

Research Article

Justification of the Track Resistance of the Working Bodies of the Potato Planting Machine

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Abstract

In this study, the authors investigated the tractive resistance forces that arise during the operation of a potato planting machine equipped with a disc-type working body. This working organ simultaneously performs two essential functions in the planting process: it opens a furrow in the soil for placing potato seeds and forms a ridge that covers and protects the seeds after planting. The analysis was carried out by taking into account a number of interrelated factors that directly influence the magnitude of draft resistance. These include the total mass of the potato planting machine, the physical and mechanical characteristics of the soil (such as density, hardness, and moisture content), as well as the geometrical parameters of the cultivated soil cross-section. The configuration and structural design of the working part, the machine's coverage width, the planting depth, and the forward speed of operation were also considered as significant variables. The findings demonstrate that the draft resistance of the potato planter is not determined by a single factor but results from the combined effects of machine design, soil conditions, and operational parameters. In particular, the resistance force depends heavily on the machine's mass, the width of coverage, and the performance of its various working components, including the furrow opener, the seeding mechanism, and other auxiliary parts that contribute to the planting process. Moreover, planting depth and soil texture strongly influence the overall resistance encountered during field operation. Based on the calculations and analysis presented, it was established that when the machine operates at forward speeds ranging from 4 to 6 km/h, the tractive resistance values vary between 1.702 kN and 2.823 kN. These results provide important insights into the design optimization of potato planting machines and offer practical guidance for selecting tractors of suitable power, improving energy efficiency, and ensuring reliable field performance under varying soil and load conditions.

Keywords

Mutual Inclination Angle, Intersection Angle, Furrow Width, Tractive Resistance, Furrow Bottom, Paired Discs, Rippers, Furrow Opener, Power, Plowing Depth, Soil Cross-section, Working Parts

1. Introduction

On a global scale, potato growing has long been considered the main agricultural product. Considering that currently 16.8 million hectares of land are sown with potatoes, and the volume of harvested crops increases by 2-3% annually [1], the

creation and implementation of a new design of a resource-saving potato planter is an urgent task.

In this regard, in potato farming, the use of a potato planter equipped with high-performance and high-consumption

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working parts is becoming increasingly important, allowing for simultaneous sowing of potato seeds with complete fertilizer application and the formation of ridges and furrows.

In the world, scientific research is being conducted aimed at creating an improved design of a potato planter equipped with technologies and improved working parts for preparing the soil for sowing potato seeds at the required level, sowing seeds at a specified depth and interval, forming ridges and furrows at the required level. In this regard, based on potato planting methods, special attention is paid to the development of new designs of potato planting machines, the substantiation of their working parts, technological processes, and parameters [2-5].

2. Experimental Procedures

Based on the foregoing, based on the analysis of the designs of potato planting machines and the analysis of the working bodies of potato planting machines, a design of a potato planting machine equipped with a simple design, convenient in use, ensuring the required level of planting quality, a disc working body for creating a ridge for planting potato seeds and creating a ridge for planting potato seeds was developed.

It consists of a frame (1), suspensions (2), a hopper (3), support wheels (4), an acute-angle opener (5), a disc dispenser (6), a seed conveyor (7), a disc soil burier (8), a gearbox (9), and a chain drive (10) shown in Figure 1. [6]

