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THE EFFECT OF SPECIFIC VERTICAL PRESSURE FORCE APPLIED TO THE ROLLER OF A COMBINED TILLAGE MACHINE ON PLOWED LAND ON ITS PERFORMANCE

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Abstract. In this article, the influence of the relative vertical pressure force applied to the roller of the combined plowing machine on plowed land on its performance was determined based on theoretical and experimental experiments, and the results were determined.

Key words. Combined, aggregate, leveler, rolling, moisture, density, fraction, pressure, force, experimental.

Currently, pre-planting of plowed fields for planting repeat and winter cereals is carried out with various separate aggregates, which leads to longer planting periods, loss of soil moisture and increased operating costs. It is possible to eliminate the shortcomings of plowed land by using machines that combine all the technological processes of preparing the soil for planting in one pass, including a machine equipped with a roller.

The combined units used in the pre-planting treatment of the lands perform some or all of the technological processes performed in the pre-planting treatment on them in one pass through the field. This leads to the reduction of the negative impact of tractors and agricultural machines on the soil, as well as the reduction of fuel consumption, the increase of work quality and yield, the shortening of the period of soil cultivation, and the preservation of moisture accumulated in it. Combined aggregates and machines that combine both basic and pre-planting technologies are currently widely used in developed countries with a high agricultural culture and enable high yields of agricultural crops with low labor and investment.

Currently, in foreign countries, various options of combined aggregates have been created to prepare the soil for planting, and various disc rollers and levelers are used as working parts for tillage.

Pre-tillage machines perform some or all of the tillage processes in one pass through the field. This leads to the negative impact of tractors and agricultural machines on the soil, as well as a decrease in fuel consumption, an increase in the quality and productivity of work, a reduction in the duration of soil cultivation, and the preservation of moisture accumulated in it [1;2].

This paper presents theoretical and experimental results of vertical loading applied to a roller for application in a combination machine.

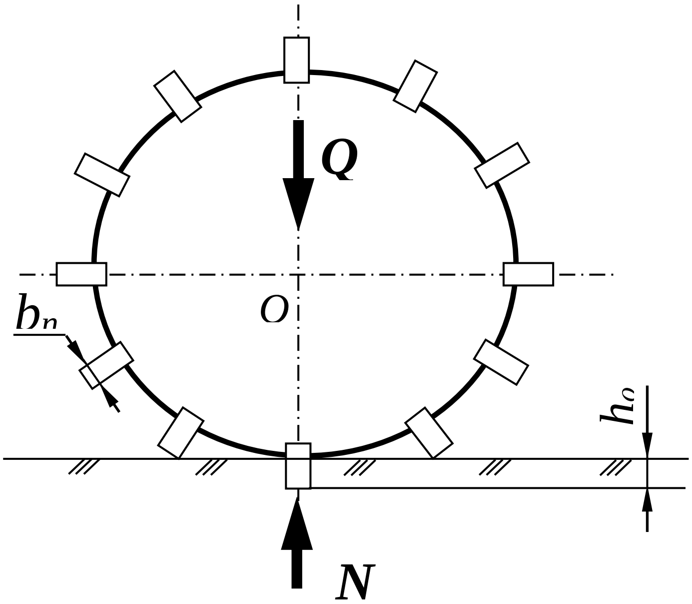
The vertical load applied to the roller was determined from the condition that it would sink to a specified depth and was generally expressed as follows (Fig. 1)

$$Q = N_1 + N_2, \quad (1)$$

in thisN_1 – vertical load required to sink the roller plates into the soil, N;

N_2– vertical load required to sink the foundation of the roller into the soil, N.

Figure 1. Scheme for determining the vertical load applied to the coil



We determine the vertical load required to sink the planks of the rollerinto the soil for one plank completely immersed in it, and it is equal to.

$$N_1 = \sigma b_n B, \quad (2)$$

in thisσ – relative resistance to vertical crushing of soil, Pa.

