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Rationale of Roller Diameter

Sadulla Aminov
Candidate of Technical Sciences, Associate Professor, Karakalpak Research Institute of Agriculture, Project Manager, Chimbay, Uzbekistan.

Makhammatdin Urazbaevich Kaipov
Candidate of Technical Sciences, Karakalpak Research Institute of Agriculture, Senior Researcher of the Project, Chimbay, Uzbekistan.

Izimbet Rakhmetovich Turdymambetov
Doctor of Geographical Sciences, Associate Professor, Karakalpak State University named after Berdakha, Vice-Rector for Science and Innovation Works, Nukus, Uzbekistan

Bakhtiyar Pirniyazovich Artykbaev
PhD in technical sciences, senior researcher, Scientific Research Institute of Agricultural Mechanization, Head of the Laboratory, Yangiyul, Uzbekistan

Bakhtiyar Usenbayevich Nurabaev
Candidate of Technical Sciences, Karakalpak Agricultural and Agrotechnological Institute, Assistant of the Department of Agricultural Mechanization, Nukus, Uzbekistan.

***Abstract* - The article presents the results of a theoretical study to substantiate the diameter of a roller for pre-sowing soil compaction when combining soil cultivation and compaction with a roller.**

Keywords - Angle, Coefficient, Friction force, Roller diameter, Soil compaction, Soil density, Soil hardness, Technological process, Unloading.

When determining the diameter of the roller, it must be borne in mind that it significantly affects the compaction of the soil. Therefore, the diameter must be sufficient to meet the compaction and rolling requirements of the soil.

The diameter of the roller is usually chosen from the condition that it does not pull through soil clods [1,2,3], i.e. when it encounters a lump of soil, the roller must roll over it without pulling it forward. When rolling over a lump, the roller pressure is concentrated on it and the lump is destroyed or pressed into the soil. Otherwise, the soil is unloaded in front of the roller and the technological process of its work is disrupted.

The roller will roll over the soil lump if the lump is pinched between the roller rim and the soil surface (fig. 1). Consider the forces acting on the lump. When meeting the roller, the lump is affected by the pressure force of the roller N1, the friction force F1 of its rim, the reaction force of the soil N2 and the friction force of the soil surface F2.

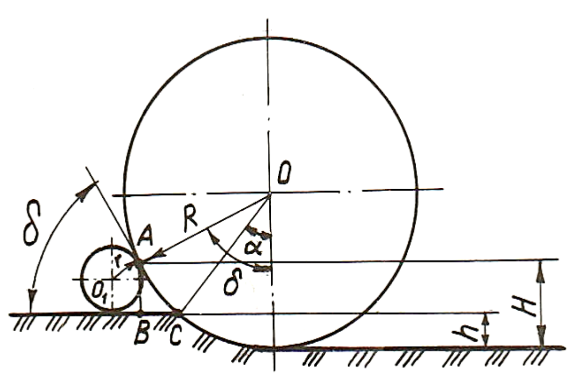

FIG. 1

Fig. 1. it follows that pinching a lump of soil between the roller rim and the soil surface is possible when:

$$F_2 + F_1 \cos\gamma \geq N_1 \sin\gamma , \qquad (1)$$

where γ is the angle between the tangent to the rim of the roller at the point of contact between the lump and the horizon.

It is known that

$$F_1 = N_1 tg\varphi \text{ и } F_2 = N_2 tg\varphi_1 ,$$

where φ1 is the angle of friction between the soil and the soil.

From the condition of the balance of forces acting on the lump, we obtain:

$$\varphi_2 = N_1 \cos\varphi + N_2 tg\varphi \sin\gamma \qquad (2)$$

Supplying in (1) the values of F1 and F2 and taking into account (2), we get:

$$N_1 \cos\gamma tg\varphi_1 + N_1 tg\varphi \sin\gamma tg\varphi_1 + N_1 \cos\gamma tg\varphi \geq N_1 \text{sir}$$

Reducing this expression by N1 and after some transformations, we get:

$$tg(\varphi + \varphi_1) \geq tg\gamma .$$

Where

$$\varphi + \varphi_1 \geq \gamma \qquad (3)$$

Thus, the lump will not be pulled in front of the roller if the angle γ is less than or equal to the sum of the angles of friction φ and φ1.

From Fig. 1 we have:

$$R - R\cos\gamma = H + h_0 , \qquad (4)$$

where H is the height of the soil lump.

