Similarity and Differences of Husking and Disking of the Soil. Prospects of Improving Disk Tools

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Abstract. On the territory of Krasnodar Area, traditional and minimal crop cultivation technologies are most often used. In these technologies, a significant proportion of all soil processing are performed with disk tools, and the operations themselves involve husking and disking the soil. Despite the similarity of these operations, they also have significant differences, the analysis of which allowed us to identify common features and formulate requirements for the use of huskers when disking soil and, accordingly, disk harrows for its husking. Based on the results obtained, the prospects of improving disk tools are determined.

1 Relevance of the study

Crop production is one of the most important branches of agricultural production in the Russian Federation, the level of development of which shows the degree of technological and economic development of the entire state. Currently, Krasnodar Territory is the leader in the production of crop growing. The total sown area of Krasnodar Territory is more than 3.5 million hectares, of which 60% is for cereals, 24% for technical crops, 12% forage and 4% potatoes and general crops [9]. Winter wheat, corn for grain, sunflower, soybeans, sugar beet and other crops have become the most widespread in the cultivated areas. The cultivation of these crops is carried out according to appropriate technologies, the purpose of which is to obtain the maximum yield, taking into account the biological potential of plants, with specified product quality parameters and minimal labor, money and energy costs.

One of the most important structural elements of any technology of cultivation of agricultural crops is tillage, which accounts for up to 30% of the total energy consumption in the cultivation of a particular crop, therefore, the development of new and improvement of existing constructive solutions is an urgent task. The process of tillage is aimed at creating such a structure that the conditions for the growth and development of cultivated plants are the most favorable [10]. In addition, tillage should lead to an increase, or at least maintenance of its fertility, accumulation and retention of moisture in it, destruction of weeds, pests and pathogens, as well as prevention from erosion and deflation. Tillage has a significant impact on most of the physical and mechanical properties of the soil, as well as on its structure and condition.

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2 Problem statement

To date, intensive and minimal tillage technologies have become the most widespread in Krasnodar Territory. Intensive tillage technology includes the largest number of passes of machine-tractor units across the field which is made up of single-operation machines, and tillage is carried out to a depth of 22-35 cm with dump plows. The minimum tillage technology is characterized by a reduction in the number of passes of the machine-tractor unit across the field by reducing or completely abandoning a number of processing, using combined units, and soil processing is carried out to a depth of 14-16 cm, as a rule, with disk harrows. Thus, the minimum technology provides for surface and shallow tillage.

In Krasnodar Territory tillage is carried out with various agricultural machines and implements, among which disk rotations can be distinguished as one of the most widely used in all agricultural crop cultivation technologies. According to recommended and promising technologies for the cultivation of basic crops, tillage machines with disk working bodies account for 10-20%, and in some technologies up to 35% of the total volume of technological operations for tillage [3, 4, 5, 6, 8, 13, 17]. Despite the great similarity of technological operations with the use of disk tools, they can have many differences, therefore, the identification of their common features and differences is necessary to determine the prospects for their improvement.

3 Presentation of the main research material

With intensive cultivation technology, rotary disk tools are used for husking the soil after harvesting grain crops to a depth of up to 8 cm, as well as cutting the soil layer after plowing. With minimal cultivation technology, rotary disk tools are also used for husking stubble of grain crops, and most importantly for basic tillage after harvesting row crops before sowing winter cereals. Thus, based on the technological operations performed, rotary disk tools can be divided into two large groups:

- rotary disk tools for tillage to a depth of 8-10 cm, or else these tools are called disk huskers and disk mulchers, and the operation itself is accordingly husking;
- rotary disk tools for tillage to a depth of more than 12 cm, while the tools are called disk harrows, and the process of soil treatment itself is disking.

Currently, the operations of husking and disking the soil are used to a greater extent, not based on the content of the basic technologies of cultivation of agricultural crops, but based on the actual availability of a machine and tractor fleet of a specific production. This fact, first of all, can be explained by the fact that soil husking, and even tillage tools for its implementation, is required once a year after harvesting grain crops, which accordingly leads to their low annual load, and, consequently, increased depreciation [11, 14, 18]. In addition, the husking operation is often carried out during a dry period of time, which is characterized by increased soil hardness. In such conditions, the use of disk huskers and mulchers is difficult due to the low sinking capacity of the latter, which creates the need for multiple passes of units across the field of tillage in accordance with agrotechnical requirements [11, 15, 16]. Thus, in agriculture, disk harrows are most often used for tillage.