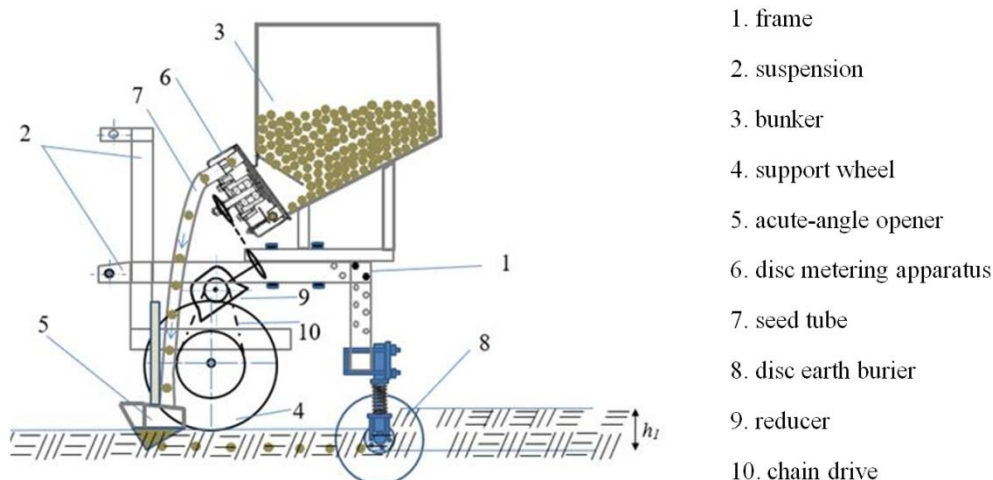
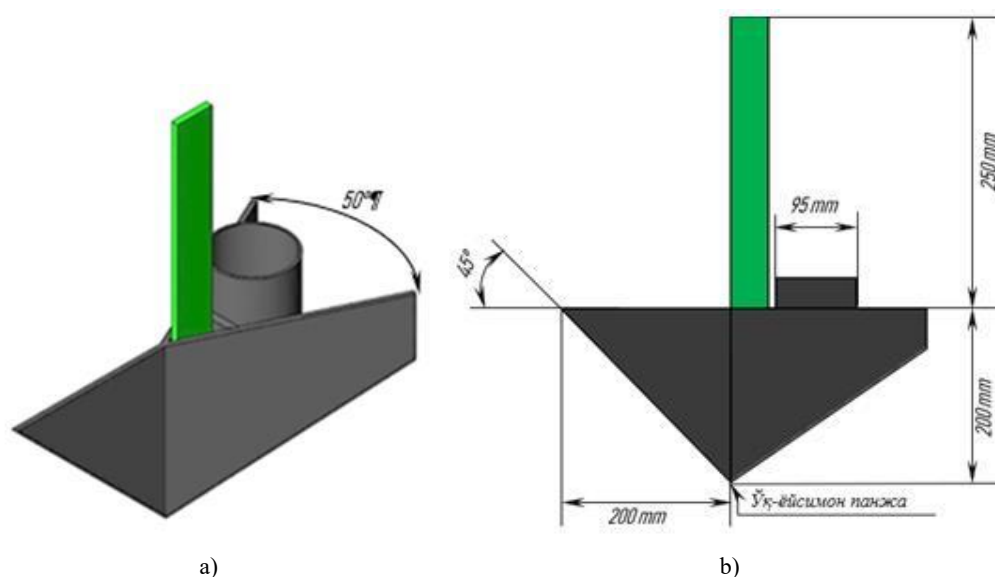
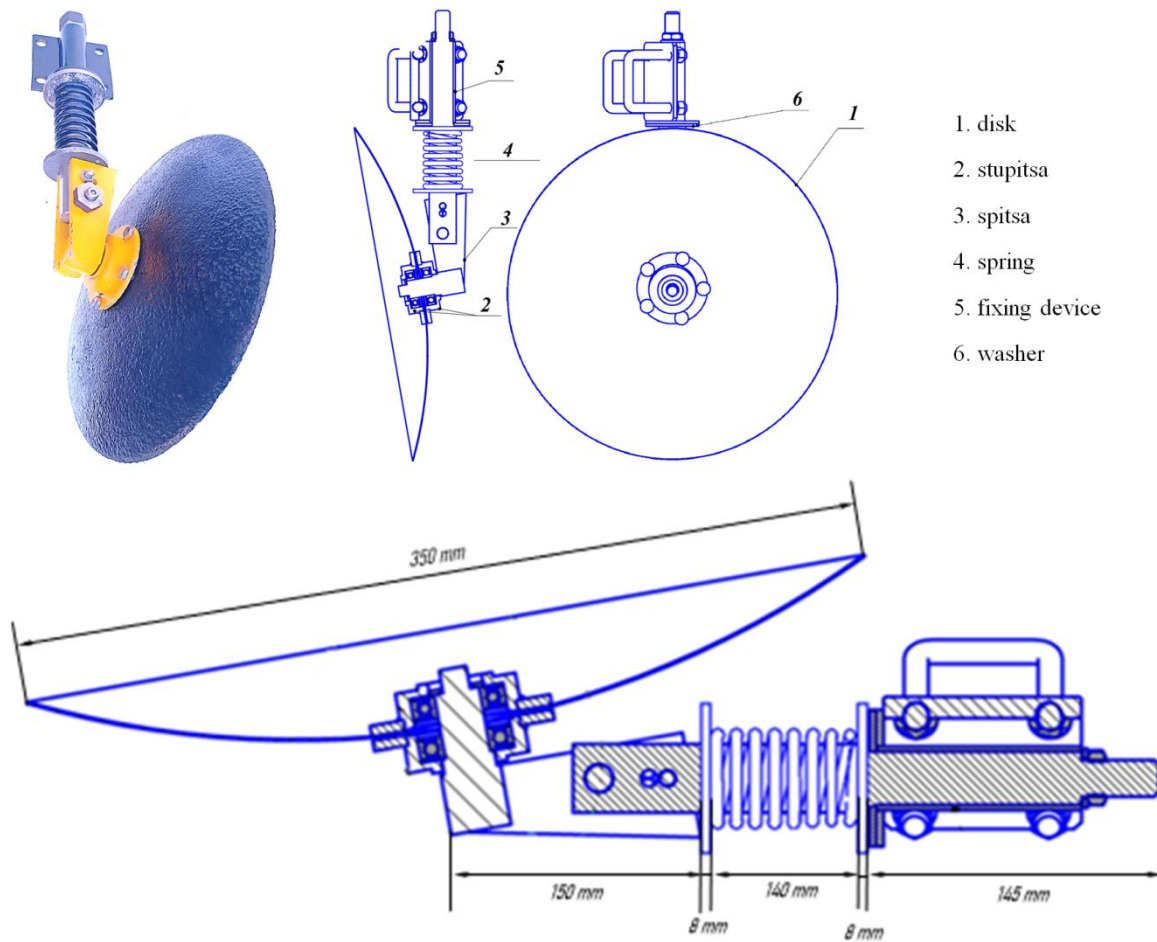


