The impact of the disc roller's diameter on the combined machine's performance during the sequential processing of freshly planted soil


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Abstract. When planting fields free of wheat or soybeans in the public conditions, the top layer of soil containing plant residues and weeds is turned over and thrown into the bottom layer, creating numerous gaps and irregularities in the planted field. Thus, when preparing freshly ploughed fields for planting, the soil particles left behind by the ploughed bodies ought to be compacted, compacted, and leveled. Based on the aforementioned, the Indian Institutes of Agriculture and Agricultural Technology and the Indian Institute of Mechanical Engineering have developed an industrial version of the combined machinery used in the preparation of new arable land for planting. The article describes the impact of the diameter of these combined machine dissection rollers on the device's performance and indicates that the diameter of the combined machine rollers should be between 415 and 490 mm to ensure quality processing at the necessary level with low energy consumption on available land.

1 Introduction

Particular attention is paid to lowering the amount of labor and energy used in agricultural production, conserving resources, building agricultural crops on the foundation of advanced technologies, and developing and implementing high-efficiency agricultural machinery. In particular, the newly plowed lands for 2022–2026 lays out the tasks to be accomplished: "...to develop a program for the transition to "a green economy" and energy efficiency to reduce losses in industrial sectors and increase resource efficiency."(1). When performing these tasks, it is necessary to develop a combined machine that combines all technological procedures for training (complete execution of the driving line, lowering and crushing the field surface) and maintaining high-quality workpiece patterns. duties. The development and introduction of a new generation of technological methods with high technical and economic performance is necessary to solve this problem. This will increase labor productivity by three to four times.

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2 Materials and methods

Economic efficiency of the combined machine used for sequential tillage of new arable lands RD Uz 63.03-98 “Tests of agricultural machinery. Methods of calculating the economic efficiency of the tested agricultural machinery” [1] and in the process of research used and existing normative documents (TSt 63.04:2001, TSt 63.03.2001) [1].

3 Results

3.1 Analysis of the current state of the problem under consideration and references to sources

Scientific and technical achievements of the world and research in the Republic shows that the existing shortcomings in the preparation of new arable lands for planting include all the technological processes of preparing the soil for planting in one pass from the field (complete compaction of the plowed field, leveling and crushing the surface of the field), ie before planting, can be overcome by developing a machine that ensures complete machining in all aspects in one pass. By combining technological processes and reducing the number of field trips, the use of such a machine in pre-sowing tillage on newly planted land can increase productivity, improve the quality of tillage and prevent moisture loss, increase crop yields quickly, and save costs [2, 3].

Combining energy-intensive planting with low-energy-volume operations (soil preparation for planting, sowing, etc.) is not advised in the majority of cases. Owing to the energy intensity of planting, the average width of the plant in a combined unit intended to perform these operations is rather small, which decreases productivity and lengthens the time needed to prepare the soil for planting. It is well known that seeding ought to be done during restricted agricultural seasons. Such aggregates can be economically unfeasible to use, particularly in large areas.

Combined aggregates used in pre-sowing tillage perform several or all technological processes of primary and pre-sowing tillage in one pass from the field. This has a negative impact on the soil of tractors and agricultural machinery, as well as a decrease in fuel consumption, increased work quality and productivity, reduced tillage time, and the retention of accumulated moisture.

4 Discussion and examples

When planting fields free of heat or secondary crops in public conditions, the top layer of soil including plant residues and weeds is turned over and thrown into the bottom layer, resulting in many gaps and irregularities in the plowed layer. If these are not eliminated or their size is not minimized, the quality of planting, irrigation, and row spacing will deteriorate. In addition, for quality planting of crops, the condition of the top layer of soil must comply with the agro-technical requirements for the background of planting in terms of density and flatness. Therefore, when preparing newly plowed lands for planting, the soil piles overturned by the plow bodies should be compacted, compacted and leveled. Based on the above, our institute has developed a combined machine used for the cultivation of new arable land [4].

