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OPTIMIZATION OF THE PARAMETERS OF THE ROTATION ROLLER USED FOR PROCESSING COTTON BROADS

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ABSTRACT: *In this article, the issue of optimizing the parameters of the developed rotary cultivator for cotton cultivators is considered. In this case, such factors as the distance (height) of installation of transverse knives on the disk of the rotary ripper, the number and width of the knives, the force of vertical pressure on the rotary ripper, and the speed of the unit were taken into account. The results of the conducted research show that at the working speeds of the unit of 5.0-6.0 km/h and the number of cross-knives 14 pieces, the distance of installation of cross-knives on the disk of the rotary ripper should be within 2.0 cm, the width of the cross-knives of the rotary ripper 5.0 cm, the vertical load force applied to the rotary ripper should be within 366.0-428.0 N. As a result of the conducted research, it was established that the distance of installation of cross-knives on the disk of the rotary ripper should be within 2.0 cm, the width of the cross-knives of the rotary ripper 5.0 cm, the vertical load force applied to the rotary ripper should be within 366.0-428.0 N.*

Keywords: *cotton cultivator, rotary ripper, cross blades, vertical load force, loosening depth, unit speed, optimization.*

INTRODUCTION

Currently, the issue of increasing the yield of cotton, which is one of the main technical crops grown in agriculture, and the mechanization of its cultivation process is very relevant. In cotton growing, inter-row cultivation of cotton is an important link in the system of agrotechnical measures, which serves not only for loosening the soil, but also for regulating its air-water regime and nutrient cycling [1,2].

In the process of cultivation with existing cultivators, an increase in soil density and, in some cases, hardening are observed in the topsoil. This negatively affects the development of the root system, hinders water absorption, and, as a result, reduces the yield of raw cotton. Therefore, the use of cultivators equipped with modern working parts plays an important role in high-quality loosening of the soil and ensuring agrotechnical requirements [3,4].

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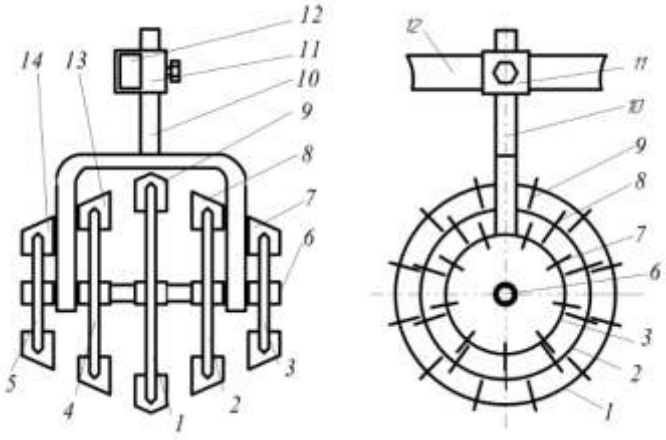
At the Research Institute of Agricultural Mechanization, a rotary ripper has been developed for processing cotton cultivators after vegetative irrigations [5]. Fig. 1 shows the design scheme of this rotary ripper.



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1 - central disc; 2, 4 - side discs; 3, 5 - edge discs; 6 - axle; 7, 14 - cross blades of the extreme disc; 8, 13 - cross blades of the side disc; 9 - cross blades of the central disc; 10 - stand; 11 - lock; 12 - Gradile cultivator.

Figure 1. Technological scheme of the rotary ripper:

In recent years, cultivators based on rotary rippers have been widely used. They have a circular impact on the soil, destroying the dense layer, preserving the natural structure of soil particles, and activating the environment. This type of unit not only improves the physical and mechanical properties of the soil in cotton growing, but also reduces energy costs and increases work efficiency [6,7,8].

However, for the effective use of cultivators equipped with rotary rippers, a scientifically based optimization of their design and parameters is required. In particular, such factors as the distance (height) of installation of transverse knives on the disk of the rotary ripper, the number of knives, the width of the knives, and the vertical load force applied to the rotary ripper are important. Incorrect selection of these parameters leads to a decrease in the quality of operation and an increase in the unit's energy consumption.

Therefore, the main goal of this research is **optimization of the parameters of the developed rotary ripper for a cotton cultivator,** ensuring the quality of work at the level of agrotechnical requirements when cultivating cotton inter-rows. Fig. 2 shows the main parameters of the rotary ripper.