Figure 1. Design and technological scheme of the improved potato planter.

The design of the working part with a disc, which creates a groove for potato seeds and forms a ridge by covering the seeds, is shown in Figures 2 and 3.





3. Research Results and Discussion

When substantiating these parameters, the calculation of the tractive resistance forces acting on them is of great importance. Therefore, in these studies, we will consider the draft resistance of the potato planter, equipped with the proposed working part [7].

According to the rational formula of V. P. Goryachkin, the tractive resistance of a potato planter is equal to:

- 1) by total weight;
- 2) physical and mechanical properties of the soil;
- 3) to the cross-section of the cultivated soil;
- 4) the shape of the working part, the width of coverage, and the depth of plowing;
- 5) depends on the speed of the potato planter.

At the same time, when calculating the tractive resistance of each working element, it is necessary to take into account the change in the technological properties of the soil after the passage of the previous working element.

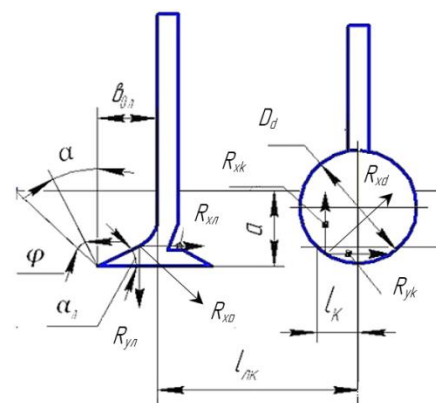
Determining the tractive resistance of a potato planter allows you to choose the necessary tractor for its aggregation.

The total tractive resistance of a potato planter can be determined as the sum of the tractive resistances of individual

working bodies. The total draft resistance of the potato planter, equipped with the working parts we propose, can be expressed as follows according to the diagram in Figure 4:

$$R_{xc} = 2R_{xp} + 2R_{xd} \quad (1)$$

where: R_{xp} - groove opener's draft resistance, N; R_{xd} - disk drag resistance, N;



4. Calculation of the Draft Resistance of the Groove Opener

First, using the formula of V. P. Goryachkin, we express the draft resistance of the seed groove opener as follows.

$$R_{xp} = k \cdot a_n \cdot b_n \quad (2)$$

When creating a groove depth of 8-10 cm, the relative resistance of the soil is $k=80 \dots 130 \text{ N/m}^2$ [8], with a width of 10 cm.

Then, according to expression (2), the draft resistance of the groove opener varies from 8 N to 13 N, respectively.

5. Calculation of Disk Traction Resistance

The draft resistance of the disk, according to the diagram of the interaction of the disk with the soil, is as follows:

$$R_{x0} = k_0 \cdot a_0 \cdot b_0 \quad (3)$$

where: k_0 - specific resistance of soil, kN/M^2 (15.... 25) [9];
 b_0 - disk-formed ridge width, m.

$$b_0 = C_0 \cdot \sin \beta \quad (4)$$

The length of the chord of the disk's circumference is determined by the following expression.

$$C_0 = 2 \cdot \sqrt{R^2 - (D_0 - a_0)^2} \cdot \cos \beta \quad (5)$$

Substituting the value C_d from expression (5) into expression (4) [10, 11].

$$b_0 = 2 \cdot \sqrt{R^2 - (D_0 - a_0)^2} \cdot \sin \beta \quad (6)$$

Substituting expression (6) into expression (3):

$$R_{x0} = 4 \cdot k_0 \cdot a_0 \cdot \sqrt{R^2 - (D_0 - a_0)^2} \cdot \sin \beta \quad (7)$$

With this expression, it is possible to determine the tractive resistance of the disk, taking into account the coefficient (k_d) determining the soil properties and the technological indicators of the formed furrow and.

