

Determination of the Optimal Values of the Parameters of the Roller of a Combined Soil Tillage Machine

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Abstract: *In our country, winter wheat, which is sown on areas cleared from repeated crops, and vegetables and potatoes, which are sown as repeated crops on areas cleared from repeated crops, are sown on newly plowed areas, that is, immediately before planting. In this case, the plowed areas are prepared for row-track sowing, and then planting activities are carried out.*

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In our republic, the preparation of plowed areas for planting is carried out separately, using toothed and disk harrows and various levelers, in several passes. This leads to a deterioration in the physical and mechanical properties of the soil, a significant loss of moisture from the soil, and an increase in fuel consumption and other costs. An analysis of scientific achievements achieved worldwide and previous research conducted in our Republic shows that these shortcomings in the preparation of newly plowed land for sowing can be eliminated by developing a machine that combines all technological processes for preparing the soil for sowing (complete compaction of the topsoil, leveling and grinding the surface of the field) in one pass, that is, provides comprehensive and complete processing of the soil before sowing in one pass. The use of such a machine for pre-sowing tillage of newly plowed lands allows to significantly reduce fuel consumption and other costs by combining technological processes and reducing the number of passes of units over the field, as well as to increase productivity, improve the quality of soil cultivation and prevent moisture loss in it, sow crops in a timely manner and harvest crops.

Based on the above, a machine for pre-sowing tillage of plowed lands was developed at the KHMITI, and its experimental copy was prepared and tested [1].

This article presents the results of multi-factor experiments conducted to determine the optimal values of the parameters of the toothed-plate roller of the developed combined machine.

Table 1 presents the factors, their designations, change intervals and levels.

When conducting multifactorial experiments, the evaluation criteria were the degree of soil compaction in layers 0-10, that is, the amount of fractions smaller than 25 mm (Y1, %), density (Y2, g/cm³) and the relative resistance of the roller to gravity (Y3, N/m). It was assumed that the influence of factors on the evaluation criteria was fully described by a second-degree polynomial, and the experiments were conducted according to the B4 plan. [2].

In order to reduce the influence of uncontrolled factors on the evaluation criteria, the sequence of experiments was established using a table of random numbers [3]. In addition, in all experiments, the angle of installation of the roller slats relative to its axis was assumed to be 15°.

Table 1. Determination of factors, levels and intervals of change

Naming of factors	Unit of measurement	Definition of factors	Factors-of range of variation	Levels of factors		
				lower (-1)	main (0)	high (+1)
1. Plank roller diameter, D	см	X_1	5	35	40	45
2. Number of bars installed on the roller, n	дона	X_2	2	8	10	12
3. Vertical load on the plank roller, Q	Н/м	X_3	100	700	800	900
4. Unit speed, V	км/соат	X_4	2	5	7	9

The data obtained during the experiments were processed according to the "PLANEXP" program developed in the experiment planning laboratory of the Research Institute of Experimental Planning. In this case, the Cochran criterion was used to assess the homogeneity of variance, the Student's criterion to assess the value of regression coefficients, and the Fisher criterion to assess the adequacy of regression models.

The results of the experiment were processed in the prescribed manner, and the following regression equations were obtained, adequately expressing the evaluation criteria:

- by the degree of soil crumbling in the 0-10 cm layer (%)

$$Y_1 = +80,136 - 0,980X_1 + 1,674X_2 + 1,830X_3 + 2,494X_4 + 0,614X_1X_1 - 0,588X_1X_2 - 0,583X_1X_3 - 0,583X_1X_4 - 0,936X_2X_2 - 0,587X_2X_3 - 0,588X_2X_4 + 0,498X_3X_3 - 0,592X_3X_4 - 0,652X_4X_4 \quad (1)$$

by soil density in the 0-10 cm layer (g/cm^3)

$$Y_2 = +1,121 - 0,030X_1 + 0,026X_2 + 0,033X_3 - 0,060X_4 + 0,017X_1X_1 + 0,024X_1X_2 + 0,055X_1X_3 - 0,014X_1X_4 - 0,038X_2X_2 + 0,006X_2X_3 + 0,010X_2X_4 + 0,013X_3X_3 + 0,013X_3X_4 + 0,040X_4X_4 \quad (2)$$

- by the specific draft resistance of the plank roller (N/m)

$$Y_3 = +214,534 - 16,926X_1 + 14,870X_2 + 14,593X_3 + 27,315X_4 + 13,299X_1X_1 + 1,937X_1X_4 + 8,799X_2X_2 - 3,368X_3X_3 + 1,937X_3X_4 + 7,799X_4X_4 \quad (3)$$

Analysis of the obtained regression equations shows that all factors had a significant influence on the evaluation criteria. The regression equations were solved from the conditions that the criterion U_1 is greater than 80%, the criterion U_2 is in the range of 1.1-1.2 g/cm^3 , and the criterion U_3 has a minimum value, and it was determined that the rollers have the following parameters in the operating speed range of 6.0-8.0 km/h (Table 2).

Table 2. Optimal values of roller parameters

$V_e(X_4)$		$D(X_1)$		$n(X_2)$		$Q(X_3)$	
Coded	Natural, km/h	Coded	Natural, mm	Coded	Natural, mm	Coded	Natural, mm
-0,5	6	-0,125	39,38	0,116	10,23	0,593	0,86
0,5	8	0,012	40,06	0,237	10,47	0,356	0,83

Consequently, at a working speed of 6.0-8.0 km/h, to ensure high-quality tillage of the field surface at the required level with minimal energy consumption, the diameter of the rollers' discs should be 39.38-40.06 cm, the number of installed plates should be 10 pieces, and the vertical load applied to them should be in the range of 0.83-0.86 kN. In this case, the degree of soil crumbling is 80.48-82.03%, the density of the soil in the 10-20 cm layer is 1.12-1.18 g/cm³, and the specific draft resistance of the roller 214-239 N/m.

Conclusion

To ensure high-quality processing of the field surface at the required level with minimal energy consumption at working speeds of 6.0-8.0 km/h, the diameter of the toothed plank rollers should be 39.38-40.06 cm, the number of installed planks should be 10 pieces, and the vertical load on them should be in the range of 0.83-0.86 kN. In this case, the degree of soil crumbling is 80.48-82.03%, the soil density in the 10-20 cm layer is 1.12-1.18 g/cm³, and the specific draft resistance of the roller is 214-239 N/m.

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