

Parameters of the robe roller for soil preparation

Asror Kiyamov^{1*}, *Tura Razzakov*¹, *Sanjar Toshtemirov*¹, *Obid Khamroev*¹, and *Gayrat Ergashev*¹

¹Karshi Engineering Economics Institute, Karshi, 180100, Uzbekistan

Abstract. Studying the parameters of a ridge-forming roller for soil preparation is an urgent task in agricultural technology. This paper examines the influence of various parameters of ridge-forming rollers on the quality of soil tillage and its preparation for sowing. The main parameters are analyzed, such as the shape of the rollers, the depth of cultivation, the angle of inclination of the ridges, as well as the influence of their combinations on the structure of the soil and its air-water regime. The effectiveness of various configurations of ridge-forming rollers is assessed in order to optimize the process of preparing the soil for further agrotechnical measures. The results obtained can be used to develop recommendations for the selection of optimal parameters of ridge-forming rollers depending on the specific conditions of the soil and climatic region.

1 Introduction

Agriculture, as an important area of human activity, requires constant improvement of soil cultivation methods to increase productivity. Preparing the soil for planting plays a critical role in successful plant growth and yield.

One of the key elements of this process is the use of specialized coil circuits that help create optimal conditions for seed germination [1-3].

In this article, we will look at various coil designs and study their characteristics in detail to achieve the best results. One of the key elements in this process is the ridge roller with elastic rods. This tool not only makes it easier to prepare the soil for sowing, but also helps improve its structure and water permeability. Justification of the correct parameters of such a tool becomes an extremely important aspect of agricultural practice [4].

2 Materials and methods

In modern agricultural technologies, elastic cable rods have become popular working elements for reels used in preparing the soil for sowing. This type of working elements are flexible structures consisting of cables connected to each other, forming a spring-like structure [5]. To determine the optimal type of working elements, the purpose of cultivation and the type of soil should be taken into account. Different types of working bodies may

* Corresponding author: bobur160189@mail.ru

require different types of energy to overcome soil resistance [6]. Calculation of this parameter involves engineering studies and testing using specific soil characteristics. Elastic cable rods are an innovative solution that combines flexibility, strength and efficiency in soil preparation, providing optimal conditions for planting crops. In this regard, they have the peculiar features of elastic cable rods [7-9]:

Adaptability to soil conditions:

Elastic rods have the ability to adapt to different types of soil. Their flexibility allows them to effectively penetrate different layers of soil, ensuring uniform loosening.

Reducing soil compaction:

Flexible spring-like operating elements minimize the risk of soil compaction, maintaining its structure and providing better ventilation and permeability.

Weed control:

Elastic rods can effectively penetrate the soil and destroy weeds through mechanical action on their roots.

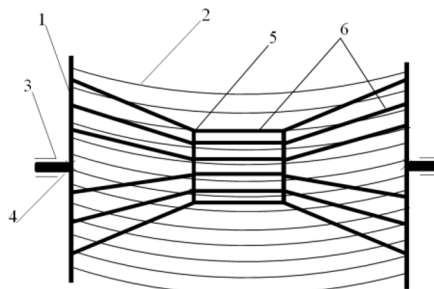
Energy Saving:

The flexible material of the cable absorbs part of the shock load upon contact with stones or roots, which reduces the load on the tractor and reduces fuel consumption [10].

Before we begin to justify the parameters of the ridge-forming roller, it is necessary to clearly define the goals that we want to achieve. The main objectives of such a tool are to improve the structure of the soil, its ventilation, and also to create optimal conditions for seed germination. The use of elastic rods as part of a ridge-forming roller is due to several reasons. First, they provide a more even distribution of soil pressure, preventing soil compaction. Secondly, the elastic rods are able to adapt to different types of soil, providing more efficient processing.

Parameters of the ridge former roller:

- Length of rods: The optimal length of rods depends on the depth of tillage. Rods that are too short may not reach the required depth, and rods that are too long may create unnecessary resistance.
- Rod diameter: The diameter of the rods also affects the depth of penetration into the soil. It should be sufficient for effective operation, but not so large as to create unnecessary resistance.
- Distance between rods: The optimal distance between rods determines the degree of impact on the soil. Rods that are too close can lead to compaction, and rods that are too far away can lead to uneven processing.



1-support disks; 2-elastic rods; 3-sleeve; 4-axis; 5-small disk; 6-rigid rods

Fig. 1. Diagram of a ridge-forming roller for ridge preparation.

In the middle, at a certain distance, two small disks 5 are installed symmetrically to each other, freely located relative to the axis. The small disks are connected to each other and the large disks by a welded joint using rigid rods 6, while between the small and large disks the

rigid rods are welded, forming the shape of a truncated cone. Elastic rods 2 are passed through the holes along the perimeter of the Disk diameter.

