small disc seeder Calculation of the diameter of the seed tube. The optimal options for seed tubes are selected for each seed. In this case, the external dimensions of the seed occupy one of the main places, and it is advisable to choose the internal diameter of the seed tube depending on the width, height and length of the seed. The seed tube installed on the seeder should be installed in such a way that the resulting seed does not scatter, but reaches the bottom of the cell through the seeder without touching or clogging it. The seed tube should provide this. Therefore, the seed tube should be as close to the cell as possible. In terms of location, it is located behind the seeder, and its outer wall protrudes beyond the seeder, which directly interacts with the soil and increases resistance. To prevent this, a guard was installed around the seed coulter, which is located at the end of the part where the seeder cuts through the soil. The purpose of this guard is to prevent the soil from hitting the coulter directly, and as the soil slowly deforms, the resistance decreases, and it also protects the coulter[10].

The requirements for the dimensions of the seed chute are that the seeds that are being fed through the seed metering device in the hopper should not accumulate in the seed chute due to the non-vertical nature of the seed chute. Another key factor is the internal diameter of the seed chute, which we theoretically justify based on the requirement that the seeds should not get clogged [11]. (See Figure 9)



**Figure 9.** Diagram of seed drill installation and diameter

Considering that the inner diameter of the seed conductor ( $d_{uo}$ ) is equal to 2 radii ( $r$ ), we find the value of  $r$  from the following expression.

$$\frac{r}{\sqrt{lm}} \geq 1$$

in this case  $r$  - inner radius of the seed tube, mm;

$l$  - seed width, mm;

$m$  - seed length, mm.

From this above expression, we find the radius ( $r$ ).

$$r \geq 4\sqrt{lm}$$

If we find the diameter from this expression (29), then we can use expression (11) taking into account  $D=2r$

$$D \geq 8\sqrt{lm}$$

we can make it look.

### Methodology

This study employs a theoretical-analytical methodology combined with empirical parameter substantiation to determine the optimal dimensions of a small-sized disc opener for grain sowing machines. The research is based on the physical and mechanical properties of irrigated soils typical of Uzbekistan's cotton-growing regions, particularly the Andijan area. Soil moisture content, hardness (MPa), and density ( $g/cm^3$ ) were taken as primary input parameters, measured at two depth intervals: the plow layer (0–30 cm) and the sub-plow layer (30–50 cm).

The main parameters investigated include: (1) the soil compaction depth required under the seeder skid ( $h_{0t}$ ); (2) the height, width, and angle of the skid chest; (3) the angle of entry of the disc coulters into the soil ( $\alpha_0$ ); (4) the radius of curvature of the disc ( $R$ ); (5) the sharpening angles of the disc blade ( $2\beta_e$ ,  $2\beta_d$ ); (6) the traction resistance of the coulters assembly; and (7) the inner diameter of the seed tube [12]. Analytical expressions derived from soil mechanics and tribological principles were used to relate each parameter to measurable soil properties and agrotechnical requirements.

The theoretical derivations follow a two-stage approach. In the first stage, dimensionless geometric and force conditions were established for each design element using established analytical models [13]. In the second stage, numerical values were substituted based on field-measured and literature-reported soil parameters – including soil density  $R_1 = 1.08\text{--}1.10 \text{ g/cm}^3$ , post-compaction density  $R_2 = 1.20\text{--}1.25 \text{ g/cm}^3$ , external friction angle  $\varphi = 35^\circ\text{--}43^\circ$ , and soil stiffness coefficient  $K_0 = 2 \times 10^6 \text{ N/m}^3$  – to obtain practical dimensional recommendations [14], [15].

### Results and Discussion

The theoretical analysis yielded consistent and internally validated results for all seven design parameters. The required soil compaction depth under the seeder skid was determined to be  $h_{0t} = 0.40\text{--}0.45 \text{ cm}$ , confirming that minor soil displacement in the seed bed is sufficient to achieve the agrotechnical density of  $R_2 = 1.20\text{--}1.25 \text{ g/cm}^3$ . This result is consistent with findings reported in earlier studies on sowing implement interactions with irrigated soils.

The geometric parameters of the skid were determined as follows: the chest height must be  $h_0 \geq 4 \text{ cm}$  to prevent soil from overflowing the working body; the chest angle relative to the horizon must be  $\beta \geq 47^\circ$  to minimize friction resistance and prevent soil accumulation; and the chest width must not exceed 10 cm in order to fit five seeders within a standard 50 cm bed width with 10 cm row spacing. These values are in close agreement with experimental data from previous designs of sliding-type seeders developed for row-crop conditions in Uzbekistan [16], [17].

