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Results of Field Tests of a Cultivator With a Ribbed Disc-Type Working Body for Soil Tillage in Cotton Row Spacings Prior to Winter Wheat Sowing

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ABSTRACT: This article presents a new cultivation technology for soil tillage in cotton row spacings prior to winter wheat sowing. The technology ensures effective soil cultivation, produces a well-loosened seedbed, and reduces energy consumption and operating costs. The design, operating principle, and field test results of a cultivator equipped with ribbed disc-type working bodies implementing the proposed technology are presented.

KEYWORDS: tillage, cotton, working body, sweep share, energy, grain crops, soil profile, ribbed disc, mouldboard sweep.

I.INTRODUCTION

The role and importance of the agricultural sector in ensuring food security for the world's population are increasing day by day. In particular, in our country, ensuring a stable supply of agricultural products to the population, further increasing crop productivity and profitability, and making rational use of existing reserves and opportunities for the introduction of scientific achievements and modern approaches into the agricultural sector are among the most pressing issues.

Particular attention is being paid in our republic to the efficient use of irrigated lands and to the introduction of modern, highly efficient, and resource-saving machinery and technologies that ensure high grain yields [1; 2; 4]. In this regard, one of the important tasks is the development and widespread implementation of methods and technologies that provide high-quality soil tillage, including the sowing of winter wheat in cotton row spacings.

The Development Strategy of the Republic of Uzbekistan for 2020–2030 identifies the modernization of agriculture, the widespread introduction of resource-saving technologies, the improvement of the productivity of irrigated lands, and the strengthening of food security as priority objectives. Achieving these objectives requires the development of efficient crop production technologies, the design of energy- and resource-efficient agricultural machinery, and their widespread implementation in agricultural practice. In this regard, the development of new working body designs capable of providing high-quality soil preparation for winter wheat sowing in cotton row spacings, while reducing labor and material costs, and the substantiation of their parameters, are among the important and relevant research tasks. [3].

Taking the above into consideration, special attention should be paid to improving and conserving soil fertility, introducing intensive methods into agricultural production, developing new crop varieties adapted to local soil, climatic, and environmental conditions, and promoting the implementation and advancement of modern agrotechnologies in grain production.

II.LITERATURE REVIEW

In our republic, a number of researchers have conducted scientific studies on the development of machines for soil tillage in cotton row spacings intended for winter wheat sowing, as well as on the substantiation and improvement of the technological processes and parameters of their working bodies.

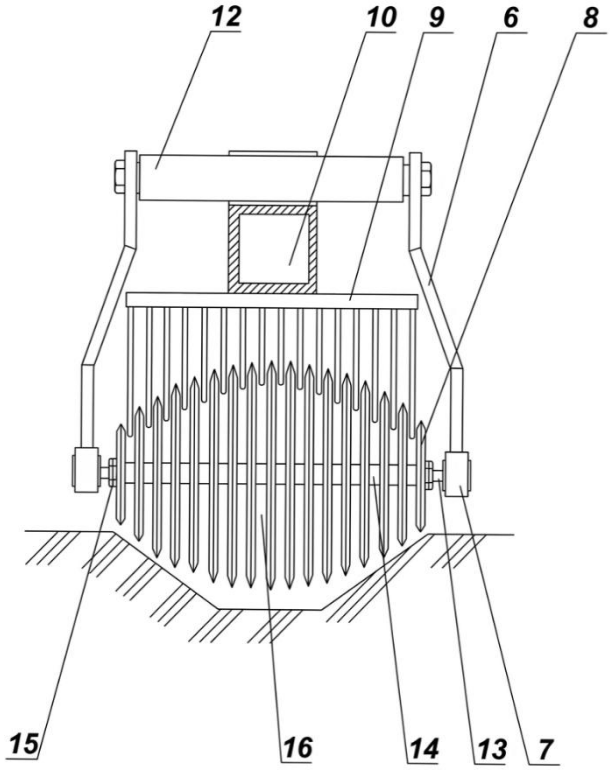
A.K. Igamberdiyev developed an efficient technology for the mechanization of winter wheat cultivation in cotton row spacings and substantiated its main parameters. The machine developed on the basis of this technology performs soil tillage over a field width of 2.7 m in a single pass [5].

S.U. Temirov developed universal working bodies for a cotton cultivator and substantiated their parameters. The machine equipped with these working bodies performs soil tillage over a field width of 3.6 m in a single pass [6].

Researchers N.A. Redkokashin, A.A. Redkokashin, and I.A. Redkokashin of the Primorskaya State Agricultural Academy of the Russian Federation proposed a universal cultivator protected by Utility Model Patent

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No. RU 86379 [7] (Figure 1). This cultivator is equipped with discs of different diameters. However, despite the installation of scrapers between the discs, soil clods may accumulate and clog the space between them under certain operating conditions, which is considered a drawback of the design.



