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DETERMINATION OF THE TRACTION RESISTANCE OF THE WORKING ORGAN USED FOR APPLYING ORGANO-MINERAL FERTILIZERS BETWEEN COTTON ROWS

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Annotation. The article describes the structure, working parts and parameters of the working organ fertilizer diverter used for applying organo-mineral fertilizers between cotton rows. In addition, the theoretical justification comprises information general resistance of the working organ, which applies fertilizer between the rows of cotton. According to the results of theoretical research, the working organ performs the specified technological process reliably and its performance indices correspond to the requirements imposed on it.

Keywords: pin, handle, fertilizer transmit part, soil layer, organo-mineral fertilizer, fertilizer guide, fertilizer transmit throat

In the world, scientific-research works aimed at developing new scientific and technical bases of resource-saving technologies of fertilizing plants and the technical means that implement them are being carried out. In this direction, the development of the constructive scheme of the working organs that apply a mixture of organic and mineral fertilizers, justification of technological processes, the implementation of scientific research on the provision of resource efficiency in the processes of their interaction with fertilizers and soil are considered to be one of urgent and necessary issues.

In world practice, various machines and working parts which ensure the high-quality execution of the processes of plant feeding and inter-row processing have been developed. They are recommended for constructing organizations to design new cars.

In the experiments conducted by Uzbek Scientific Research Institute of Cotton Breeding (Uz.SRICB) (S.A.Kudrin, F.N.Skryabin), while organic and mineral fertilizers were applied to cotton, the plant's use of nitrogen was 51 and 49%, and phosphorus use was 36%, without organic fertilizers, nitrogen absorption without organic fertilizer was 43 and 48% and phosphorus was 14- 15% only [21; pp. 296–331].

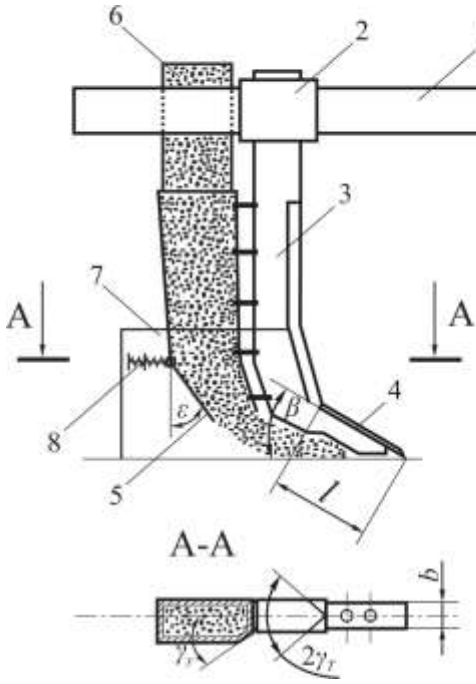
A.Sultanov studied the state of adding organic and mineral fertilizers to cotton sown on gray soil and determined that when organic-mineral fertilizers were added together, the shedding of flowers and buds decreased by 3-11% compared to when only mineral fertilizers were added [13]. At the same time, productivity increased from 1.7 c/ha to 3.8 c/ha.

According to T.P.Pirokhunov, application of organic fertilizers together with phosphorus increased the mass of cotton roots up to 21.4-37% [14].

A number of scientists, including L.S.Golyshev, G.M.Rudakov, A.Kh.Khadjiev, G.M.Kiselev, T.Khidirov, S.Khusainov, M.Mamadaliev, I.Atajanov, A.Shadiev, Z.Botirov, N.M.Komilov and others carried out scientific-research works on the development, testing and substantiating of the constructions of working organs and machines that apply fertilizers to different layers of the soil between the rows.

When processing the rows of cotton, the working organ that applies the mixture of organo-mineral fertilizers will consist of a lock 1, gryadil 2, handler 3, chisel 4, fertilizer guide 5, fertilizer transmit throat 6, a ground barrier 7 and an adjustment device 8. Its technological working process is as follows: the fertilizers falling from the fertilizer conveyer pass through the fertilizer conveyer throat 6, then they go to fertilizer guide 5 and to the depth of plant bed which is opened by chisel of the working organ.

The main parameters affecting the quality and energetic performance of the working organ, which puts a mixture of organic and mineral fertilizers between the rows of cotton, are as follows: *b* - the width of the chisel of the working organ, m; *l* - the length of the chisel of the working organ, m; β - angle of entry of the working organ entering the ground, °; γ_T - is the sharpening angle of the handle of the working organ, °; γ_y – installation angle of the symmetrical side of the fertilizer transmit part of the working organ relative to the direction of movement, °; ε - the angle of installation of the fertilizer guide relative to the vertical, °. (See Figure 1).