We can express s in the expression (1) by the volume compression coefficient of the soil, the speed of movement and the depth of immersion of the roller into the soil [6]

$$\sigma = q_0 \left(1 + K_v V_u^2\right) h_0, \quad (3)$$

in thisq_0 – volume compression coefficient of the soil, N/m^3;

K_v – proportionality coefficient, c^2/m^2.

Taking (3) into account, expression (2) is written as follows

$$N_1 = q_0 \left(1 + K_v V_u^2\right) h_0 b_n B. \quad (4)$$

We can express the vertical load required to sink the foundations of the roller into the soil as follows.

$$N_2 = \left(\frac{B}{l_a} + 1\right) N_A, \quad (5)$$

in this N_A – vertical load required to sink one base of the coil into the soil, N.

We determine N_A according to the following expression [3; 7]

$$N_A = q_0\left(1+K_v V_u^2\right)h_0 b_a\left(R-h_n+h_a\right)\left[\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}-\right.$$

$$\left.-\left(R-h_0+h_a\right)\arcsin\frac{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}}{R-h_n+h_a}\right]\cdot \quad (6)$$

Taking this into account, the expression (2.40) will have the following form

$$N_2 = q_0\left(1+K_v V_u^2\right)b_a\left(R-h_n+h_a\right)\left[\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}-\right.$$

$$\left.-\left(R-h_0+h_a\right)\arcsin\frac{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}}{R-h_n+h_a}\right]\left(\frac{B}{l_a}+1\right). \quad (7)$$

If we put the values of N_1 *and* N_2 according to expressions (4) and (7) into expression (3.36), the following expression is derived to determine the vertical load applied to the coil.

$$Q = Bq_0\left(1+K_v V_u^2\right)\left[h_0 b_n + b_a\left(R-h_n+h_a\right)\left\{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}-\right.\right.$$

$$\left.\left.-\left(R-h_0+h_a\right)\arcsin\frac{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}}{R-h_n+h_a}\right\}\left(\frac{B}{l_a}+1\right)\right]\cdot \quad (8)$$

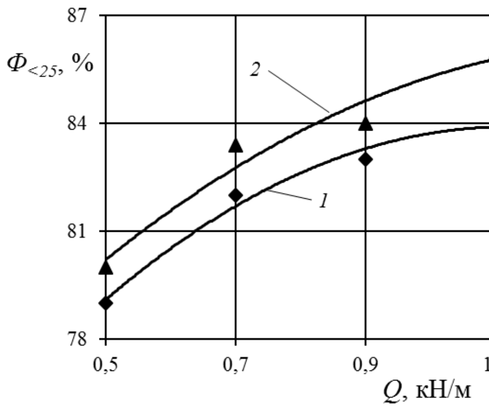
Dividing both sides of this expression by B, we determine the specific vertical load per unit span of the coil.

$$Q_c = q_0\left(1+K_v V_u^2\right)\left[h_0 b_n + b_a\left(R-h_n+h_a\right)\left\{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}-\right.\right.$$

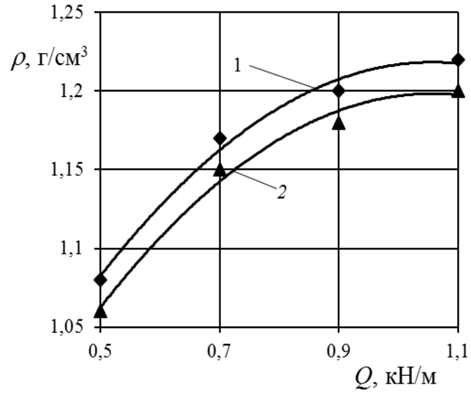
$$\left.\left.-\left(R-h_0+h_a\right)\arcsin\frac{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}}{R-h_n+h_a}\right\}n_a\right], \quad (8, a)$$

in this $n_a = \dfrac{B+l_a}{Bl_a}$ – the number of bases of the coil corresponding to the coverage width of 1 m, pieces/m.

