Combined machine for preparing the soil for re-sowing crops

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Abstract. The technologies used to prepare the soil from under winter crops for re-sowing consist of numerous soil preparation operations, which lead to loss of moisture, delay in the preparation of the soil for sowing and increase operating costs. The purpose of the research is to develop a combined machine for preparing the soil from under winter crops for sowing repeated crops. The authors developed a combined machine consisting of non-shaft housings, spherical disk batteries and a roller. The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. It is established that the most optimal design scheme of a combined machine is considered to be a scheme consisting of non-shaft housings with crushers, a battery with cut-out spherical disks and a roller. The experimental studies have established that the shaft-free body of the machine with dyes provides high-quality crumbling of the soil with minimal energy consumption. The main parameters of the machine and its technical characteristics are given. It is established that the proposed machine reliably performs the specified technological process and its performance indicators fully meet the requirements. The use of the developed combined machine for non-tillage of the soil and its preparation for sowing of repeated crops makes it possible to reduce operating costs in comparison with the existing technical means for processing each hectare of the field by 53.4%.

1. Introduction

All over the world a number of research works are being carried out to reduce energy and resource costs during tillage and increase labor productivity, in particular in the following priority areas: development of the optimal type of high-tech modular-block unified tillage machines with minimal energy consumption; creation of a complex of plows for smooth plowing; development of dump and non-dump longline plows, as well as combined machines; creation of high-performance machines for moisture conservation and soil protection technologies; introduction of tillage technologies that reduce energy and resource costs [1-13].

The creation of combined machines for dump and non-dump tillage, as well as its preparation for sowing in one pass through the field and the justification of the parameters of their working bodies were carried out by M.Yamaletdinov [1], N.Aldoshin [4, 11, 12, 20, 21, 25], F.Mamatov [2-4, 6-12, 14-21, 24, 26, 29], I.Ergashev [3, 4, 7, 13, 24], B.Mirzaev [5-7, 10, 12-22, 24, 29], D.Chuyanov [6, 28], H.Fayzullaev [6, 26, 30, 31], I.Temirov [31], H.Ravshanov [5-7, 21, 26, 27, 31], U.Kodirov [7,
25, 31], S. Toshtemirov [9, 13] and others. The machines and tools created as a result of these studies are used in agricultural production with certain positive results. However, in these studies, the issues of substantiating the design schemes of machines and the parameters of working bodies for non-fall tillage of the soil from under grain with its simultaneous preparation for sowing of repeated crops are not sufficiently studied.

2. Methods
The basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. Based on theoretical and experimental research, an experimental version of the combined machine was created. The combined machine (Fig. 1) consists of a frame 1, support wheels 2, disc blades 3, overturned housings 4, shredder blades 5, cut spherical disc batteries 6 and roller 7.

![Figure 1. Design diagram of the combined machine (side view): 1 – frame; 2 – support wheel; 3 – disc knife; 4 – non-shaft housing; 5 – knife of the crumbler; 6 – battery with cut-out spherical disks; 7 – roller]

The combined machine is aggregated with tractors of 5-6 classes. The body of the combined machine is fixed without a turntable, and the roller is mounted on a hinged mechanism. In non-overturning housings, the soil softening element, the grinding blades, is fixed. During the work, the hulls without tillers work on the soil layer at a depth of \( d = 25-27 \) cm without overturning. The shredder blade intensively loosens the middle layer of soil. The broken spherical discs are crushed by the accumulated batteries to break up large pieces of slag and plant debris formed during overturning. The crossbeam is mounted on the crossbeam without the use of crutches. The non-overturning body consists of welded boots and a lemex, a chisel, a grinding knife and a column. The suspension of the plow is designed to be mounted on Class 5 and 6 tractors. A series of disc blades and support wheels are produced. The adjustment mechanism of the base wheels of the combined machine allows adjusting the working depth in the range of 22-27 cm. The leveling roller is hinged to the frame with beams. By changing the compressive strength of the springs, it is possible to change the quality of soil compaction with a roller.