1- beam; 2- lock; 3- handle; 4- chisel; 5 – fertilizer guide; 6- fertilizer transmit throat; 7- ground barrier; 8- correction device

Figure 1. The scheme of the working organ that applies organo-mineral fertilizers between cotton rows

The working organ consists of a chisel, a handle (column) with a sharpened front part and fertilizer transmit parts. Its general resistance to traction can be expressed as follows [15]

$$R_y = R_u + R_T + R_{\breve{y}}\,, \tag{1}$$

here R_y is the total resistance of the working organ to traction, N;
R_u is resistance of the working organ of chisel to traction, N;
R_T is the resistance of the handle of the working organ to traction, N;
$R_{\breve{y}}$ is the resistance of the fertilizer-transmit part of the working organ to traction, N.

The chisel of the working organ is designed in the form of a two-sided flatsurface of plow, and affects the solid soil on which there is a softened (in previous cultivation) layer. Taking this into account, its resistance to traction can be determined according to the following expression [16]

$$R_u = K_{ш} T t_T l + [\tau_к] \frac{b\cos\frac{1}{2}(\alpha+\varphi+\rho) + H_2 tg\left(\frac{\pi}{4}-\frac{\rho}{2}\right)}{\cos\frac{1}{2}(\alpha+\varphi+\rho)} \times$$

$$\times H_2 [\sin\frac{1}{2}(\alpha+\varphi+\rho) + tg\varphi\cos\frac{1}{2}(\alpha+\varphi+\rho)\cos\alpha] +$$

$$+ \Big\{ b(H_2\rho_2 + H_1\rho_1) Lg tg(\alpha+\varphi) + 2\big[(b + H_2 ctg\psi_{ё2}) + H_2\rho_2 +$$

$$+ (2H_2 ctg\psi_{ё2} + b + H_1 ctg\psi_{ё1}) H_1\rho_1\big] \times$$

$$\times V^2 \frac{\sin\alpha\sin(\alpha+\varphi)}{\cos^2\frac{1}{2}(\alpha+\varphi+\rho)\cos\varphi} \Big\} \left(1+\frac{W}{100}\right), \qquad (2)$$

here $K_{ш}$ is a coefficient that takes into account the shape of the chisel blade;
T is soil hardness, Pa;
t_T, l – thickness and length of the chisel blade, m;
H_1, H_2 – thickness of the layers of softened and compacted soil affected by the chisel, m;
ρ_1, ρ_2 – density of layers of softened and compacted soil affected by chisel, kg/ m^3;
g– acceleration of free fall, m/ s^2;
W – soil moisture, %;
$\psi_{ё1}$, $\psi_{ё2}$ – lateral fracture angle of softened and solid soil layers, °.

The working part of the handle of the working organ, which sinks into the soil, is sharpened, and its impact on the soil can be considered as the impact of a two-sided vertical plow. It pushes the softened soil layer to both sides during the work process (during the previous processing between the cotton rows and by the working organ's chisel). Based on these points, we can find the resistance to traction of the handle of the working organ, by using the theorem of change in the amount of soil particles that interact with it [17].

The equation representing the change in the amount of soil movement with the right or left side of the handle of the working organ is as follows

$$Ndt = dm(V_N - V_{NO}), \tag{3}$$

here *N* is the normal force generated on the working surface of the handle, N;
t – time, s;
m – mass of soil particles which were in interaction with the right or left side of the handle of the working organ, kg;
V_N normal (perpendicular) projection of the absolute speed of soil particles to the working surface of the handle, m/s;
V_{N0} – the initial speed of soil particles, m/s.

Taking into account that the initial velocity of soil particles is zero, the expression (3.43) has the following form:

$$N = \frac{dm}{dt} V_N \tag{4}$$

Mass of soil particles interacting with the right or left side of the handle per unit time

$$\frac{dm}{dt} = \rho_1 \frac{b_T + (h - L\sin\alpha) ctg\,\psi_{ё1}}{2} (h - L\sin\alpha) V \left(1 + \frac{W}{100}\right), \tag{5}$$

here b_T is the width of the handle, m.

Putting the value of *dm/dt by* (5) into (4) and taking into account that $V_n = V \sin\gamma$ (here γ is half of the sharpening angle of the front part of the handle), we get the following:

$$N = 0{,}5\rho_1 [b_T + (h - L\sin\alpha) ctg\,\psi_{ё1}] (h - L\sin\alpha) V^2 \sin\gamma \left(1 + \frac{W}{100}\right) \tag{6}$$

Taking into account this force and the resulting frictional force, the traction resistance of the handle is equal to:

$$R_T = 2N \frac{\sin(\gamma + \varphi_1)}{sos\kappa_1} = \rho_1 [b_T + (h - L\sin\alpha) ctg\,\psi_{ё1}] \times$$

$$\times (h - L\sin\alpha) V^2 \sin\gamma \frac{\sin(\gamma + \varphi_1)}{\cos\varphi_1} (1 + \frac{W}{100}) \tag{7}$$

By determining the traction resistance of the fertilizer transmit part of the working organ in the above order, we get the following expression:

$$R_{\breve{y}} = 0{,}5\rho_1[(b_{\breve{y}} - b_T) + hctg\,\psi_{\ddot{e}1}]hV^2 \sin\gamma_{\breve{y}} \frac{\sin(\gamma_{\breve{y}} + \varphi_1)}{\cos\varphi_1}(1 + \frac{W}{100}), \quad (8)$$

here $b_{\breve{y}}$ - is the width of the fertilizer transmit part of the working organ, m;
$\gamma_{\breve{y}}$ - installation angle the part of the working organ that transmits fertilizer relatively to the chest in the direction of movement, grade.