For the disc coupler, the soil entry angle was found to be  $\alpha_0 > 125^\circ$ , ensuring that plant residues and foreign objects are cut off rather than deflected. The seeding depth was set at  $h_0 = 4\text{--}6 \text{ cm}$ , consistent with agrotechnical requirements for winter wheat, and the disc radius was adopted as  $R = 8 \text{ cm}$  with a 2 cm safety margin. The blade sharpening angle was determined to be  $2\beta_e = 55^\circ$  and the disc blade angle  $2\beta_d = 65^\circ$ , both derived from the soil external friction angle  $\varphi = 35^\circ$  [18], [19]. The soil contact width was set at  $2b = 5 \text{ mm}$  based on resistance optimization analysis.

The traction resistance of a single coupler pair was calculated in the range of 28.64–47.39 N at operating speeds of  $V = 1.1\text{--}2.5 \text{ m/s}$ . Since one section contains five coupler pairs and a full machine contains four sections, the total traction resistance of the complete assembly can be derived directly. This relatively low resistance per unit confirms the suitability of the small-sized disc opener for integration into multi-row sectional seed drills without overloading the tractor drawbar.

The inner diameter of the seed tube was theoretically determined using seed dimensions for winter wheat: seed width  $l = 0.27\text{--}0.41 \text{ cm}$  and seed length  $m = 0.23\text{--}0.34 \text{ cm}$ . Substituting these values into the geometric compatibility expression yielded  $D = 2.00\text{--}2.98 \text{ cm}$ , and the inner diameter was set at  $D \geq 30 \text{ mm}$  to accommodate the full range of seed sizes and prevent blockage. This value provides a practical design target that balances seed flow reliability with the structural constraints of the small-sized disc opener [20].

Taken together, the results demonstrate internal consistency: all derived parameters are mutually compatible and satisfy both the theoretical constraints and the agrotechnical requirements simultaneously. The compaction depth, skid geometry, disc angles, traction resistance, and tube diameter all fall within ranges that support reliable seed placement at 4–6 cm depth with minimal soil disturbance outside the seeded row. The analytical approach proves sufficient for the primary dimensioning stage, though experimental validation under field conditions is recommended as a subsequent step to refine the parameter values for specific soil types and crop varieties.

### Conclusion

In conclusion, it was theoretically determined that in order to get seedbed skimmer to compact the soil layer where the seeds are sown to the agrotechnical level and create a favorable soil climate for seed germination, it is optimal to sink the skimmer into the soil between  $h_{st} = 0.40\text{--}0.45 \text{ cm}$ , the height of the skimmer's chest should be equal to or greater than  $h_{st} - 4 \text{ cm}$ , the angle of deviation of the skimmer's chest relative to the horizon should be  $\beta \geq 47^\circ$ , the width of the skimmer's chest should be equal to or less than the width of the skimmer  $\leq 10 \text{ cm}$ , and the length should be 10 cm longer than the skimmer.

It is known that according to agrotechnical requirements, winter wheat sowing is recommended to be sown to a depth of 3–8 cm, depending on the physical and mechanical properties

of the soil and the state of the environment. Based on agrotechnical requirements, we set a planting depth of 4-6 cm. As a result, the seed planting depth  $h_u$  is a maximum of 6 cm, and we have adopted a sowing radius  $R$  of 8 cm, adding 2 cm to prevent the seeds from slipping and not being cut off, creating a soft base and retaining moisture.].

As a result, it was determined that  $\varphi$  is equal to  $35^\circ$ ,  $\alpha$  is greater than  $125^\circ$ , the seeding depth is up to  $h_u = 6$  cm, and the radius of the small-sized disk-shaped seeder is  $R = 8$  cm.

Substituting the corresponding values into this expression,  $K_p = 2 \cdot 10^6 \text{ N/m}^3$ ;  $h = 0.04 \div 0.06$ ;  $\varphi = 35^\circ$ ;  $2b = 0.005 \text{ m}$ ;  $f = 0.4$ ;  $B = 0.03$ ;  $P = 2 \cdot 10^4 \text{ Pa}$ ;  $R = 0.08 \text{ m}$ ;  $V = 1.1 \div 2.5 \text{ m/s}$ , we find that  $F$  is in the range of  $28.64 \div 47.39 \text{ N}$ . This is the resistance to traction of one pair of shoes, and considering that there are five shoes in one section and four sections in the machine, we can also find the total resistance of the shoes.

(30), we put the numerical values, i.e.  $l = 0.27 \div 0.41 \text{ cm}$  and  $m = 0.23 \div 0.34 \text{ cm}$ . As a result, when these values are put into expression (30) and calculated, we get  $D = 2.00 \div 2.98 \text{ cm}$ . We determine that the inner diameter of the seed conductor is equal to or greater than 30 mm, taking into account the maximum values of the seeds.

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