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Theoretical Study of Macro and Micro Fertilizer Compositions in the Water Solution of Mobile Seeds after Dropping from the Spreader

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ABSTRACT

This article presents the results of research on the theoretical substantiation of the behavior of hairy seeds soaked in an aqueous solution of mineral fertilizers and micronutrient compositions after falling from the spreader.

In recent years, important decisions and many measures have been taken in the country to radically improve the seed industry, increase the production of quality and competitive products. Particular attention is paid to the development of resource-saving technologies and techniques in the preparation of seeds for sowing, sorting and chemical treatment of agricultural crops.

With this in mind, we offer a device that ensures the coating of hairy seeds in a continuous technological process with an aqueous solution of mineral fertilizers and trace elements.

The essence of this technology is that the seeds are first sorted in an electric field on all their physical and mechanical properties. The sorted hairy seeds are delivered to the vertical cylinder at a certain rate and spread in conical spreaders, soaked in a mixture of water and mineral fertilizers, then collected in truncated cone-shaped collectors and dropped into a hemispherical shell drum rotating at a certain speed around a vertical axis.

The hairy seeds move in a stream of a mixture of mineral fertilizers with water sprinkled by the shelling device after the velocity has dropped from the conical spreader.

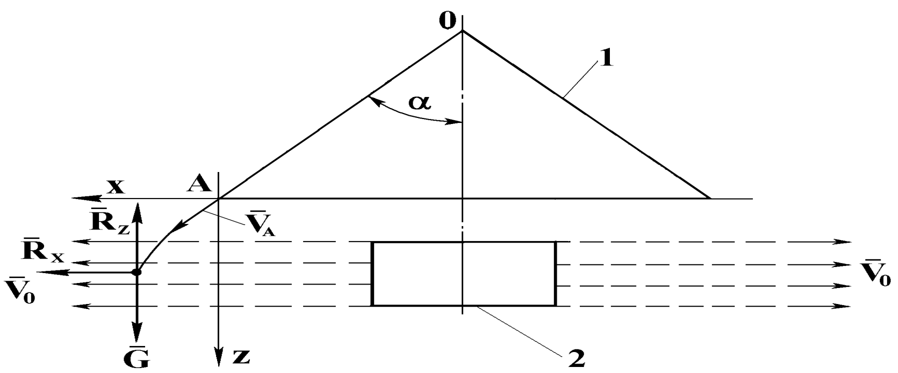
Seeds moving in the aqueous solution of macro- and micronutrient compositions are affected by the driving force $R_x=km(V_0-\dot{x})$ of the flow along the X axis and the resistance force $R_z=km\,\dot{z}$ along the Z axis and the gravitational force G = mg (Fig. 1).

Taking into account these forces, we construct the differential equation of the motion of the hairy seeds along the X and Z axes.

$$m\ddot{x} = km(V_0 - \dot{x}) \qquad (1)$$

and

$$m\ddot{z} = -km\dot{z} + mg \qquad (2)$$



1 – conical spreader; 2 – sprayer

Figure 1. Scheme for studying the movement of hairy seeds in the flow of aqueous solution of macro and micronutrient compositions

or

$$\ddot{x} = k(V_0 - \dot{x}) \qquad (3)$$

and

$$\ddot{z} = -k\dot{z} + g\,, \qquad (4)$$

where k - is a proportional coefficient of constant magnitude;

V_0 –is the flow rate of the mixture of water and mineral fertilizers, m /s.

m-seed mass, kg.

g -is the acceleration of free fall, m / s^2

We integrate equations (3) and (4). To do this, we replace $\ddot{x}$ (dx/dt) in equation (3) and write it in the following form

$$\frac{d\dot{x}}{V_0 - \dot{x}} = kdt\,. \qquad (5)$$

Integrating equation (5), we obtain the following result

$$-\ln[V_0 - \dot{x}] = kt + C_1\,, \qquad (6)$$

where C_1 -is the integration constant

According to the scheme in figure 1, it occurs when t = 0, $\dot{x} = V_A \sin\alpha$ will be. $\dot{x}$ expressing this value of (6), $C_1 = -\ln(V_0 - V_A \sin\alpha)$ we find that. $C_1$by putting this value of in equation (6)

$$-\ln[V_0 - \dot{x}] = kt - \ln(V_0 - V_A \sin\alpha) \quad (7)$$

or

$$kt = \ln\frac{V_0 - V_A \sin\alpha}{V_0 - \dot{x}} \quad (8)$$

we get the equation.