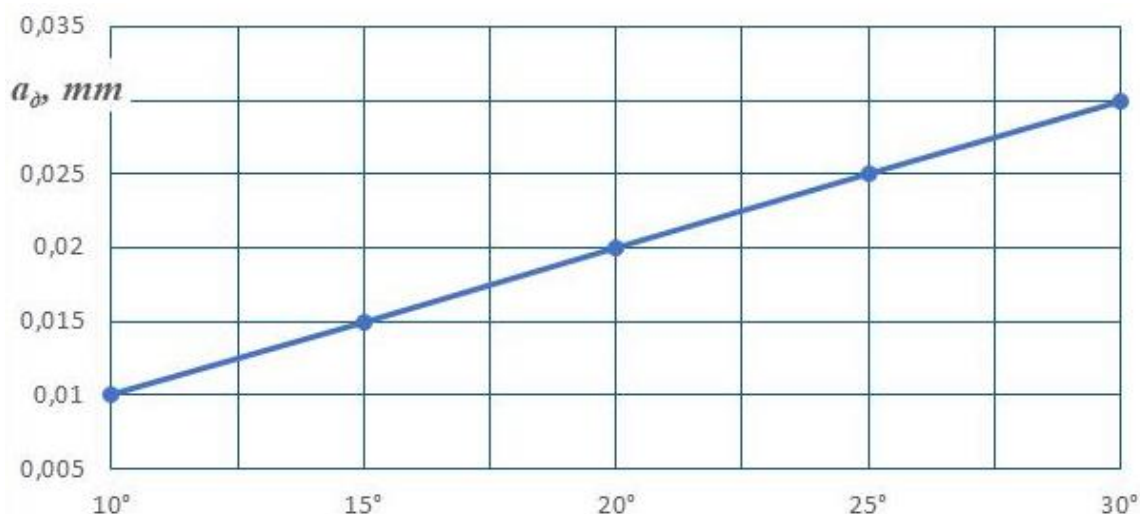
When the radius of the disk changes from 17.5 cm to 22.5 cm, $a_d=32.65$ cm, $b_d=15$ cm, $k_d=15000\text{N/m}^2$, respectively, according to expression (7), the tractive resistance of the disk changes from 1.694 kN to 2.81 kN [12, 13].

According to the justified design scheme of the potato planter, when the width of the groove opener for seeds is, the diameter of the disk is, and the angle of attack is β , the depth of movement of the disk is determined by formula (5).

According to the justified design scheme of the potato planting machine, when the width of the seed opening is $b_n=2b_d$, the diameter of the disc is D_d , and the angle of attack is β , the depth of the disc movement is determined by the following expression according to formula (5).

$$a_0 = R + \sqrt{R^2 - \frac{b_0^2}{4 \sin \beta}} \quad (8)$$

$D_d=0.35$ m; $\beta=10^\circ \dots 30^\circ$; The change in the disk penetration depth when $\beta = 10^\circ$ to 30° for an attack angle of $b_n=0.1$ m is shown in Figure 5.



An increase in the disk's angle of attack leads to an increase in the components of the disk's drag resistance. In this regard, based on the calculation results, we obtain the attack angle of the disks $\beta=30^\circ$, their depth $a_d=32.65$ cm. With such design and technological parameters, the disk tension resistance varies from 1,694 kN to 2,81 kN. Thus, according to expression (1), the draft resistance of the potato planter, equipped with the proposed working part, will be from 1,702 kN to 2,823 kN [14, 15].

6. Conclusions

In conclusion, it can be said that the tractive resistance of the potato planter depends on its mass, width of coverage, resistance of the working parts for sowing, making furrows, burying, and other parts, planting depth, soil properties, and at a speed of 4-6 km/h, the tractive resistance ranged from 1.702 kN to 2.823 kN.

Abbreviations

R_{xp}	Groove Opener's Draft Resistance
R_{x0}	Disk Drag Resistance
k_0	Specific Resistance of Soil
b_0	Disk -Formed Ridge Width

Author Contributions

Yuldashev Odiljon Tashpulatovich is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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Biography



Yuldashev Odiljon Tashpulatovich is working on his doctoral research and contributes to the field through his scientific participation. In 2007, he graduated from Kokand State Pedagogical Institute, and in 2009, from Kokand State Pedagogical Institute with a master's degree in Labor Education Methodology. In recent years, he has participated in a number of international scientific cooperation projects.

Research Field

Yuldashev Odiljon Tashpulatovich: Helical Gear Transmission with Elastic Elements, Applied Mechanics, Machine Design and Analysis, Dynamic Behavior of Mechanical Systems, Torsional and Axial Vibration Analysis, Structural Optimization in Mechanical Drives.