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SCIENTIFIC RESULTS ON TECHNOLOGICAL PROCESS OF VARIOUS LEVEL FERTILIZERS APPLICATION AND SOWING SEEDS WITH A COMBINED SEEDER

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Abstract

The design-technological scheme and design of the combined opener for laying and embedding of seeds of grain crops and granules of mineral fertilizers at their multilevel application have been substantiated and developed. It has been substantiated that the most urgent is the sowing of grain crops with simultaneous multilevel fertilization below the sowing bed with the formation of a soil layer, which ensures uniform distribution of seeds and fertilizers over the area of application and allows the most rational use of mineral fertilizers and reduce labor and production costs for production. The technique of researching the technological process of multilevel fertilization and sowing of seeds is presented. The results are determined based on theoretical research. The values of design parameters have been determined: the width of the bed seal (7 ... 25 mm), the distance between the planes of the outlet of the guide and the seed tube (20 ... 80 mm), the distance from the base of the outlet of the guide to the U-shaped harrow (40 ... 50 mm).

Key words: *opener, soil, seeder, ecology, furrow former.*

INTRODUCTION

According to the results of an analytical review of modern designs of openers for laying and embedding seeds of grain crops and granules of mineral fertilizers with their multilevel application, double-disc openers are most suitable for high-quality sowing. However, they have a number of disadvantages, which include: loosening of the walls and bottom of the furrow, shattering of the furrow during the placement of seeds along its bottom, the absence of a stable soil layer between the seeds and fertilizers, as well as the uneven flow of seeds and the ingress of seeds onto the rotating discs of the opener. All this reduces the quality of sowing, which leads to a decrease in crop yields and an increase in production costs.

Currently, we have made a combined opener with a U-shaped harrow (Figure 1) for laying and embedding seeds of grain crops and granules of mineral beads at their multilevel application. Since this combined opener was used for the first time, the task of theoretical research includes the determination of the necessary design parameters.

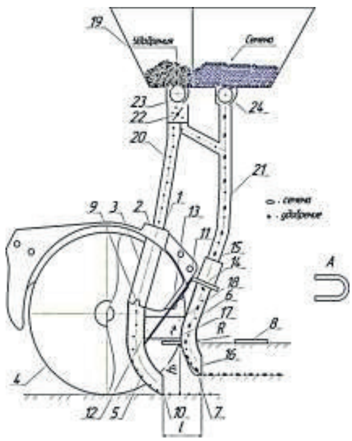

Figure 1. Structural and technological diagram of a combined opener with a U-shaped harrow for laying and embedding seeds of grain crops and granules of mineral fertilizers with their multilevel application: 1 - rack; 2 - neck; 3 - funnel; 4 - discs; 5 - directional note; 6, 21 - seed tube; 7 - bed sealant; 8 - closing working body; 9 - eyelet; 10 - outlet; 11 - bracket; 12 - stiffening rib; 13 - scrapers; 14 - shelf; 15 - neck; 16 - outlet; 17 - U-shaped harrow; 18 - bar; 19 - bunker; 20 - pipeline; 22 - fertilizer flow divider; 23 - fertilizer dispenser; 24 - sowing device; l is the distance between the planes of the outlet openings of the guide and the seed tube; h1 - distance from the base of the outlet of the directional guide to the U-shaped harrow;

MATERIALS AND METHODS

The basic laws of classical mechanics, mathematics and the working processes of seeding and planting machines are taken as the basis for theoretical research. Experimental studies were carried out on the basis of comparative laboratory-field studies of the estimated indicators of laying and embedding of seeds of grain crops and granular mineral fertilizers with their multilevel application by a seeder equipped with combined openers with a U-shaped harrow.

Experimental studies were carried out using standard techniques (GOST 31345-2007, STO AIST 5.6-2010). Analysis and processing of research results were carried out using the programs Statistica 6 RUS, Microsoft Office, etc.

RESULTS AND DISCUSSIONS

The covering of the granules of mineral fertilizers with the soil occurs due to the soil layer flowing around the fertilizer guide and naturally shedding it from the walls of the furrow.