The soil and climatic conditions of Kuban are quite diverse, while some of the territories are located in the zone of insufficient moisture. During the period when the soil is under semi-fallow, which, as a rule, occurs from July to October, the amount of precipitation does not exceed from thirty to fifty percent of the total annual volume. The main task of tillage during this period is to preserve moisture, which is achieved by creating a moisture-retaining layer from the soil with mixed crushed crop residues [2].
After harvesting the predecessor, tillage with rotary disk tools consists in husking and disking the soil. The processes of husking and disking the soil have completely different purposes.

The main tasks of soil processing include crumbling and mixing the soil with crop residues, which leads to the closure of soil moisture, provocation to the germination of weed seeds and losses of the main crop, cutting of weeds, pest control and pathogens. When performing the husking operation, the deviation of the average value of the depth of tillage from the set one should be located in the range ± 1 cm. After husking, the treated soil layer should be in a finely lumpy loose state, while the number of soil units up to 5 cm in size should be at least 90% of the total, and the formation of individuals in the soil structure larger than 10 cm should not occur. In addition, the technological operation of soil peeling should ensure 95% cutting of weeds, the completeness of incorporation of plant and crop residues is at least 60%, and the height of the ridges is not more than 5 cm [1, 12].

The main tasks of disking are cutting the soil after plowing, i.e. its crumbling and leveling. In addition to cutting the soil after plowing, disking is used as a fallow or basic treatment. At the same time, the weeds are cut, crushed and mixed with the soil. At the same time, the depth of tillage varies between 12-25 cm depending on the purpose. The deviation in depth is allowed within ± 3 cm, soil units up to 5 cm in size should be at least 80%, and the formation of individuals larger than 10 cm in the soil structure should not occur. The size of the adjacent furrows should not exceed ± 5 cm. Cutting of weeds should be complete, and the completeness of the incorporation of plant and crop residues should be at least 60% [1, 12].

To describe the characteristics of the structural composition of the soil horizon, the structural coefficient is most often used, which is determined by the expression [7]:

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K = \frac{C}{B},
\]

where \(K\) – the coefficient of soil structure;

\(C\) – the number of microunits ranging in size from 0.25 to 7 mm, %;

\(B\) – the sum of soil units smaller than 0.25 mm and lumps larger than 7 mm.

The coefficient of structurality shows the quantitative ratio of the sizes of soil aggregates in a given soil horizon, and the higher the coefficient value, the higher its structurality.

Based on the requirements, it can be concluded that soil husking should lead to more intensive crumbling of the soil and its mixing with crop residues compared to disking. Therefore, tillage tools for disking the soil can be used for husking only if they are sufficiently crumbled and mixed with the soil. On the other hand, disk huskers can be used for disking only if the soil is cultivated to a sufficient depth. This is complicated by the fact that soil disking as the main tillage is usually carried out after harvesting long-stemmed row crops before sowing winter ears, which characterizes the operation of disk harrows in conditions of a large number of crop residues and often with soil of high hardness. These facts make it quite difficult to use disk huskers for soil disking due to their low sinking capacity. Some manufacturers of tillage implements provide for the possibility of placing additional ballast loads on the frame of the huskers for better deepening of the working bodies, however, the diameter of the working bodies, as a rule, does not exceed 510 mm, which calls into question the possibility of cultivating the soil to the required depth. In addition, the disking process has a significantly higher traction resistance, as well as higher values of the forces acting on the working bodies, which imposes additional technical requirements on the design.
4 Conclusion

Based on the above, it can be concluded that the most promising direction for improving disk tools for tillage is to increase the degree of crumbling and uniformity of mixing of soil and crop residues by the working bodies of disk harrows, as well as reduce the energy intensity of the process, which will allow them to be used not only in various soil and climatic conditions, but in various technological operations.

References

15. Konovalov, V. Analytical study of the design parameters of the grinding unit of disk 
harrows / V. Konovalov, S. Konovalov, V. Igumnova // IOP Conference Series: Earth 
and Environmental Science : 12th International Scientific Conference on Agricultural 
Machinery Industry, INTERAGROMASH 2019, Rostov-on-Don. Vol. 403. – Rostov-
on-Don: Institute of Physics Publishing, 2019. – P. 012086. – DOI 10.1088/1755-
1315/403/1/012086. – EDN PTSUKR.

16. Konovalov, V. I. Justification of design parameters of a disk working body with a 
changing radius of curvature / V. I. Konovalov // E3S Web of Conferences, Sevastopol. 
– Sevastopol, 2020. – P. 01014. – DOI 10.1051/e3sconf/202019301014. – EDN 
CTQPQJ.

17. Serguntsov, A. Operational parameters and modes of rotary working body for 
harrowing crops / A.Serguntsov, V. Serguntsova, N.Malashikhin // E3S Web of 

18. Rykov V. B. System of energy criteria in the justification of technical units for field 
production / V. B. Rykov, S. I. Kambulov, E. I. Trubilin, Yu. K. Kastidi // E3S Web of 