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Resistance of the Work Organ Used to Apply Organo-Mineral Fertilizers to the Cotton Row

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Annotation

The article describes the development of a work organ for the application of organo-mineral fertilizers between the rows of cotton, and according to the results of theoretical research, the tensile resistance of the work organ should be in the range of 623.1-884.7 N to ensure quality application of organic-mineral fertilizers between cotton rows with low energy consumption. highlighted.

Keywords: cotton, organo-mineral fertilizers, working organ, wedgener, sharpened handle (column), fertilizer-carrying part, traction resistance.

This paper presents the results of theoretical studies conducted to determine the gravitational resistance of the work organ [1, 2], designed to put a mixture of organic and mineral fertilizers between the rows of cotton.

The work organ consists of a chisel, the front part of which consists of a sharpened handle (column) and fertilizer-carrying parts, the total resistance of which to gravity can be expressed as follows.

$$R_t = R_w + R_h + R_f \text{ , (1)}$$

in this R_t– the total resistance of the work organ to gravity;

R_w – the traction resistance of the work organ wedge;

R_h – the traction resistance of the work organ handle;

R_f – the tensile resistance of the fertilizing part of the work organ.

The work organ wedge is designed in the form of a two-sided flat-surfaced pile, on which a softened (in previous cultivation) layer is applied to the entire soil. With this in mind, its resistance to gravity can be determined by the following expression [3, 4]

$$R_u = K_b H t_b l + [\tau_u] \frac{w \cos\frac{1}{2}(\alpha+\varphi_1+\varphi_2) + T_2 tg\left(\frac{\pi}{4}-\frac{\varphi_2}{2}\right)}{\cos\frac{1}{2}(\alpha+\varphi_1+\varphi_2)} \times$$

$$\times T_2[\sin\frac{1}{2}(\alpha+\varphi_1+\varphi_2) + tg\varphi_1 \cos\frac{1}{2}(\alpha+\varphi_1+\varphi_2)\cos\alpha] +$$

$$+\left\{ w(T_2\rho_2 + T_1\rho_1)Lgtg(\alpha+\varphi_1) + 2\left[(w + T_2 ctg\psi_{s2}) + T_2\rho_2 + \right.\right.$$

$$\left. + (2T_2 ctg\psi_{s2} + w + T_1 ctg\psi_{s1})T_1\rho_1\right] \times$$

$$\left. \times V^2 \frac{\sin\alpha \sin(\alpha+\varphi_1)}{\cos^2\frac{1}{2}(\alpha+\varphi_1+\varphi_2)\cos\varphi_1} \right\}\left(1+\frac{M}{100}\right), \quad 1$$

in this K_b – a factor that takes into account the shape of the wedgening blade;

H– soil hardness;

T_b, l – the thickness and length of the wedge blade;

τ_u – specific resistance to soil displacement;

w – the width of the wedge;

α – the angle of entry of the scythe into the ground;

φ_1, φ_2 – external and internal friction angles of the soil;

T_1, T_2 – the thickness of the softened and monolithic soil layers affected by the wedge;

ρ_1, ρ_2 – the density of the softened and monolithic soil layers affected by the wedge.;

L – the length of the working surface of the wedge;

g – free fall acceleration;

M – soil moisture;

Ψ_{s1}, ψ_{s2} – lateral fracture angle of loosened and solid soil layers.

The working part of the work organ holder, i.e. the part that sinks into the ground, is sharpened, and its impact on the ground can be seen as the effect of a two-sided vertical plow. It pushes the soil layer loosened during the work (in the previous processing between the rows of cotton and by the wedge of the work organ) in two directions. Based on these assertions, we determine the gravitational resistance of the work organ holder using the theorem of change of the amount of motion of the soil particles interacting with it [5, 6].

The equation representing the change in the amount of soil movement in which the right or left side of the work organ handle interacts is as follows

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$$Ndt = dm(V_N - V_{NO}), \quad (2)$$

in this N – the normal force generated on the working surface of the handle;

t – time;

m – the mass of soil particles that interact with the right or left side of the work organ holder;

V_N – projection of the absolute velocity of soil particles to the normal (perpendicular) to the working surface of the handle;

V_{N0} – the initial velocity of the soil fragments.

Given that the initial velocity of the soil particles is zero, expression (2) has the following form

$$N = \frac{dm}{dt} V_N \quad (3)$$

The mass of soil particles that interact with the right or left side of the handle in a unit time

$$\frac{dm}{dt} = \rho_1 \frac{w_h + (h - L\sin\alpha)ctg\,\psi_{ё1}}{2}(h - L\sin\alpha)V\left(1 + \frac{M}{100}\right), \quad (4)$$

in this w_h– the width of the handle.