During the operation of the combined coulter with a U-shaped harrow, the soil is deformed and rises to a certain height. After passing through the opener, the gap formed by the fertilizer guide manages to close, and some lower part of the soil lies at a certain distance from it, having time to cover the bottom of the furrow with fertilizers. Thus, a technologically important indicator of the process under consideration is the distance at which the particle is deposited after the soil has descended.

reliability The range of falling soil particles is determined by the dependence:

$$L = \mu(\frac{v^2 cos^2\alpha}{2g} tg\alpha + + \sqrt{vtg^2\alpha + \frac{2gB_{л} sin\alpha}{v_0^2 \sin(2\gamma_{п}) cos^2\alpha}}), \quad (1)$$

where v_o – is the rate of descent of soil particles, m/s;

α –angle of setting the directional guide to the bottom of the furrow, degrees;

$2\gamma_{п}$ – disc opening angle, degrees;

B_A – width of the furrow formed, m

For the mathematical calculation of the sowing process, we make the following assumptions:

1. The soil is represented by particles of certain sizes in a volume close to a spherical shape.
2. Particles of soil when interacting with the coulter move, obeying general laws.
3. Soil particles have small dimensions d = 1 to 3.47 mm and mass m = 0.1 to 2 g.
4. Moisture content of the soil is 18-24% in accordance with the norm.
5. The structure of the soil is fine crumbly, stickiness does not appear.
6. Speed of movement of the unit v = 1-3 m/s.
7. Values of parameters α = 20o,, = 0.015m.$2\gamma_{п} = 32^{o} B_A$

The graph of the change in the distance of laying a soil particle after the seam vanished is given L from its descent speed v_o . The calculation results show that when changing from 1 m/s to 3 m/s, the values vary from 0.015 m to 0.078 m.

Then the point of installation of the seed tube is determined from the expression:

$$l \geq L, \quad (2)$$

The L value is determined at the maximum value v.

Based on the obtained values of L, following expression 2, we take l from 0.02 m to 0.08 m.

The width of the bed compactor determines the width of the bottom of the furrow for which the seeds will be placed.

The width of the bottom of the furrow should be sufficient for the placement of seeds from the sowing unit and good contact with the compacted soil. For this, it is necessary that the width of the compactor is greater than the maximum length of the placed seed, but less than the width of the furrow formed by the discs, i.e.:

$$c > b > l_{max}, \quad (3)$$

where

b is the width of the bed seal, m;

l_{max} - maximum length of the laid seed, m (0.007 m);

c - width of the furrow formed by the coulter discs, m (0.025 m).

The soil is deposited at an angle of self-deposition α, also called the angle of repose and also depends on the location of the U-shaped doses of the harvester. Particles located in adjoining layers will crumble first. Their fall can be taken as a free fall with an initial vertical velocity equal to zero. Then, almost at the same time, the particles will begin to move, which are at an angle of self-falling.

Let us take the direction of the Ox axis in the direction of the velocity vector, and the direction of the Oy axis vertically downward, the coordinates will be counted from the point O located in the center of the particle located on the outer surface of the adjoining layers (Figure 2).

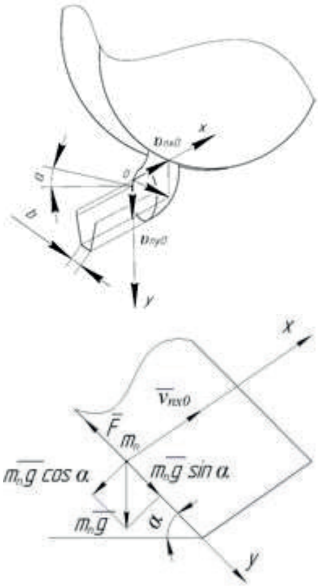

Figure 2. Falling soil: a - into the furrow; b - along lines located at an angle of slope of soil particles; α - angle of incidence; b - the width of the bed seal

At the moment the soil particle passes the cut of the fertilizer guide, it begins to fall into the furrow under the action of its weight mg and the force of air resistance.

Taking into account the absence of the initial vertical component of the particle velocity during the descent from the directional fuel and the small distance between the compaction to the furrow surface, the air resistance is not taken into account.