During the movement of the ridge-forming roller, the disks are immersed in the side parts of the ridge to a certain depth, while the elastic rods are also immersed in the ridge layer. Elastic rods installed along the rim of the disk, when rotating along the ridge, crush soil lumps and completely loosen it along the entire perimeter of the ridge section, i.e. its top and slope.

3 Results and Discussions

Determining the optimal bar spacing for a ridge roller depends on several factors, including soil type, cultivation goals, and seeding requirements. However, there is a basic approach for determining the distance between bars.

Let (D) be the distance between the bars. The following expression can be used to determine this distance:

$$D = K \cdot \sqrt{A} \quad (1)$$

Where: (D) - distance between bars, (K) - coefficient taking into account the characteristics of the soil and cultivation, (A) - area of influence of one rod.

Determination of coefficient (K): This coefficient depends on many factors such as soil structure, soil moisture, and the type of ridge roller used. The coefficient (K) can be determined by analyzing the results of preliminary studies or experimental data.

Determination of the area of influence of one bar (A): The area of influence of one bar depends on its length, shape and angle of inclination. This can be calculated using geometric formulas or the results of experimental observations.

However, it should be noted that the specific values of the coefficient (K) and area of influence (A) will depend on the specific soil conditions and treatment requirements.

Bar Angle: Bar angle affects the tool's ability to penetrate the soil. The optimal angle ensures efficient operation with minimal resistance.

Calculation of the angle of inclination of the rods of the ridge-forming roller can be performed based on some physical and agrotechnical considerations. The optimal angle of inclination ensures effective penetration into the soil and minimal resistance. Let's look at the basic formula for calculating the angle of inclination of rods [1]:

$$\text{tg}(\beta) = h/L \quad (2)$$

Where: (β) - angle of inclination of the rods, (h) - depth of penetration of rods into the soil, (L) - length of the rod.

To determine the optimal angle of inclination, let's consider the following factors:

Soil penetration depth (h):

Penetration depth depends on soil type and seeding requirements. Preliminary research and experimental data can be used to determine the optimal depth.

Rod length (L):

The length of the rods also depends on the type of soil and processing tasks. Long rods can be effective in deep soil, but they must be strong enough to withstand the load.

The substantiation of the parameters of the ridge former roller includes the following design indicators:

B_k – interdisk distance, m; D_{cp} – average diameter m; D_{ok} – disk diameter, m; D_o – final diameter of the disk, m; L_n – rod length, m.

The working width B_k (Figure 2) of the ridge-forming roller is determined depending on the height of the ridge surface being processed. At the same time, based on numerous studies, we accept that the external shape of the unevenness of the ridge at a given row spacing differs slightly and is described in the form of a sinusoid.

$$Y = h_{cp} \sin(x \pm e) \quad (3)$$

Where h_{cp} – is the amplitude of the sinusoid, depending on the depth of the irrigation furrows; H_{ao} – average ordinate of field unevenness; e – phase shift of the sinusoid, x – change in the abscissa of the sinusoid.

It is known that the width of the upper part of the ridge b_{sh} should be 160-170 mm. During the sowing process, the tops of the ridges are cut off, after which the profile of the ridge takes the shape of an isosceles trapezoid.

$$H_1 = H_{ao} - H_3. \quad (4)$$

Then the height of the H_3 ridge after leveling will be equal to

$$Y_3 = H_3 = H_{ao} \sin \frac{b_{sh} \pi}{B_M}. \quad (5)$$

We have:

$$AB = b_{sh} \quad (6)$$

Where B_M - row spacing.

Substituting the value of b_{sh} according to expression (6) into expression (5) we have:

$$H_3 = H_{ao} \sin \left\{ b_{sh} \frac{\pi}{B_M} \right\}. \quad (7)$$

$$B_k = b_{sh} + 2B_3 = b_{sh} + 2H_2 \operatorname{ctg} \beta. \quad (8)$$

We have:

$$\operatorname{ctg} \beta = \frac{x_1}{AE} = \frac{x_1}{H_3}. \quad (9)$$

Substituting the value of x_1 and H_3 according to expressions (6) and (7) into expression (9) we have:

$$\operatorname{ctg} \beta = \frac{b_{sh}}{H_{ao} \sin \left[\left(\frac{b_{sh}}{B_M} \right) \pi \right]}, \quad (10)$$

Then:

$$B_k = b_{sh} + 2H_2 \frac{b_{sh}}{H_{ao} \sin[b_{sh} / B_M] \pi}. \quad (11)$$

With $B_M=90$ sm, $b_{sh}=16$ sm, $H_2=12-15$ sm, according to expression (11), the working width of the ridge former roller is $B_k=50-60$ sm [8].