The combined machine for cultivating newly plowed lands (Figure 1) consisted of rollers, levelers and plank rollers equipped with ponasimon working surface discs.

The machine processes operate as follows: the discs driven by the lower bodies are affected first by the disc rollers. After pulverizing the pancakes and affecting the entire
surface, they spread the bottom surface. Following that, the soil is exposed to the pool roller, bringing the pool's surface down to the necessary level and creating a gentle layer within it to collect moisture.

Using this machine to pre-sow fertilizer on newly arable land will boost output, enhance the quality of the fertilizer, and prevent soil erosion. It will also result in a significant decrease in fuel consumption and other expenses because technological procedures will be added, reducing the number of field trips. Permits you to plant and harvest. However, the parameters of these developed combined machine working bodies, including disc rollers, are not sufficiently scientifically substantiated. Based on this, one of the optimal parameters of the combined machine disc rollers developed in this work is aimed at substantiating the diameter of the roller discs. It is one of the main parameters of the combined machine disc rollers that affect its quality and energy performance. We justified it as follows.

Determining the diameter of the discs of rollers, taking into account the depth of their immersion in the soil, we determine by the following expression derived by A.D. Nuriddinov [5, 6] and K.B. Imankulov [7].

\[ D \geq \frac{h_{r} + h_{u}}{\sin^{2}(\varphi_{1} + \varphi_{2})} \]  \( (1) \)

Where \( h_{r} \) – depth of sinking of discs of disc rollers, m;
\( h_{u} \) – height of irregularities on the plowed surface, m;
\( \varphi_{1}, \varphi_{2} \) – external and internal friction of the soil, respectively angles, degrees.

(1) expressions from expressions known from the literature [8, 9, 10] differs in that the depth at which the discs sink into the ground is taken into account.

(1) Once the condition is satisfied, the discs of the rollers pass over the furrows on the plowed surface without pushing them forward, and thus they are crushed. Otherwise, the technological process is not sufficiently performed as a result of the piles on the plowed surface crumbling and falling asleep in front of the discs.

![Image](image-url)

1-frame equipped with a suspension device; 2,3-disc rollers; 4- leveler; 5-plank roller coaster.

**Fig. 1.** Schematic of a combined machine used in the cultivation of a new plowed field.
We determine that \( h_1 = 6 \text{ cm}, h_2 = 5 \text{ cm}, \varphi_1 = 25^\circ \) and \( \varphi_2 = 35^\circ \) [1] and the diameter of the roller discs should be at least 44 cm according to expression (1), and we accept \( D = 45 \text{ cm} \) as the final result.

Experiments to study the effect of roller discs on the performance of the device were performed using discs with a diameter of 400, 450 and 500 mm. The width of the tracks between the discs is 100 mm, the longitudinal distance between the rollers is 600 mm, the thickness of the discs is 20 mm, the sharpening angle is 60\(^\circ\), the vertical load on each disc is 600 N, the depth of the discs is 5-6 cm and assumed to be constant. Experiments of the aggregate Conducted at speeds of 6.7 and 8.3 km / h. The results obtained in the experiments are given in Table 1 [1].

It is evident that the quality of soil contact has improved with increasing diameter of rollers; that is, in the 0–10 cm layer, the size of larger than 100 mm and between 100 and 50 mm has decreased, and the number of smaller than 50 mm interactions has increased. This is due to the possibility of passing through the lumps encountered in the path of the discs without advancing and aligning increases as the diameter increases. When the diameter of the roller discs increased from 400 mm to 500 mm at a speed of 6.7 km / h, the amount of fractions larger than 100 mm and in the range of 100-500 mm decreased by 4.0 and 3.8\%, respectively, fractions smaller than 50 mm. while the amount increased by 7.8\%, at a speed of 8.3 km / h, these figures were 3.7\%; 1.9 and 5.6 percent, respectively [1].