Consider the obtained law of motion of a soil particle

$$\begin{cases} m\dfrac{d^2x}{dt^2} = 0 \\ m\dfrac{d^2y}{dt^2} = mg \end{cases}, \quad (4)$$

where m is the mass of a soil particle, kg;

Suppose that $\dfrac{d^2x}{dt^2} = \dfrac{d\upsilon_x}{dt}$, and $\dfrac{d^2y}{dt^2} = \dfrac{d\ \upsilon_y}{dt}$ and canceling all refer to m we get

$$\begin{cases} \dfrac{d\upsilon_x}{dt} = 0 \\ \dfrac{d\upsilon_y}{dt} = g \end{cases} \quad (5)$$

Multiplying both sides of expressions (5) by dt and integrating them, we find

$$\upsilon_x = C_1, \text{ m / s}, \quad \upsilon_y = gt + C_2, \text{ m/s}. \quad (6)$$

From the initial conditions, we have that for t = 0 $\upsilon_x = \upsilon_{x0}$, $\upsilon_y = 0$.

Then $C_1 = \upsilon_{x0}$, $C_2 = 0$.

After substituting the integration constants into expression (6), we obtain

$$\frac{dx}{dt} = \upsilon_x = \upsilon_{x0}; \quad \frac{dy}{dt} = \upsilon_y = gt;$$

where will we find

$$x = \upsilon_{x0}t + C_3; \quad y = \frac{gt^2}{2} + C_4.$$

From the initial conditions, we define $C_3 = C_4 = 0$. Then

$$x = \upsilon_{x0}t; \quad y = \frac{gt^2}{2},$$

from where

$$y = \frac{gx^2}{2\upsilon_{x0}^2}. \quad (7)$$

Substituting the value $\upsilon_x = \upsilon_{x0}$ from expression (5) to equation (7) we obtain

$$y = \frac{x tg\alpha}{(tg\varphi - tg\varphi_1) + (tg\varphi - tg\beta)\sin\beta}. \quad (8)$$

Speed can now be found

$$\upsilon_y = \frac{gx}{\upsilon_{x0}} = \sqrt{\frac{gx \cdot tg\alpha}{(tg\varphi - tg\varphi_1) + (tg\varphi - tg\beta)\sin\beta}}, м/с. \quad (9)$$

Resultant falling velocity of the particle

$$\upsilon_n = \sqrt{\upsilon_{x0}^2 + \upsilon_y^2}, м/с, \quad (10)$$

and the angle of incidence

$$\alpha = arctg\frac{\upsilon_y}{\upsilon_{x0}} \quad (11)$$

running Soil particles, far from the boundary layer, slide along the inclined ones, making up the angle of laying or natural slope α.
The particle is affected by weight, the component of which mg sin α (Figure 2, b) makes the particle move along an inclined surface. This movement is counteracted by the friction force F = mg cos α tan φ1. Particle motion equation:

$$m\frac{d^2x}{dt^2}=0$$

$$m\frac{d^2y}{dt^2}=mg\sin\alpha-mg\cos\alpha\cdot tg\varphi_1. \quad (12)$$

depreciation After transformations we get

$$\frac{d\upsilon_x}{dt}=0,\ \frac{d\upsilon_y}{dt}=g\cos\alpha(tg\alpha-tg\varphi_1),$$

mixing or

$$\upsilon_x=C_1, м/c$$

$$\upsilon_y=gt\cos\alpha(tg\alpha-tg\varphi_1)+C_2, м/c \quad ... \quad (13)$$

segments Since at t = 0 $\upsilon_x=\upsilon_{x0}$, $\upsilon_y=0$, we find $C_1=\upsilon_{x0}$, $C_2=0$.
After substitution of constants in the expression for υx and υy we get:

$$\upsilon_x=\upsilon_{x0}, м/c.$$

$$\upsilon_y=gt\cos\alpha(tg\alpha-tg\varphi_1), м/c.$$

or

$$\frac{dx}{dt}=\upsilon_{x0},\ \frac{dy}{dt}=gt\cos\alpha(tg\alpha-tg\varphi_1), \quad (14)$$

from where

$$x=\upsilon_{x0}t+C_3,$$

$$y=\frac{1}{2}gt^2\cos\alpha(tg\alpha-tg\varphi_1)+C_4. \quad (15)$$

According to the initial conditions, we define $C_3=C_4=0$. Finally, we obtain

$$x=\upsilon_{x0}t;$$

$$y=\frac{1}{2}gt^2\cos\alpha(tg\alpha-tg\varphi_1)=$$

$$=\frac{1}{2\upsilon_{x0}^2}gx^2(tg\alpha-tg\varphi_1). \quad (16)$$

Looking for the vertically directed part of the speed of a soil particle

$$\upsilon_y=\frac{gx\cos\alpha}{\upsilon_{x0}}(tg\alpha-tg\varphi_1), м/c \quad (17)$$