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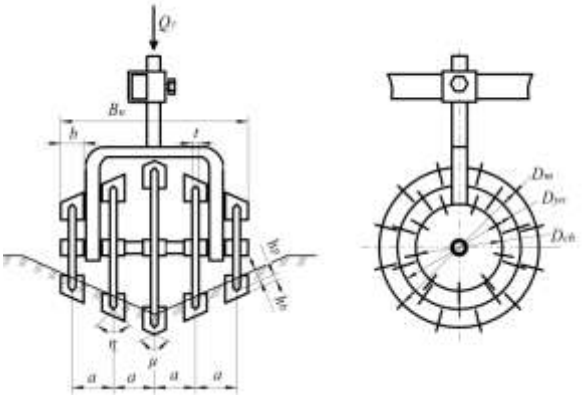

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Figure 2. Main parameters of the rotary ripper:

μ - total disc set cone angle, °;

B_u- total gripping width of the rotary ripper, *m*;

a - distance between disks, *m*;

t - disc thickness, *m*;

n - number of discs, pieces;

- disk sharpening angle, °;

D_{min} - minimum disk diameter, *m*;

D_{max} - maximum disk diameter, *m*;

Q - power of vertical load on the rotary ripper, *N*;

b - width of crossbars, *m*;

h_b - dip depth of the discs in the soil, *m;*

h_p - distance (height) of installation of cross blades, *m.*

To verify the results of theoretical and one-factor experimental studies to substantiate the parameters of the rotary tiller and determine its optimal values, the method of mathematical planning of multi-factor experiments was used. Considering that the influence of factors on the evaluation criteria is fully explained by the second-degree polynomial, the experiments were conducted according to the Hartley-5 (Na5) plan [9,10].

Based on the results of theoretical studies and one-factor experiments, the distance, number and width of installation of cross-knives on the disk of the rotary ripper, the vertical load on the rotary ripper, the degree of soil crumbling and the degree of weed destruction, as well as draft resistance were adopted as the most influencing factors. The factors were conditionally determined as follows: $_{X1}$ - distance of installation of cross-knives on the rotary ripper disk, $_{X2}$ - number of cross-knives on the rotary ripper disk, $_{X3}$ - width of cross-knives of the rotary ripper, $_{X4}$ - vertical pressure force on the rotary ripper and $_{X5}$ - speed of movement of the unit. Table 1 shows the factors, their

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designations, intervals, and levels of change.

When conducting multifactorial experiments, the degree of soil crumbling, the degree of weed destruction, and the draft resistance of the rotary tiller were taken as evaluation criteria [11].

In order to reduce the influence of uncontrolled factors on the evaluation criteria, the sequence of conducting experiments was determined using a table of random numbers.

Table 1

Factors, their designation, intervals and levels of change

Factors and their units	Conditional designation	Change interval	Level		
			Lower **(-1)**	basic **(0)**	top **(+1)**
Distance of installation of cross blades on the rotary ripper disk, cm	X_1	2.	0	2.	4.
Number of transverse knives on the disk of the rotary ripper, pcs.	X_2	2.	12.	14.	16.
Width of the transverse knives of the rotary ripper, cm	X_3	1.	5.	6.	7.
Force of vertical load applied by rotary ripper, N	X_4	50.	350	400	450
Unit movement speed, km/h	X_5	1.	4.	5.	6.

The data obtained in the experiments were processed according to the program "Construction of second-order regression models based on the results of a multifactorial active experiment and 3D graphs based on them," developed in the information and resource department of the institute [12]. In this case, the Cochrane criterion was used to assess the homogeneity of the variance, the Student's criterion was used to assess the values of the regression coefficients, and the Fisher criterion was used to assess the adequacy of the regression models.

