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SUBSTANTIATION OF MAIN PARAMETERS OF A COMBINED DEVICE FOR SHREDDING COTTON STALKS AND COARSE WEEDS SIMULTANEOUSLY WITH PLOWING

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Abstract: This article examines the scientific substantiation of the main constructive-technological parameters of a combined device for shredding cotton stalks and coarse weeds simultaneously with plowing. The device is mounted on the front of a tractor and receives motion from the NSh hydraulic system. The main research parameters are defined as: number of blades (n), blade diameter (d), rotational torque (F), distance between blades (l), and distance between vertical working columns (L). The research is planned to be conducted under the soil-climatic conditions of the Bukhara region. Based on mathematical modeling and multi-factor experimentation, optimal parameter values have been determined.

Keywords: cotton stalk, shredding, plowing, combined device, blade, parameters, Box-Behnken design, Bukhara region.

Cotton cultivation is one of the main branches of agriculture in the Republic of Uzbekistan. After harvesting each year, large quantities of cotton stalks and coarse weed residues remain in the fields. Based on the decrees of the President of the Republic of Uzbekistan on agricultural development and mechanization, addressing this problem comprehensively has become an urgent task.

The heavy mechanical composition of soil and the arid climate in the Bukhara region further complicate the utilization of cotton stalk residues.

Currently, shredding and plowing operations are performed separately, leading to additional tractor passes, fuel consumption, and time expenditure. Therefore, the development and scientific substantiation of a combined device that integrates these two processes is of great importance. An analysis of existing research shows that cotton stalk shredding devices are divided into two main types: horizontal and vertical cylindrical shredders. Combined devices developed by foreign researchers (CSPS — Cotton Stalk Puller and Shredder) perform shredding and soil preparation in a single pass, but these devices have not been adapted to the conditions of Uzbekistan [1, 2].

The KIR-1.5 type shredder widely used in Uzbekistan operates as a separate unit attached to the rear of a tractor via PTO. The main drawbacks of this device are: incompatibility with simultaneous plowing, low efficiency in hard and dry soil conditions, and coverage of only 1–2 rows [3].

In research, optimization of device parameters using Response Surface Methodology (RSM) and Box-Behnken experimental design is widely applied. The best results were obtained at a forward speed of 0.6 m/s and a cutting speed of 1.2 m/s as optimal operating parameters [4].

Research Methodology

The device is mounted on the front of the tractor and receives motion from the NSh hydraulic pump. Four vertical columns with spiral blades cover 4 cotton rows in a single pass. The blades are designed to be replaceable and the inter-column spacing is adjustable. The device for shredding cotton stalks and incorporating them into the soil during plowing consists of a frame with four axles attached using special brackets. These axles are composed of several specially designed arc-shaped blades intended for shredding cotton stalks and coarse weeds.

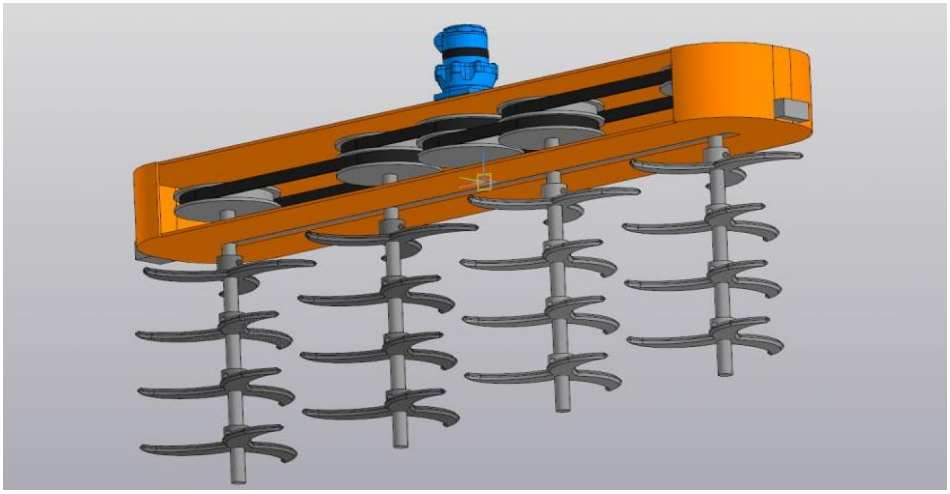


Figure 1. Device for shredding cotton stalks and coarse weeds.