Putting the value of dm/dt on (4) to (3) and assuming that $V_n = V\sin\gamma_T$(in this γ_T is half the angle of sharpening of the front part of the handle) we obtain the following

$$N = 0{,}5\rho_1[b_w + (h - L\sin\alpha)ctg\,\psi_{s1}](h - L\sin\alpha)V^2 \sin\gamma_T\left(1 + \frac{M}{100}\right) \quad (5)$$

Given this force and the frictional force generated by it, the tensile resistance of the handle is equal to

$$R_h = 2N\frac{\sin(\gamma_T + \varphi_1)}{\cos\kappa_1} = \rho_1[w_h + (h - L\sin\alpha)ctg\,\psi_{s1}]\times$$
$$\times(h - L\sin\alpha)V^2\sin\gamma_T\frac{\sin(\gamma_T + \varphi_1)}{\cos\varphi_1}(1 + \frac{M}{100}). \quad (6)$$

Determining the traction resistance of the fertilizing part of the work organ in the above order, we obtain the following expression

$$R_f = 0{,}5\rho_1[(w_f - w_h) + hctg\,\psi_{f1}]hV^2\sin\gamma_f\frac{\sin(\gamma_f + \varphi_1)}{\cos\varphi_1}(1 + \frac{M}{100}), \quad (7)$$

in this b_f – the width of the fertilizing part of the work organ;

γ_f– The angle of installation of the work organ fertilizer part relative to the direction of movement of the chest.

To determine the total resistance of the work organ to gravity, we obtain the following expression by substituting the values of R_w, R_h and $R_f$for expressions (2), (6), and (7) into expression (1).

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$$R_t = K_b H t_b l + [\tau_u]\,\frac{w\cos\frac{1}{2}(\alpha+\varphi_1+\varphi_1)+T_2 tg(\frac{\pi}{4}-\frac{\varphi_2}{2})}{\cos\frac{1}{2}(\alpha+\varphi_1+\varphi_2)}\times$$

$$\times T_2\left[\sin\frac{1}{2}(\alpha+\varphi_1+\varphi_2)+tg\varphi_1\cos\frac{1}{2}(\alpha+\varphi_1+\varphi_2)\cos\alpha\right]+$$

$$\Big\{b(T_2\rho_2+T_1\rho_1)Lgtg(\alpha+\varphi_1)+2[(b+T_2ctg\psi_{s2})T_2\rho_2+$$

$$+(2T_2ctg\psi_{s2}+w+T_1ctg\psi_{s1})T_1\rho_1]V^2\frac{\sin\alpha\sin(\alpha+\varphi_1)}{\cos^2\frac{1}{2}(\alpha+\varphi_1+\varphi_2)\cos\varphi_1}+$$

$$+\rho_1 b_b+(h-L\sin\alpha)ctg\psi_{s1}](h-L\sin\alpha)V^2\sin\gamma_b\frac{\sin(\gamma_b+\varphi_1)}{cos\varphi_1}+$$

$$0{,}5\rho_1[(w_f-w_b)+hctg\psi_{f1}]hV^2\sin\gamma_f\frac{\sin(\gamma_f+\varphi_1)}{\cos\varphi_1}\Big\}\left(1+\frac{M}{100}\right). \qquad (8)$$

The analysis of this expression shows that the gravitational resistance of the work organ depends on the physical and mechanical properties of the soil (S, $[\tau_u]$, φ_1, φ_2, T_1, T_2, ρ_1, ρ_2, ψ_{s1}, ψ_{s2}),, its density (w, L, α), depending on the parameters of the handle (w_f, γ_f) and the conductive part of the fertilizer (w_f, γ_f), the depth of fertilizer application (h) and the speed of movement of the aggregate. (8) using the expression it is possible to calculate the total resistance of the work organ to gravity and also to determine the contribution of each organizer [7, 8] according to the data given in the literature K_b=1; S=2,5·10^6 Pa, t_T=0,001 m; w_h=0,02 m; $[\tau_4]$=2·10^4Pa, w=0,02; α=30°; γ_h=γ_f=30°; φ_1=30°; φ_2=40°; T_2=0,05 м; T_1=0,15m; ρ_1=1100 kg/m^3; ρ_2=1320 kg/m^3; L=0,1 m; g=9,81 m/s^2; M=12 %; ψ_{s1}=60°; ψ_{s2}=50°; h=0,2m; w_f=0,06 m ва γ_f=30°; assuming that b_o = 0.06 m and g_o = 30 °, the calculations made by expression (8) show that the gravitational resistance of the work organ in the range of velocities V=1,5–2,5 m/s is 623.1-884.7 N. of which 85-87 per cent falls on the scythe, 6-7 per cent on the handle and 7-8 per cent on the fertilizer-carrying part.

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