The data obtained in the experiments were processed in the established order and the following regression equations were obtained, adequately describing the evaluation criteria:

- by the degree of soil crumbling, %:

$$Y_1=77.309-0.134\ X_1+0.308\ X_2+0.418\ X_3-0.331\ X_4+0.532\ X_5-0.287\ X_1^2+$$
$$+0.232\ X_1X_3+0.147\ X_1X_4-0.156\ X_1X_5-0.291\ X_2^2+0.157\ X_2X_3+$$

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+0.206 X_2X_4-0.231 X_2X_5-0.327 X_3^2+0.166 X_3X_4-
-0.225 X_3X_5+0.333 X_4^2-0.187 X_4X_5-0.992 X_5^2; (1)

- by the degree of weed destruction, %:

Y_2=98.209-0.257X_1+0.351X_2+0.357X_3+0.493X_4+0.440X_5+
+0.266X_1X_2+0.266X_1X_3+0.416X_1X_4-0.416X_1X_5-0.789X_2^2+0.416X_2X_3-
-0.265X_2X_5-0.557X_3^2-0.765X_3X_4-0.416X_3X_5-0.250X_4X_5-0.555X5^2; (2)

- by tensile strength of the rotary ripper, N:

Y_3=395.155+13.111X_1+38.037X_3-0.667X_4+9.537X_5+3.984X_1^2-
-12,979X_1X_2-13,104X_1X_3+11,484X_2^2+10,313X_2X_3-
-15.313X2X4-15.688X3X4+10.984X42; (3)

Analysis of the obtained regression equations (1) - (3) shows that all factors had a significant influence on the evaluation criteria.

The regression equations (1) - (3) were solved from the conditions that the criterion "Y1," the degree of soil crumbling is improved, i.e., the number of fractions with a size of less than 25 mm is higher than 75%, the criterion "Y2," weed loss is higher than 98%, and the criterion "Y3" has a minimum value, and the following variants of factors ensuring the fulfillment of these conditions were determined (Table 2).

Table 2

Optimal values of the rotary ripper

X_1		X_2		X_3		X_4		X_5		1	2	3
ode.	atural.	ode	ature	ode	ature	ode	ature	ode	ature			
-1.	0	0.5	13.	1.	5.	0.254	413		5.	6.3	8.	42.9
-1.	0		14.	1.	5.	0.217	411		5.	6.5	8.	38.7
-1.	0	.5	15.	1.	5.	0.648	432.		5.	6.4	8.	48.5
-1.	0	1.	12.	1.	5.	-0.577	371.	.	6.	7.1	8.	39.4
-1.	0	0.5	13.	1.	5.	-1.	350	.	6.	7.8	8.	34.3
-1.	0		14.	1.	5.	-0.684	366.	.	6.	7.3	8.1	39.3
-1.	0	.5	15.	1.	5.	-0.06	397.	.	6.	6.5	8.	48.2

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						4						
0	2.		14.	1.	.5	0.56	428.		.5	6.4	8.	369.3
0	2.	.5	15.	1.	.5	0.743	437.		.5	6.5	8.	366.4
0	2.		14.	1.	.5	0.402	4.20.	.	.6	6.1	8.	374.5
0	2.	.5	15.	1.	.5	0.761	438.	.	.6	6.	8.	376.3

To ensure the required quality of the unit's operation at a speed of 5.0-6.0 km/h with minimal energy consumption, the installation distance of cross-knives on the rotary ripper disk should be 2.0 cm, the number of cross-knives on the rotary ripper disk should be 12-15 pieces, the width of the cross-knives of the rotary ripper should be 5.0 cm, the vertical pressure force on the rotary ripper should be 350.0-438.0 N. At the unit speed of 5.0-6.0 km/h, taking into account the best options, we repeatedly optimize the number of cross-knives, taking 14 pieces, and obtain the following result (Table 3).

Table 3

Optimal values of the rotary ripper

X_1		X_2		X_3		X_4		X_5		1	2	3 Y
code.	natural.	code.	natural.	code.	natural.	code.	natural.	code.	natural.			N
-1.	0	0	14.	-1.	5.	0.217	411	0	5.	6.5	8.	338.7
0	2.	0	14.	-1.	5.	0.56	428.	0	5.	6.4	8.	369.
-1.	0	0	14.	-1.	5.	-0.684	366.	1.	6.	7.3	8.1	339.3
0	2.	0	14.	-1.	5.	0.402	4.20.	1.	6.	6.1	8.	374.5

Thus, at the working speeds of the unit 5.0-6.0 km/h and the number of cross-knives 14 pieces, the distance of installation of cross-knives on the rotary ripper disk should be 0.0-2.0 cm, the width of the cross-knives of the rotary ripper 5.0 cm, the vertical pressure force applied to the rotary ripper should be 366.0-428.0 N.

At these values of the factors, the degree of soil crumbling was 76.1-77.3%, the degree of weed destruction was 98.0-98.1%, and the draft resistance was 338.7-374.5 N.

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