6 – fork; 7 – fork support; 8 – discs of different diameters; 9 – scraper; 10 – working section frame; 12 – working section support; 13 – shaft; 14 – spacers for adjusting the distance between the discs; 15 – fastening nut; 16 – disc working body.

Figure 1. Schematic diagram of the universal cultivator proposed under Utility Model Patent RU No. 86379 U1

Scientists L.F. Babitskiy and I.V. Sobolevskiy of the Crimean Federal University developed a disc-type soil tillage section (Figure 2.) [8].

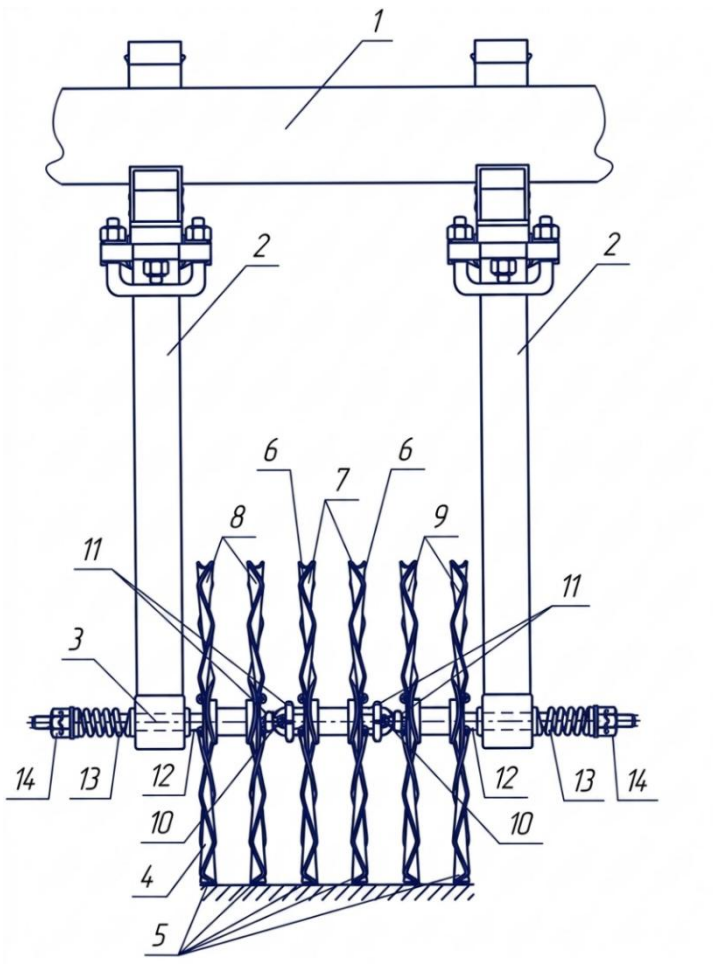
The disc section is hingedly attached to the frame through a spring-loaded S-shaped tine. The axle carrying the disc assembly is mounted on the tine. The central wavy discs are connected to the right and left ribbed discs by means of cross-type universal joints, which enable better adaptation to field surface irregularities. These universal joints also induce oscillatory motion of the discs during operation. However, this disc section was not designed for preparing cotton row spacings for winter wheat sowing.

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1 – frame; 2 – U-shaped spring tine; 3 – cross-type universal joint; 6 – battery of central ribbed discs; 9 – outer ribbed discs; 13 – tension spring; 14 – screw adjustment mechanism.

Figure 2. Design of the Disc-Type Soil Tillage Section According to Patent No. 173236

III.MATERIALS AND METHODS.

Based on the conducted theoretical and experimental studies, a cultivator for preparing the soil in cotton row spacings for winter wheat sowing was developed. A prototype of the cultivator was manufactured, and field and farm tests were carried out under actual farming conditions.

The developed cultivator is designed for soil tillage in cotton row spacings with a row width of 76 cm. Each section of the cultivator consists of two mouldboard sweeps, a centrally mounted sweep share, and a ribbed disc working body. The cultivator can be mounted on tractors belonging to the 1.4 and 2.0 traction classes.

The cultivator equipped with ribbed disc working bodies performs tillage in cotton row spacings with a total working width of 3.04 m (four rows spaced 76 cm apart) in a single pass and prepares the soil for sowing. The transverse distance between the oppositely arranged mouldboard sweeps was set at 60 cm, the working width of the sweep share was 16 cm, and the tillage depth was maintained at 10 cm. In addition, the operating speed of the unit was kept within the range of 6–8 km/h, while the longitudinal distance between the sweep share and the ribbed disc working body was set at 55 cm. As a result, a well-prepared seedbed was formed in the cotton row spacings, with 80–85% of the soil aggregates being smaller than 25 mm, making the field suitable for sowing.

The general view of the machine and its operation in the field are shown in the figures.