We find $\dot{x}$ from equation (8)

$$\dot{x} = V_0 - (V_0 - V_A \sin\alpha)e^{-kt}. \quad (9)$$

By substituting $\dot{x}$ (dx/dt) for, we obtain the following equation

$$dx = V_0 dt - (V_0 - V_A \sin\alpha)e^{-kt}dt. \quad (10)$$

Integrating this equation, we obtain the following result

$$x = V_0 t + \frac{(V_0 - V_A \sin\alpha)}{k}e^{-kt} + C_2. \quad (11)$$

According to the scheme in figure 1, at t = 0, x = 0. If we put these values in (11), $C_2 = -(V_0 - V_A \sin\alpha)/k$ it follows that. With this in mind, we bring equation (11) to the following form

$$x = V_0 t - \frac{(V_0 - V_A \sin\alpha)}{k}\left(1 - e^{-kt}\right). \quad (12)$$

Now we move on to the integration of equation (4). $\ddot{z} = (d\dot{z}/dt)$ given that, we write equation (4) in the following form

$$\frac{d\dot{z}}{g - k\dot{z}} = dt. \quad (13)$$

Integrating equation (13) once, we obtain the following expression

$$-\frac{1}{k}\ln(g - k\dot{z}) = t + C_3. \quad (14)$$

When t = 0, $\dot{z} = V_A \cos\alpha$ .Putting these values of t and $\dot{z}$ in the expression (14),

$C_3 = -\frac{1}{k}\ln(g - kV_A \cos\alpha)$ we get the result. C_3substituting this value of (14) into the expression, we obtain the following final result

$$\ln\frac{g - kV_A \cos\alpha}{g - k\dot{z}} = kt. \quad (15)$$

from the last expression

$$\dot{z} = \frac{g}{k} - \frac{g - kV_A \cos\alpha}{k} e^{-kt} \qquad (16)$$

arises.

$\dot{z}$ =(*dz/dt*) using equation, we write equation (16) as follows

$$\mathrm{dz} = \frac{g}{k} dt - \frac{g - kV_A \cos\alpha}{k} e^{-kt} dt\,. \qquad (17)$$

Integrating equation (17), we obtain the following

$$z = \frac{g}{k} t + \frac{g - kV_A \cos\alpha}{k^2} e^{-kt} + C_4\,. \qquad (18)$$

According to the scheme in figure 1, z = 0 at t = 0. If we express these values in (18), $C_4 = -\left(g - kV_A \sin\alpha\right)/\,k^2$ it turns out that.

With this value of the integration constant C_4, expression (18) looks as follows

$$z = \frac{g}{k} t - \frac{g - kV_A \cos\alpha}{k^2}\left(1 - e^{-kt}\right). \qquad (19)$$

The following expression was obtained to determine the velocity V_A of hairy seeds falling from the distributor of the peeling device.

$$V_A = \sqrt{\left(V_{\text{T}} \cos\alpha\right)^2 + 2g\left(\frac{0{,}5D}{\sin\alpha} - l_{\text{T}}\right)\left(\cos\alpha - f_1 \sin\alpha\right)} \qquad (20)$$

Taking into account expression (20), the equations of motion in an aqueous solution of mineral fertilizers and micronutrient compositions of hairy seeds are as follows:

$$X = V_0 t - \frac{1}{k}\left\{V_0 - \left[\sqrt{\left(V_t \cos\alpha\right)^2 + 2g\left(\frac{0{,}5D}{\sin\alpha} - l_T\right)\left(\cos\alpha - f_2 \sin\alpha\right)}\right]\sin\alpha\right\}\left(1 - e^{-kt}\right); \qquad (21)$$

$$Z = \frac{g}{k} t - \frac{1}{k^2}\left\{g + k\left[\sqrt{\left(V_t \cos\alpha\right)^2 + 2g\left(\frac{0{,}5D}{\sin\alpha} - l_T\right)\left(\cos\alpha - f_2 \sin\alpha\right)}\right]\sin\alpha\right\}\left(1 - e^{-kt}\right). \qquad (22)$$

Based on the analysis of the obtained expressions (21) and (22), it can be argued that the quality and amount of adhesion in an aqueous solution of mineral fertilizers to the surface of the pubescent cotton seeds depends on the time t of their interaction with the solution flow, the solution velocity V_0, the diffuser diameter D, the angle taper α, velocity Vt and place l_{T} of pubescent seeds getting to it.

By changing these factors, it is possible to achieve the quality and quantity of adhesion of the solution to the surface of the pubescent seeds.

After leaving the flow of an aqueous solution of mineral fertilizers, the pubescent seeds V_{xz} at a rate

$$V_{xz} = \sqrt{(\dot{x})^2 + (\dot{z})^2} = \sqrt{\left[V_0 - \frac{(V_0 - V_A \sin\alpha)e^{-kt}}{k}\right]^2 + \left[\frac{g}{k} - \frac{g - kV_A \cos\alpha}{k} e^{-kt}\right]^2} \quad (23)$$

fall on the truncated cone-shaped collector and, being collected in its lower part, fall on the working surface of the second cone-shaped diffuser and the technological process is repeated [6,7,8,9,10].

In order for the pubescent seeds that have fallen into the truncated cone-shaped collector to move along its working surface and collect in its lower part, the following condition must be met

$$\beta < 90° - \varphi_2, \quad (24)$$

where β is the angle of inclination of the generatrix of the cone-shaped collector relative to the vertical plane, degree; φ_2 - angle of friction of pubescent seeds sprayed with an aqueous solution of mineral fertilizers on the working surface of a truncated cone-shaped collector, degree.

Based on the results of experimental studies, we assume that the maximum value of φ_2 is 60 °, and we express this value (24) to ensure that the pubescent seeds, coated with an aqueous solution of mineral fertilizers and a composition of trace elements, that the coal of the setting of the forming cone-shaped collector should not be more than 30 ° from the vertical plane.

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