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Research Article

OF COMPARATIVE VERTICAL PRESSURE FORCE ON ITS PERFORMANCE INDICATIONS

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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.

KEYWORDS

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

INTRODUCTION

Currently, pre-planting of plowed fields for planting repeat and winter cereals is carried out with a variety of 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.

of the lands perform some or all of the technological processes performed in the pre-planting treatment in one pass of the field. This leads to the reduction of the negative impact of tractors and agricultural machines

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on the soil, the reduction of fuel consumption, the increase of work quality and productivity, the reduction of the period of tillage, and the preservation of moisture accumulated in it. Combined aggregates and machines that combine the technologies of basic and pre-planting treatment to the soil are now widely used in developed countries with a high agricultural culture and allow to get a high yield of agricultural crops with low labor and investment.

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

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 is submerged to a specified depth and was generally expressed as follows (Fig. 1)

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

where N_1 is the requirement for immersing the roller plates into the soil

vertical load to be achieved, N;

N_2 - the requirement to sink the foundations of the roller into the ground vertical loading, N.

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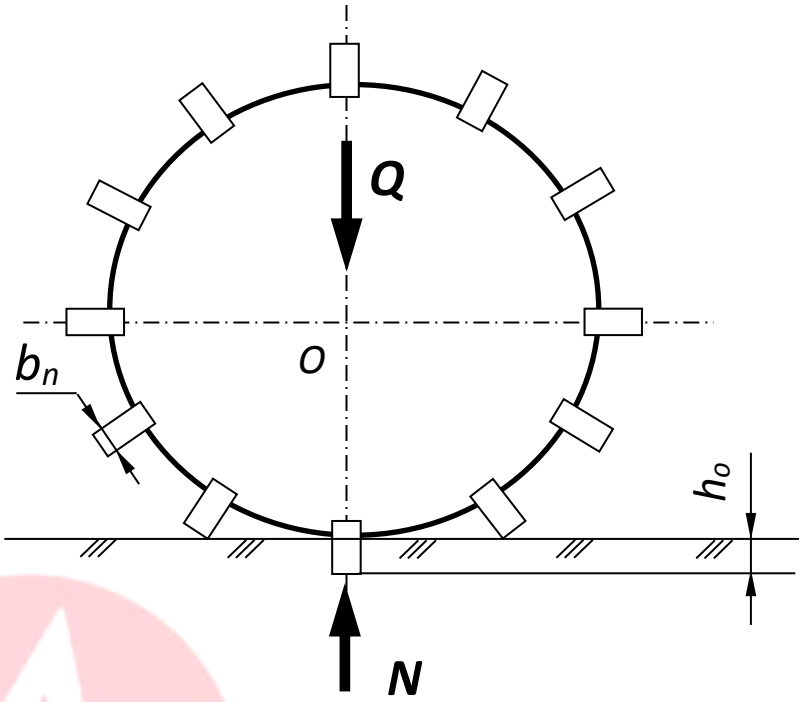

Figure 1. Scheme for determining the vertical load applied to the coil

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

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

where *s* is the relative resistance of the soil to vertical crushing, Pa.

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]

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

where q_o is the volume compression coefficient of the soil, N/m ^{3};

K_v – proportionality coefficient, s ^{2}/m ^{2}.

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

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

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

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

where N_A is the requirement for submerging one base of the roller into the soil vertical loading, N.

N_A according to the following expression [3; 7]

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

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

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

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

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

N_1 and N_2 according to the expressions (4) and (7) into the expression (3.36), the following expression is derived to determine the vertical load applied to the coil

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

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

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

$$Q_c=q_0\left(1+K_vV_u^2\right)\Bigg[h_0b_n+b_a\left(R-h_n+h_a\right)\Bigg\{\sqrt{2\left(R-h_n+h_a\right)\left(h_0-h_n+h_a\right)-\left(h_0-h_n+h_a\right)^2}-$$

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

where $n_a=\frac{B+l_a}{Bl_a}$ - the number of bases corresponding to the coverage width of 1 m of the coil, units/m. d_k=0.1 m, h_o=0.05 m, φ_1=30°, φ_2=40°, b_n=0.01 m, q_{o1}=2·10 ^{6} H/m ^{3}, [4 , 5] K_v=0.01 c ^{2} / m ^{2}, b_a=0.006 m, h_p=0.04 m, h_m=0.02 m, h_a=0.02 m, l_a=0, 25 m, n_a =4 units/m and V_u=1.75-2.25 m/s are accepted, and the calculations made according to the expressions mean that the diameter of the coil is at least 36 cm, the number of plates to be installed on it is 12 pieces, their length is 27 cm, the coil showed that the angle between the teeth is 90°, the step of the teeth of the planks is 4 cm, the diameter of the roller base is 30 cm, the vertical load applied to each meter of coverage should be in the range of 1.04-1.06 kN/m [8,9]

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 Figure 2. It can be seen from them that with the increase of the specific vertical pressure force applied to the roller, the degree of crushing of the soil, 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 degree 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 drag resistance from 203 N/m to

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286 N/m and from 235 N/m at 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 Figure 2 can be expressed by the following empirical formulas determined by the method of least squares:

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

V =6 km/h, $F_{<25}$ = -8.75 Q^2 +23.3 *Q* +70.748, (p^2 =0.9528) (9)

When *V* =8 km/h $F_{<25}$ =-12.5 Q^2 +28 *Q* +68.225; (r^2 =0.9857) (10)

b) by soil density (g/cm ^{3}):

r when V =6 km/h =-0.4375 Q^2 +0.925 *Q* +0.72938, (p^2 =0.98911) (11)

V = 8 km/h; when *r* = -0.4375 Q^2 +0.925 *Q* +0.70938; (p^2 =0.98911) (12)

c) according to the specific resistance of the coil to the pull (N/m):

V = 6 km/h, *R* = -175 Q^2 +4015 *Q* +78.95, (p^2 =0.9969) (13)

R =-100 Q^2 +308 *Q* +71.1 *when V* =8 km/h . (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 to ensure that the relative resistance of the gear-plate roller is minimal, the vertical pressure force applied to it should be in the range of 700-900 N/m.

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]

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