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Figure 3. General View of the Cultivator Equipped with Ribbed Disc Working Bodies

The following agrotechnical requirements are imposed on soil tillage prior to sowing winter wheat in cotton row spacings:

-The soil in the cotton row spacing cultivated by the pre-sowing tillage working bodies shall have at least 80% of soil aggregates smaller than 25 mm in size.

- The depth of the prepared furrow in the cotton row spacing, measured across its cross-section, shall be not less than 10–12 cm. Deviations from the specified depth shall not exceed ±10%.

- Pre-sowing soil tillage and winter wheat sowing operations shall be performed in accordance with agrotechnical requirements to ensure fuel and lubricant savings, reduced material and labor costs, and increased crop productivity.



Figure 4. View of the Cultivator Equipped with Ribbed Disc Working Bodies During Field Operation

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The quality performance indicators of the cultivator were determined in accordance with Tst 63.04:2001 “Испытания сельскохозяйственной техники. Машины и орудия для поверхностной обработки почвы. Программа и методы испытаний” va Tst 63.03:2001 “Испытания сельскохозяйственной техники. Методы энергетической оценки машин” [10; 11].

Table 1
Test Conditions for the Cultivator Equipped with Ribbed Disc Working Bodies

№	Parameter	Value
1	Date of testing	November 2, 2024
2	Test location	Farmers’ fields in Qarshi and Kasbi districts
3	Field condition (background)	Field intended for winter wheat sowing
4	Macrorelief	Level
5	Microrelief	Level
6	Soil type	Typical gray soil
7	Soil texture	Medium-to-heavy loam
8	Soil moisture content in the following layers (cm), %: 0–10 10–20 20–30	 12.2 14.1 15.7
9	Soil penetration resistance in the following layers (cm), MPa: 0–10 10–20 20–30	 1.82 2.51 3.12

IV.RESULTS AND DISCUSSION.

During the field tests, soil moisture content, soil penetration resistance, the depths of the measured soil layers, and the tillage depth were determined using a ruler, a soil probe, and a measuring tape. To evaluate the soil pulverization quality of the tilled layer, soil samples were collected from five replicated plots, each having an area of 0.25 m², over the full tillage depth. The collected samples were sieved through screens with mesh openings of 100, 50, 25, and 10 mm. The masses of soil aggregates retained on each sieve and those passing through the final sieve were measured using a LIBOR EL-600 balance. Based on these measurements, the percentages of soil fractions larger than 100 mm, 100–50 mm, 50–25 mm, 25–10 mm, and smaller than 10 mm were determined. The sieving procedure was performed sequentially from sieves with larger openings to those with smaller openings. The measurement accuracy for the soil fractions was ±5 g.

The obtained results indicate that the operational performance of the machine satisfies the specified agrotechnical requirements.

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Table 2
Field Test Results of the Developed Cultivator for Soil Tillage in Cotton Row Spacings Prior to Winter Wheat Sowing

№	Parameter	Agrotechnical Requirement	Test Result
1	Operating speed, km/h	6–8	6–8
2	Overall tillage depth of the cultivator, cm	Mean: 10–12Deviation: ±2	Mean: 10–12Deviation: ±1.5
3	Tillage depth of the ribbed disc working body, cm	–	Mean: 10Deviation: ±1.4
4	Distribution of soil aggregate fractions after tillage by the ribbed disc working body, %		
	100–50 mm 50–25 mm < 25 mm	6.4 13.6 ≥ 80	4.5 13.5 82
5	Degree of removal of plant residues from the cultivated area, %	> 90	92.4
6	Fuel consumption, kg/ha	–	5.9

During the tests, the developed cultivator performed the specified technological process completely and reliably. The results obtained from the field tests fully complied with the established requirements and performance criteria.



a) b)

Figure 5. Cotton Row Spacings Prepared for Winter Wheat Sowing Following Soil Tillage
a) Cotton row spacing cultivated using the conventional technology;
b) Cotton row spacing cultivated using the cultivator equipped with ribbed disc working bodies.

According to the results of the field tests, the tilled soil in the cotton row spacings contained 81–83% soil aggregates smaller than 25 mm, indicating a high degree of soil pulverization. The depth of the prepared furrow, measured across its cross-section, ranged from 9 to 11 cm. The width of the cultivated area was 3.04 m [9; 12–20].

V.CONCLUSION

The introduction of a cultivator equipped with ribbed disc working bodies for pre-sowing soil tillage in cotton row spacings made it possible to form a well-pulverized furrow with a level surface that meets agrotechnical requirements.

The economic efficiency of the cultivator developed for soil preparation prior to winter wheat sowing in cotton row spacings was evaluated in accordance with established regulatory procedures. The developed cultivator was compared with the KXU-4B cultivator.

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The calculations showed that the use of the cultivator equipped with ribbed disc working bodies reduces direct (operating) costs per hectare by 35.5%, increases field productivity by 42.2%, and decreases fuel and lubricant consumption by 20.6%. The seasonal economic benefit obtained from the use of one machine amounts to 31,231,600 UZS.

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