d_k=0,1 m, h_0=0,05 m, φ_1=30°, φ_2=40°, b_n=0,01m, q_{01}=2·10^6 N/m^3, [4, 5]K_v=0,01 c^2/ m^2, b_a=0,006 m, h_n=0,04m,h_m=0,02m, h_a=0,02 m,l_a=0,25 м,n_a=4 pieces/m ва V_u=1,75-2,25 m/saccepted, calculations made according to the expressions, the diameter of the roller is at least 36 cm, the number of plates installed on it is 12 pieces, their length is 27 cm, the angle between the teeth of the roller is 90°, the step of the teeth of the plates is 4 cm, the diameter of the base of the roller is 30 cm, the vertical load given to each meter of its coverage width showed that it should be in the range of 1.04-1.06 kN/m [8,9]



a)



b)

1) *At V=6 km/hr*; 2) *V=8 km/hr*

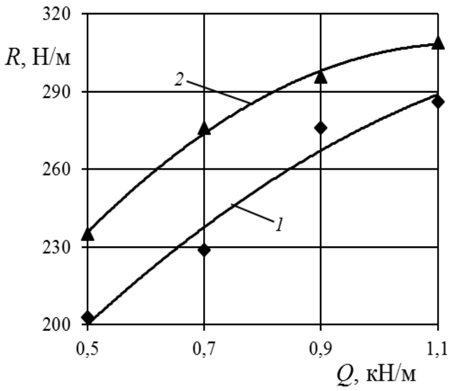


Figure 2. Changes in soil compaction (a), density (b) and rollingresistance (v) depending on the vertical compressive forceapplied to it

In the experiments, based on theoretical studies, the specific vertical load applied to the roller was changed from 500 N/m to 1100 N/m at intervals of 200 N/m, and the effect of these changes on its performance was studied. 10 pieces, the angle of installation of the planks relative to the axis of rotation of the roller was 15°.

The results of the experiments are presented in Picture 2. It can be seen from them that with an increase in the specific vertical pressure force applied to the roller, the level of soil compaction, that is, the amount of fractions with a size smaller than 25 mm in it, increased. This is due to the fact that with the increase of the vertical pressure force applied to the roller, the level of soil crushing of the roller plates increases, and as a result, the soil is well compacted.

Due to the above reason, the specific vertical load applied to the roller from 500 N/m to 1100 N/m increases its specific resistance to traction from 203 N/m to 286 N/m and from 235 N/m at travel speeds of 6 and 8 km/h, respectively. up to 309 N/m, and caused the soil density to increase from 1.08 g/cm^3 to 1.22 g/cm^3 and from 1.06 g/cm^3 to 1.2 g/cm^3, respectively [10]

The relationships shown in Picture 2 can be expressed by the following empirical formulas determined by the method of least squares:

a) according to the level of soil fertility (%):

When V=6 km/hr $\Phi_{<25}$= -8,75Q^2+23,3Q+70,748, (r^2=0,9528) (9)

When V=8 km/hr $\Phi_{<25}$=-12,5Q^2+28Q+68,225; (r^2 =0,9857) (10)

b) by soil density (g/cm³)according:.

When V=6 km/hr ρ=-0,4375Q^2+0,925Q+0,72938, (r^2=0,98911) (11)

When V=6 km/hr ρ = -0,4375Q^2+0.925Q+0,70938; (r^2 =0,98911) (12)

v) according to the specific resistance to traction (N/m) of the coil:

When V=6 km/hr P =-175Q^2+4015Q+78,95, (r^2=0,9969) (13)

When V=8 km/hr P =-100Q^2 +308Q+71,1. (r^2=0,9635) (14)

Based on the experimental researches, we can conclude that the compaction quality and density of the soil meet the agrotechnical requirements, and the vertical compressive force applied to it should be in the range of 700-900 N/m in order to ensure that the relative resistance to traction of the gear-plate roller is minimal.

According to the technical and economic calculations, the use of a row tillage machine on plowed lands equipped with a toothed plate roller reduces labor costs by 34.4% and costs per hectare of cultivated area by 38% [8; 9; 10]

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