This shredding device primarily receives motion from the machine shaft, transmits it through a gearbox to belt drives, after which the special blades cut the cotton stalks into several small pieces.

The main research parameters are: number of blades n (units), blade diameter d (mm), rotational torque F (N·m), vertical distance between blades l (mm), and horizontal distance between columns L (mm).

Table 1. Research Parameters and Their Levels

Symbol	Parameter Name	Level −1	Level 0	Level +1
n	Number of blades (units)	5	7	9
d	Blade diameter (mm)	250	300	350
l	Inter-blade distance (mm)	80	100	120
L	Inter-column distance (mm)	800	900	1000

Symbol	Parameter Name	Level −1	Level 0	Level +1
F	Rotational torque (N·m)	800	1000	1200

Experimental Methodology

Experimental research is planned to be conducted in the Bukhara region. Experimental conditions: soil — meadow-gray, heavy loamy; moisture content 12–18%; soil bulk density 1.35–1.45 g/cm³. The Box-Behnken experimental design was applied based on a 3-factor × 3-level scheme.

The following were designated as response functions: Y_1 — shredding quality coefficient (share of pieces with length ≤100 mm, %); Y_2 — fuel consumption (L/ha); Y_3 — work productivity (ha/hour). Optimization conditions: $Y_1 \rightarrow$ max, $Y_2 \rightarrow$ min, $Y_3 \rightarrow$ max.

Based on the experimental results, a second-order regression equation will be formulated and optimal parameter values will be determined. Expected optimal values: n = 6–8 units, d = 280–320 mm, l = 90–110 mm, shredding quality $Y_1 \geq 85\%$.

Conclusion

— A combined device for shredding cotton stalks and coarse weeds simultaneously with plowing has been proposed; it is mounted on the front of the tractor and receives motion from the NSh hydraulic system.

— Based on theoretical calculations, the values of the main parameters were determined: number of blades n = 7 units, blade diameter d = 300 mm, rotational torque F ≈ 1000 N·m, inter-blade distance l = 100–120 mm, inter-column distance L = 900 mm.

— Kinematic analysis shows that the shredding index $\lambda = 7.8 > 3$, meaning the agrotechnical requirement is met.

— Experiments with 15 variants based on Box-Behnken design are planned to be conducted under Bukhara region conditions, and the results will be analyzed using a regression model.

— Introducing the device into production is expected to reduce fuel consumption by 25–30% and shorten working time by 40%.

References

1. Mushtaq A. et al. Structural analysis of cotton stalk Puller and Shredder Machine // Computers and Electronics in Agriculture. — 2022. — Vol. 201. — P. 107296.
2. Mushtaq A. et al. Field Performance Evaluation and Finite Element Simulation of Cotton Stalk Puller-Shredder // Sustainability. — 2020. — Vol. 12. — P. 3284.
3. Toshpo'latov X.T. Foundations of Mechanization in Agriculture. — Tashkent: Fan, 2019. — 280 p.

4. Zhang B. et al. Calibration and test of contact parameters between chopped cotton stalks using response surface methodology // Agriculture. — 2022. — Vol. 12. — P. 1851.

5. Decree No. PQ-273 of the President of the Republic of Uzbekistan dated June 7, 2022 “On organizing the implementation of tasks set in the Strategy for Agricultural Development for 2020–2030.”

6. Results of an experimental sample test of an advanced perforated deep softener / FU Zhuraev, YZ Rajabov, UY Rajabov, SS Turaev et al. — ACADEMICIA: An International Multidisciplinary Research Journal, 2021.

7. Efficient use of preparation aggregates for planting lands in a single pass with a straightening torsion work / S. To‘rayev. — Conference Proceedings, MCND, 2020.

8. The test laboratory results of a new device for creating hole drainage / ZS Isakov, SS Turaev, FU Juraev. — Conference on Innovative Technologies in Agriculture, 2020.

9. Water-saving technology for intra-soil irrigation of intensive gardens / SS Turaev, GH Arimov, FU Juraev. — Conference: The Role of Young Scientists and Researchers, 2020.

10. Substantiation of technology and equipment for improving the reclamation state of saline soils in irrigated agriculture / FU Juraev, MM Artikova, LB Isayeva, SS Turaev. — The Way of Science, 2014.