Resulting speed of falling soil particle

$$\upsilon=\sqrt{\upsilon_{x0}^2+\upsilon_y^2}, м/c \quad (18)$$

Soil particle incidence angle

$$\alpha=arctg\frac{\upsilon_y}{\upsilon_{x0}},. \quad (19)$$

The time of falling of particles of the boundary layer and particles at the angle of self-precipitation is, respectively,

$$t_1=\sqrt{\frac{2y}{g}}, c.\ t_2=\sqrt{\frac{2y}{g\cos\alpha(tg\alpha-tg\varphi_1)}}, c \quad (20)$$

During this time period, the fertilizer bed is open. Depending on the speed of the seeder, the length of the open part of the furrow L, the path measured from the outlet of the fertilizer guide to the crumbling soil ridge, i.e. a2a3, will be different (Figures 3,4).

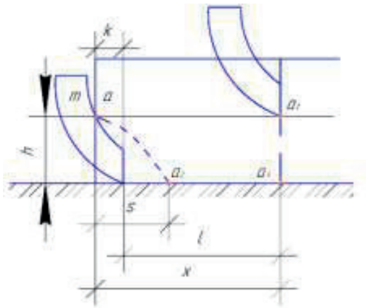

Figure 3. Scheme for calculating the shedding time of the furrow: L - the length of the open part of the furrow; s - the path of the traversed soil during the shedding; H is the height of the fall of the soil particle; k - distance of the beginning of particle motion to the exit hole

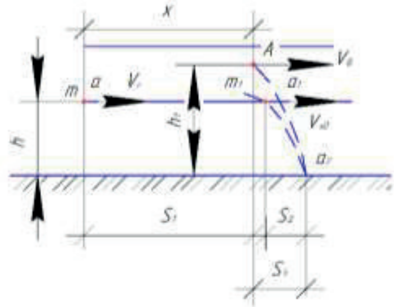

Figure 4. Fixation of fertilizers at the moment of falling to the bottom of the furrow during self-filling of the soil: H - height to the U-shaped harrow; h is the height of the fall of the soil particle; m is a particle of soil; S1, S2, S3 - the path traveled by the soil

During the time of shedding, a soil particle passes the following path $s=\upsilon_{x0}t$, and the path traversed by the seeding unit during this time period will be equal to $\upsilon_m t$... Then

$$L = l - m + k, м,$$

$$L = l - m + k = (\upsilon - \upsilon_{x0})\sqrt{\frac{2H}{g}}, м \quad (21)$$

type where υ - seeder speed, m / s.

$$l \geq (\upsilon - \upsilon_{x0})\sqrt{\frac{2H}{g}}, м$$

From here

With an increase in the speed of the seeding unit and the depth of the coulter, the opening of the furrow increases. Until the furrow closes, the fertilizers ejected by the guide must fall to its bottom, and in addition, the geometrical location of the ejection relative to the outlet of the guide and the ejection speed must be such that the fertilizers have time to settle down at the bottom until the furrow closes. In this case, there will be a minimum unevenness of the response of the soil layer.

Conferences $$\sqrt{\frac{2H}{g}} = \frac{s_1}{\upsilon_c} + \sqrt{\frac{2h}{g}}, \quad (22)$$

Where

$$s_1 = \upsilon_c \sqrt{\frac{2(H-h)}{g}}. \quad (23)$$

On the other hand, the quantity x can be determined from the equality

$$x + s_3 = s_1 + s_2, \quad (24)$$

or

$$\upsilon_B \sqrt{\frac{2h_1}{g}} = \frac{l+k}{\upsilon} + \upsilon_{x0}\sqrt{\frac{2h}{g}}, \quad (25)$$

specific From this condition at known speeds of the seeder υ_c, fertilizer ejection υ_B and soil crumbling υ_{x0}, were processed by specifying the height of the fall of soil particles h and the distance between the planes of the outlet openings of the seed tube and the guide l, it is possible to determine the height to the U-shaped harrow N.

$$h_1 = \frac{\left(\frac{l+k}{\upsilon} + \upsilon_{x0}\sqrt{\frac{2h}{g}}\right)^2}{2\upsilon_B^{\,2}}$$

Substituting the previously obtained values of the distance between the planes of the outlet openings of the seed tube and the guide from 0.02 m to 0.08 m, the height to the U-shaped harrow will be 0.04 ... 0.05 m.