### Table 1. Variation of the performance of the laboratory-field device depending on the diameter of the rollers discs.

<table>
<thead>
<tr>
<th>№</th>
<th>Name of the indicators</th>
<th>Diameter of disks, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td></td>
<td><strong>Values of indicators</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Movement speed, km/h</td>
<td>6.7</td>
</tr>
<tr>
<td>2</td>
<td>Soil smoothing quality (the amount of fractions of the following size), %</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>&gt;100 mm</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>100-50 mm</td>
<td>17.1</td>
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<tr>
<td></td>
<td>&lt;50 mm</td>
<td>76.3</td>
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<tr>
<td>3</td>
<td>Density of soil in the following layers, g/cm(^3):</td>
<td></td>
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<tr>
<td></td>
<td>10-20 cm</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>20-30 cm</td>
<td>1.12</td>
</tr>
<tr>
<td>4</td>
<td>Comparative resistance to gravity, kN/m</td>
<td>1.12</td>
</tr>
</tbody>
</table>

With an increase in the diameter of the discs of rollers, a decrease in soil density in layers of 10-20 and 20-30 cm was observed. Because at the same processing depth, as the diameter of the discs increases, their surface area interacting with the soil increases, and as a result, their pressure on the soil decreases. This in turn leads to a decrease in soil compaction. At speeds of 6.7 and 8.3 km / h, an increase in the diameter of the roller discs from 400 mm to 500 mm resulted in a decrease in soil densities in layers of 10–20 and 20–30 cm by 0.02–0.03 g / cm\(^3\) [5].

The gravitational resistance of the rollers decreased with increasing diameter of the discs. Because as is known from the literature [9], As the diameter of the discs increases, their rolling resistance coefficient decreases.

As the diameter of the discs increased from 400 mm to 500 mm, the specific gravity of the rollers decreased by 0.07 kN / m at a speed of 6.7 km / h and by 0.08 kN / m at a speed of 8.3 km / h.

In all variants, the increase in speed from 6.7 km / h to 8.3 km / h resulted in improved soil compaction quality, reduced compaction and increased traction resistance. This is mainly
due to the increase in the rate of exposure of the discs to the soil and the decrease in the exposure time.

In accordance with the research findings, the roller disc diameter should be as large as feasible to guarantee the soil's quality crushing and decrease its resistance to deterioration, along with a minimal value for compliance. Such a contradiction is resolved by performing multi-factor experiments and determining the value of the diameter of the roller discs, which provides the necessary level of cooperation and cooperation of the soil with minimal energy consumption [11, 12].

Based on the outcomes of multiple factor experiments, as illustrated by the graphical connections in Figure 2, the degree of soil erosion increased with increasing roller diameters, soil density decreased, and the specific resistance of rollers decreased [1].

![Graphs of changes in agrotechnical and energy performance of rollers depending on the diameter of the discs.](https://example.com/graphs.png)

1, 2 and 3 X5 correspondingly when -1, 0 and +1

Fig. 2. Graphs of changes in agrotechnical and energy performance of rollers depending on the diameter of the discs.

These results are fully consistent with the results obtained in theoretical studies.

5 Conclusions

When the diameter of the discs increased from 400 mm to 500 mm, the specific resistance to traction of the rollers decreased by 0.07 kN/m at a speed of 6.7 km/h, and by 0.08 kN/m at a speed of 8.3 km/h.

In all options, increasing the speed from 6.7 km/h to 8.3 km/h led to the improvement of soil compaction quality, reduction of its compaction level and increase of traction resistance. This is mainly due to the increase in the speed of impact of the discs on the ground and the decrease in the impact time.
Therefore, according to the results of the researches, the diameter of the roller discs should be as large as possible to ensure high-quality compaction of the soil and to reduce the resistance to traction. And to have a small value for compaction. Such a contradiction is solved by conducting multi-factor experiments and determining the value of the diameter of the roller discs that ensures the soil compaction and compaction at the required level with low energy consumption. This means that the diameter of the discs is 415-490 mm, so that the rollers can provide quality work at the required level with low energy consumption on the field surface at operating speeds of 6.0-8.0 km / h.

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