Putting the value expressions of R_u, R_T and $R_{\breve{y}}$ into the expression (1) according to the expressions (2), (7) and (8), we get the following expression to determine the total resistance of the working organ to traction.

It can be seen from the analysis of this expression that the resistance of the working organ depends on the physical and mechanical properties of the soil (T, $[\tau_u]$, φ_1, ρ, H_1, H_2, ρ_1, ρ_2, $\psi_{\ddot{e}1}$, $\psi_{\ddot{e}2}$), parameters of its chisel (b, L, α), handle (b_T, γ) and fertilizer transmit part ($b_{\breve{y}}$, $\gamma_{\breve{y}}$), depth of fertilizer application (h) and the speed of aggregate movement. Using the expression (9), it is possible to calculate the total resistance of the working organ to traction and determine the contribution of each component. Due to the reference given in literature, $K_{ш}$=1; T=2,5·10^6 Pa, t_T=0,001 m; b_T=0,02 m; $[\tau_u]$=2·10^4 Pa, b=0,02; α=30°; γ=$\gamma_{\breve{y}}$=30°; φ_1=30°; ρ=40°; H_2=0,05 m; H_1=0,15 m; ρ_1=1100 kg/m^3; ρ_2=1320 kg/m^3; L=0,1 m; g=9,81 m/s^2; W=12 %; $\psi_{\ddot{e}1}$=60°; $\psi_{\ddot{e}2}$=50°; h=0,2 m; $b_{\breve{y}}$=0,06 m and $\gamma_{\breve{y}}$=30° are accepted and will have the following:

$$R_y = K_ш T t_T l + [\tau_u] \frac{b\cos\frac{1}{2}(\alpha+\varphi+\rho) + H_2 tg(\frac{\pi}{4} - \frac{\rho}{2})}{\cos\frac{1}{2}(\alpha+\varphi+\rho)} \times$$
$$\times H_2\left[\sin\frac{1}{2}(\alpha+\varphi+\rho) + tg\varphi\cos\frac{1}{2}(\alpha+\varphi+\rho)\cos\alpha\right] +$$
$$\Big\{ b(H_2\rho_2 + H_1\rho_1)Lgtg(\alpha+\varphi) + 2[(b + H_2 ctg\,\psi_{\ddot{e}2})H_2\rho_2 +$$
$$+ (2H_2 ctg\,\psi_{\ddot{e}2} + b + H_1 ctg\,\psi_{\ddot{e}1})H_1\rho_1]V^2 \frac{\sin\alpha\sin(\alpha+\varphi)}{\cos^2\frac{1}{2}(\alpha+\varphi+\rho)\cos\varphi} +$$
$$+ \rho_1 b_T + (h - L\sin\alpha)ctg\,\psi_{\ddot{e}1}](h - L\sin\alpha)V^2\sin\gamma\frac{\sin(\gamma+\varphi_1)}{cos\,\varphi_1} +$$
$$0{,}5\rho_1[(b_{\breve{y}} - b_T) + hctg\,\psi_{\ddot{e}1}]hV^2\sin\gamma_{\breve{y}}\frac{\sin(\gamma_{\breve{y}}+\varphi_1)}{\cos\varphi_1}\Big\}\left(1 + \frac{W}{100}\right). \quad (9)$$

Calculations based on the expression (9) showed that the resistance of the working organ to traction composed 623,1-884,7 N in the range of speeds V=1,5–

2,5 m/s and here 85–87 percent is applied to the chisel, 6–7 percent to the handle and 7-8 percent corresponds to the fertilizer-transmit part.

Conclusions

1. The interaction of the fertilizing cone with the soil during the growing season between the rows of cotton, the processes of the direction of fertilizers in the fertilizer conveyor were studied, and on this basis, analytical connections that give the opportunity to determine their parameters were calculated.

2. The condition and development prospects of the constructions of technical equipment used in the application of organomineral fertilizers to cotton rows, as well as the results of the research conducted on them, show that their composition allows to improve the fertilization working organs and to optimize their parameters.

3. Increasing the efficiency of organic and mineral fertilizers applied between cotton rows leads to reduction of the material and energy capacity of the cultivator-feeder.

4. In order to ensure that the fertilizers are evenly sprinkled on the bottom of the plant bed created by the working organ, they should move along the guide, and for this, the angle of its installation relative to the vertical should not exceed 18° and the cross section of the fertilizer should be symmetrical.

5. Speeds of V=1,5–2,5 m/s between rows of cotton plant showed that the resistance of the working organ is 623.1-884.7 N, of which 85-87 percent is on the chisel, 6-7 percent is on the handle, and 7- 8 percent corresponds to the part that transmits fertilizer.

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