Solving (4) with respect to the radius of the roller, we get:

$$R = \frac{H + h_0}{1 - \cos\gamma} = \frac{H + h_0}{2\sin^2 \gamma/2} \qquad (5)$$

Taking into account (3) and replacing the radius of the roller with its diameter, we get:

$$D \geq \frac{H + h_0}{\sin^2\left(\frac{\varphi + \varphi_1}{2}\right)} \qquad (6)$$

Taking into account (6.1), this expression has the following form:

$$h_0 = h_T = h_1(1 - \frac{\rho_0}{\rho}) , \qquad (6.1)$$

where h1 is the depth of the compacted layer, which is equal to the processing depth of KFG-3.6 (15-18 cm);

ρ0 - soil density after passing KFG-3.6;

ρ is the density of the soil prepared for sowing.

$$D \geq \frac{H\rho + h_1(\rho - \rho_0)}{\rho \sin^2\left(\frac{\varphi + \varphi_1}{2}\right)} \qquad (7)$$

Unlike the known formulas, this formula takes into account the depth of the compacted layer, the initial and required soil density.

It follows from this expression that the diameter of the roller depends on the size of the soil lump, the depth of the compacted layer, the density of the soil before and after compaction, as well as the coefficients of friction of the soil against metal and against the soil.

In expression (7), the values of H, ρo, ρ and especially φ and φ1, depending on the type and condition of the soil, vary within significant limits. Therefore, in order for the roller to be efficient in a wide range of operating conditions, the calculations must be guided by the highest values of H, h, ρ and the values of ρo, φ and φ1.

Substituting into (7) the largest size of the soil lump after the passage of KFG-3.6 N = 10 cm [4], the greatest processing depth h = 18 cm and taking for medium-heavy loamy soil ρ = 1.29 g / cm3, ρo = 1.16 g / cm3, φ = 350 and φ1 = 440, we get D≥ 290 cm.

Thus, for the roller to work without unloading, its diameter must be at least 0.29 m.

It should be noted that the roller diameter also has a significant effect on soil compaction [5,6,7]. Under other conditions, an increase in the diameter of the roller leads to a decrease in the depth of its track, and, consequently, to a decrease in soil compaction and vice versa. In addition, an increase in the diameter of the roller also leads to an increase in its metal consumption.

In this regard, a certain value of the roller diameter should be considered as the most permissible.

The objective of the experimental research was to obtain empirical dependences that determine the effect of the diameter of the roller, the specific load on it and the speed of its movement on the magnitude and nature of soil compaction.

Compaction of the soil by rollers can be characterized by the density and hardness and depth of the track.

Research results carried out at Q_y = 2.5 kN⁄m and v = 1.7 m⁄s show that soil density and hardness (at a depth of 0-10 cm) and track depth decrease with increasing roller diameter on all types of soils.

So, on medium loamy soil with a roller diameter of 0.25 m, the soil density was ρ = 1.28 g⁄〖cm〗^3, the hardness T = 0.43 MPa, and the rut depth

h = 2.2 cm, and with a diameter of 0.5 m, respectively ρ = 1.21 g⁄〖cm〗^3, T = 0.36 MPa, h = 1.6 cm, or density by 0.07 g⁄〖cm〗^3, hardness 0.07 MPa, track depth 0.6 cm less.

This is due to the fact that with an increase in the diameter of the roller, the contact surface of the roller on the soil increases, which leads to a decrease in the specific pressure.

A more significant change in the density, hardness and depth of the track is observed on light loamy soil, and heavy loamy soil is less amenable to compaction.

It was found that with a roller diameter of 0.25 m and on light loamy soil, there is some unloading of the soil. In other cases, unloading was not observed.

REFERENCES

[1] Klenin, N.I., & Sakun, V.A. (1994). *Agricultural and reclamation machines.* M.: Kolos.

[2] Mamatov, F.M. (2007). Agricultural machinery. Tashkent: Fan, 340.

[3] Aminov, S. (1988). *Substantiation of the parameters of the compaction roller for the pre-sowing tool for cotton growing.* Abstract of the thesis. diss. ... Cand. tech. sciences. - Yangiyul: SAIME, 16.

[4] Agrotechnical requirements for a universal tool for loosening, fertilizing, leveling and compaction of the soil before sowing. 1983. - No. 1385. 4.

[5] Klenin N.I., Popov N.F., Sakun V.A. Agreecultural machines. *Agreecultural equipment. M.: Kolos.* S. 75-86.

[6] Skorik, V.I. (1965). *Investigation of some questions of the process of interaction of smooth rollers and soil.* Diss. Cand. tech. sciences. M. 160.

[7] Kuznetsov, Yu. I. (1981). Improvement of ring-spur rollers and reduction of their metal consumption. *Tractors and agricultural machines, 5,* 31-32.