According to the diagram shown in Figure 2, the length L_n of the elastic rods of the ridge former is determined by the following formula:

$$L_n = b_{sh} + [2H_3] / \sin \beta. \quad (12)$$

Substituting the value of β according to expression (9) into expression (12) we have:

$$L_n = b_{sh} + [2H_3] / \left\{ \sin \arccotg \frac{b_{sh}}{H_{ao} \sin[b_{sh}] \pi} \right\}. \quad (13)$$

From this expression it is clear that the length of the elastic rods is influenced by the row spacing and the height of the processed part of the ridge H_3 .

With $B_M=90$ sm, $b_g=16$ sm, $H_3=22-25$ sm, according to expression (13), the length of the elastic rods of the ridge-forming roller is $L_n = 65-70$ sm [8].

The ridge former roller is characterized by the following parameters: the diameter of the middle part D_{cp} , the outer diameter D_d , the diameter D_{ok} , along the perimeter of which elastic rods on the disk are located, and the small diameter D_M , b_t the thickness of the discs and L_k the length of rigid rods installed at an angle to the horizontal axis of the roller.

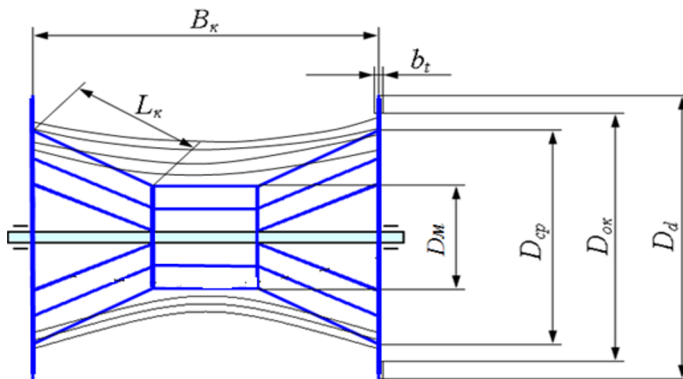


Fig. 2. Scheme for determining design diameters ridge-forming roller.

First, we determine the diameter of the middle part of the ridge-forming roller that interacts with the ridge. We determine this diameter from the condition of easy rolling of the elastic rods of the roller over the lumps located on the surface of the ridge, i.e. at the same time, due to the specific pressure of the elastic rods on the lumps, they are destroyed. The diameter of the middle part of the ridge-forming roller is determined by the following formula

$$D_{cp} \geq hctg^2 \frac{\varphi_1 + \varphi_2}{2} \quad (14)$$

Where h – is the overall size of the lump, cm; φ_1, φ_2 – angles of friction between the lump and the rod and soil.

According to Figure 2 the diameter of the circle D_{ok} is determined by the following formula:

$$D_{ok} \geq hctg^2 \frac{\varphi_1 + \varphi_2}{2} + \frac{0,5(B_k - b_{sh})}{ctg\beta}. \quad (15)$$

The diameter of the disk is determined by the following formula[18]:

$$D_o \geq hctg^2 \frac{\varphi_1 + \varphi_2}{2} + \frac{0,5(B_k - b_{sh})}{ctg\beta} + 2h_{nao} \quad (16)$$

Where h_{nao} – is the depth of immersion of disks into the soil, determined experimentally, mm. From the analysis of expressions (14), (15) and (16) it follows that the diameters D_{cp} , D_{ok} and D_o depend on the width B_k , the size of the lumps h , their angles of external and internal friction φ_1, φ_2 , the width of the top of the ridge b_{sh} and the angle of inclination of its slopes to the horizon φ_g .

With $\varphi_1=30^\circ$, $\varphi_2=40^\circ$ $h=100$ mm, $b_{sh}=160$ mm, $H_z=270$ mm and $\varphi_g=40^\circ$, $h_{nao}=100$ mm, as well as substituting the above value of B_k into expressions (14), (15) and (16) we get that $D_M=200$ mm $D_{ok}=550$ mm and $D_{\bar{d}}=600-750$ mm.

4 Conclusions

Justification of the parameters of a ridge roller with elastic rods is a complex and multifaceted process that requires a deep understanding of the physical and agronomic aspects.

Effective parameters will depend on specific soil conditions, climate and planting requirements. Systematic research and adaptation of parameters will help agricultural enterprises to improve the quality of soil cultivation and, consequently, increase the level of yield.

The width between the support disks of a ridge-forming roller for soil cultivation is a complex and multifaceted process. It should take into account not only the physical properties of the soil, but also economic factors. Working with equipment manufacturers, using recommendations and conducting field research will help achieve optimal tillage results and increase agricultural yields.

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