3. Results and Discussions
To select the main working body of the combined machine, experimental studies were carried out with three types of housings: a screw housing with a cap (Fig. 2 a), a non-shaft housing (Fig. 2 b) and a non-shaft housing with soil crumblers (Fig. 2 c).
In the experiments, the coverage width of the housings was 0.45 m, the angle of entry of the plowshare into the ground was 25 °, the mounting angle was 42 ° relative to the direction of movement, the mounting angle was 35 ° relative to the bottom of the jaw, the number of grinding blades was 4, the height was 35 mm, length 120-140 mm, mounting angle 10 ° relative to the direction of movement, mounting angle 30 ° relative to the horizon, and height of the housing without overturning 420 mm. At the same time, the working speed was set at 5-9 km/h, the coverage of all buildings was 45 cm, and the processing depth was 25 cm. The results of the experiments are shown in Figure 3.

From the graphs shown (Fig.3) it can be seen that the non-shaft housing with dyes provides high-quality crumbling of the soil with minimal energy consumption.
When the developed combined machine is aggregated with tractors of 5-6 classes, its operating speed is 6.5-8.5 km/h, coverage width is 2.7 m, non-dumping housings are 25-27 cm without overturning the soil layer, depth processing.

The economic tests of the combined machine were conducted in the fields of farms of Kashkadarya region of the Republic of Uzbekistan. It identified the following quality characteristics of the combined machine: depth of tillage, degree of soil compaction, leveling of the treated field surface and productivity. The experimental field soil moisture was 11.8% and hardness was 4.2 MPa. In the tests, the combined machine was aggregated with a Case IH Magnum MX255 tractor. The results of the economic test of the combined machine are given in Table 1. According to the results of economic tests, the total depth of the combined machine is 27.6 cm, the number of fractions is less than 25 mm on average 81.3%, the height of irregularities on the processed surface of the field is 4.3 cm. These results show that the performance of the combined machine meets the requirements of agricultural technology. The combined machine developed in the tests reliably performed the technological processes specified in the technology.

| №  | Name of indicators       | According to agrotechnical requirements | Based on the test results |
|----|--------------------------|----------------------------------------|---------------------------|
| 1. | Operating speed, km / h  | 6-10                                   | 8.5                       |
2. Capture width:

\[
\begin{align*}
M_{\text{ave}}, \text{ cm} & \quad \pm \sigma, \text{ cm} \\
\nu, \% & \quad <10 \\
\end{align*}
\]


|     | 270±10 cm | 270,6 |
|-----|-----------|-------|
|     | -         | 0,91  |
|     | \(<10\)   | 2,56  |

3. Depth of tillage:

\[
\begin{align*}
M_{\text{wp}}, \text{ cm} & \quad \pm \sigma, \text{ cm} \\
\nu, \% & \quad <10 \\
\end{align*}
\]


|     | До 27 | 27,6 |
|-----|-------|------|
|     | -     | 1,78 |
|     | \(<10\) | 8,46 |

4. Soil fractions of the following sizes, %

|     | > 50 mm | < 10 |
|-----|-------|------|
|     | 8,5   | 10,2 |
|     | 10,2  | 81,3 |

4. Height of irregularities on the surface of the treated field, cm

|     | > 5 | 4,3 |

4. Conclusion

1. The most optimal design scheme of a combined machine for non-tillage of the soil and its preparation for sowing of repeated crops is considered to be a scheme consisting of non-tillage housings with crushers, a battery with cut-out spherical disks and a roller.

2. It is established that the non-shaft housing with crumblers provides high-quality crumbling of the soil with minimal energy consumption.

3. The combined machine, developed on the basis of theoretical and experimental research, reliably performed the specified technological work process, and its performance fully complies with the requirements of agrotechnics and the terms of reference.

4. When using the developed combined machine, compared to existing technologies, fuel and lubricants consumption per 1 hectare increased by 29.4%, labor costs by 38.2%, direct (operating) costs by 53.48 percent decreased.

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