Due to the fact that the falling out of soil particles behind the opener has a certain sequence, they are mixed. As noted above, the particles that are in direct contact with the plane of the U-shaped harrow first fall out, the lower particles fall off faster than the upper ones. Therefore, the bottom of the fertilizer furrow will be covered with a very thin bottom layer and then the top one. Following this, the bulk of the soil will crumble.

The pressure exerted by the bed compactor on the bottom of the furrow is determined by the formula:

$$p = \frac{R_1}{b_1 l_o}, \quad (26)$$

where l0 is the length of the platform providing crushing, m;

b1 - revealed the width of the crumple area, m;

R1 is the resulting reaction;

$$l_o = 2r_1 sin\delta, \quad (27)$$

a

$$p = \frac{R_1}{2b_1 r_1 sin\delta}... \quad (28)$$

The R1 value is determined by the technical formula:

$$R_1 = \frac{2}{3} q b_1 \sqrt{2r_1}\, h_o... \quad (29)$$

Substituting expression (29) into (28) we get:

$$p = \frac{\sqrt{2qh_o}}{3\sqrt{r_1} sin\delta}, \quad (30)$$

Because

$$надлежащая \sin\delta = \frac{R_{1x}}{R_1} = \frac{3h_o}{4\sqrt{2r_1}}, \quad (31)$$

we get:

$$p = \frac{8qh_o}{9}... \quad (32)$$

The density of the soil at the bottom of the furrow can be determined by the coefficient of porosity, which is defined as:

$$\epsilon = \frac{\gamma}{\rho} - 1, \quad (33)$$

where γ is the density of soil particles, g / cm^3;

ρ - soil density, g/cm^3

and the density of the soil:

$$\rho = \frac{\gamma}{\epsilon - 1}... \quad (34)$$

To determine the coefficient of porosity at pressure p V.F. Babkov proposed dependence:

$$\epsilon = \epsilon_o - \frac{1}{B_1} разных \ln \frac{\rho}{9{,}8\ 10^4} \quad (35)$$

where p is pressure, Pa,

ϵ_o - coefficient of porosity under load;

B_1 - the degree of change in the porosity coefficient under load.

Substituting the obtained values into formula (34), we get:

$$p = \frac{\gamma \boldsymbol{B}_1}{B_1(1+\epsilon_o) - \ln(\frac{qh_o}{1{,}1\ 10^5})} \quad (36)$$

For highly compressible chernozem soils, the following values are recommended: = 0.75 ... 0.85; B = 5 ... 10. The specific mass of the solid phase of the soil is 2.4 g/cm^3 for ordinary chernozems at a depth of 0 ... 20 cm. With the coefficient of volumetric crushing of the soil q = 2 · 106 N/m^3 and the depth of the bed compactor stroke h0 = 0.06 m, the density of the furrow bottom will be:ϵ_o

$$p = \frac{2{,}4 \cdot\ 10^7 \cdot 7}{7(1 + 0{,}8) - \text{концом} \ln(\frac{2 \cdot 10^6 \cdot 0{,}06}{1{,}1\ 10^5})} \approx 1{,}34 \cdot 10^3, , \text{кг/м}^3$$

CONCLUSIONS

We have substantiated and developed the structural and technological scheme and design of a combined opener with a U-shaped harrow for laying and embedding seeds of grain crops and granules of mineral fertilizers with their multilevel application (patent series for a mass invention applied by RF No. 2671704). A distinctive feature of this design is the use of a closed-type seed tube and feed guide, a U-shaped harrow, a bed compactor designed to seal the walls and bottom of the furrow, without shedding the furrow during the placement of seeds along the bottom of the furrow, preventing the opener from clogging with soil. According to the results of theoretical calculations, it can be noted that the distance from the base of the outlet of the guide to the U-shaped harrow will be equal to 0.04 ... 0.05 m; the width of the bed seal is 0.007… 0.025 m; the distance between the planes of the outlet openings of the seed tube and the guide is equal to 0.02 ... 0,

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