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Determination Of The Rational Form Of Seed Lines For Seeders.

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ABSTRACT

This article presents the results of studying the method of improving the uniformity of seeding due to the definition of a rational form seed tube of seed drill. A method has been developed for determining the optimal shape of the seed line of the seeder based on the working hypothesis that it is necessary to choose a form of seed line that ensures the most rapid descent of the seed flow from the sowing unit to the opener. The developed method allows determining the seed line parameters that meet the specified requirements for any type of seeders.
Keywords: seed tube, seeder, seeding mechanization, grain crops.

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INTRODUCTION

The process flow diagram of the grain drill involves the transportation of seeds of a sown crop from the sowing apparatus to the coulter. In this case, the seed tubes convert the seed flow obtained from the sowing apparatus, and thereby change its parameters, therefore, the design of the seed tubes affects the sowing uniformity.

Due to the complexity of the technological process of sowing seeds of agricultural crops and the continuity of the seeding process, the statistics of the internal processes of individual technology elements are very poor. Most often, researchers pay attention to the output indicators of the work of the seeders, such as the uniform depth of seed embedding, uneven sowing between sowing machines, general uneven sowing, the distribution of seeds of the sowed crop by area of nutrition, and others. characteristics of seed lines. At the same time, this element works in the most difficult conditions, since its angle of inclination to the horizon and the length are constantly changing, which undoubtedly influences the formation of the flow of seeds supplied to the opener group.

In the works [1, 2, 3] in experimental studies of seeders with different sowing devices it was found that the placement, the angle of inclination of the seed line to the horizon, its size and shape affect the quality of work of the seeders. With a slope angle of 15-18�, the requirement for uneven seeding is not violated, but of the nine crops sown with which experiments were carried out, only two crops (winter wheat and chickpeas) meet the requirements of agrotechnology (uneven seeding less than 3%). Thereby, it is emphasized that such a problem exists especially for multi-strand sowing devices and systems with a centralized sowing system.

In [4, 5], the effect of the seed line on the uniformity of sowing of a square-breeding seeder was studied, where it was found that the seed-line of the seeder had a significant impact on the uniform distribution of seeds across the nests. At the same time, one of the main reasons for the disturbance of seeding uniformity is an increase in the time of seed movement along the seed tube. This time depends mainly on the number of strokes of seeds on the walls of the seed tube and its height. With a seed line length of 39-45 cm. The time spent by seeds in the seed tube increases by 30-45% [6].

In the work [7], when studying the influence of the structural elements of the tukovysevayushchy systems on the unevenness of seeding, it is noted that the unevenness of seeding depends largely on the quality of operation of the metering and distribution systems of the machine.

The aim of the work was to improve the uniformity of seeding due to the definition of a rational form of seed line of the seeder.

RESULTS AND DISCUSSION

The task can be set as follows: it is necessary to find such a trajectory of the sowing material, which would provide the shortest time required to overcome the distance between the sowing unit and the opener. The coordinates of the initial $A\ (x_1,\ y_1)$ and end $B\ (x_2,\ y_2)$ points are known from the construction of the planter. For the mathematical formulation of the problem, we can denote the unknown equation of the sought trajectory by y = y (x), then this equation must first of all meet the conditions:

$$y(a) = y_a,\ y(b) = y_b, \qquad (1)$$

where y_a, y_b – ordinates of given points A and B.

It is clear that a set of curves can be drawn through two points, but for the case in question it is important that the curve passes through the set points A and B and provides the minimum amount of time to travel a given path.

Such a statement of the problem puts it in a series of typical tasks of the calculus of variations [8, 9].

Thus, unlike mathematical analysis, the independent variable in the calculus of variations is a function, not a single number.

A variable that depends on a variable of a function is called a functional. In this case, among the various paths of movement of seeds passing through the given points, it is required to find one that would correspond to the shortest travel time of this path.

The variational calculus problem is written as follows:

$$y = y(x) \in c^2;$$
$$\int_{x_1}^{x_2} F(x, y(x), y'(x))dx \rightarrow min; \quad (2)$$
$$y(x_1) = y_1, \quad y(x_2) = y_2.$$

That is, from the set of all curves belonging to the class c^2 and passing through the points $A(x_1, y_1)$ and $B(x_2, y_2)$, find one on which the value of the functional is *min*.

In the calculus of variations, it is proved that the integral in formula (2) for each function passing through given points has a well-defined value, and the condition of the function to be found that gives the functional an extreme value is that the increment of the functional is zero (variation of the functional).

In the study of the functional, it is important to determine how its value changes with a small change in the function on which it depends. Let there be a functional $I = \int_0^1 y^2 dx$, let us increment the function on which it depends, equal to $y(x)+\delta y(x)$, then we get:

$$I = \int_0^1 (y + \delta y)^2 dx = \int_0^1 y^2 dx + 2\int_0^1 y \cdot \delta y dx + \int_0^1 (\delta y)^2 dx \qquad (3)$$

Comparing the obtained expression with the given one, we see that the increment of the functional is the sum of the last two terms of formula (3), but since the value $(\delta y)^2$ is small, the most significant part of the increment is the second term of expression (3). This term is called the variation of the functional.

To find the curve on which the extremum of the functional is realized, it is necessary to integrate the Euler equation and find arbitrary constants for the boundary conditions. Consequently, it is necessary to find the differential equation for the motion of a point along the desired trajectory.

Let the material point *M* (in the case under consideration, this is the seed of the crop being sown) moves along the *AB* trajectory (Figure 1), the equation of which is $y = y(x)$ needs to be established.

Point *M* moves under the action of gravity without friction with zero initial velocity. As already noted, the desired function $y = y(x)$ must satisfy the conditions $y(a) = y_a$, $y(b) = y_b$, where y_a and y_b are the ordinates of points *A* and *B*. The speed of movement of a point can be determined taking into account the energy conservation law $\frac{mV^2}{2} = mg(y_a - y)$, from where after reduction on *m* it is possible to receive the equation of speed of movement of a point $V = \sqrt{2g(y_a - y)}$.

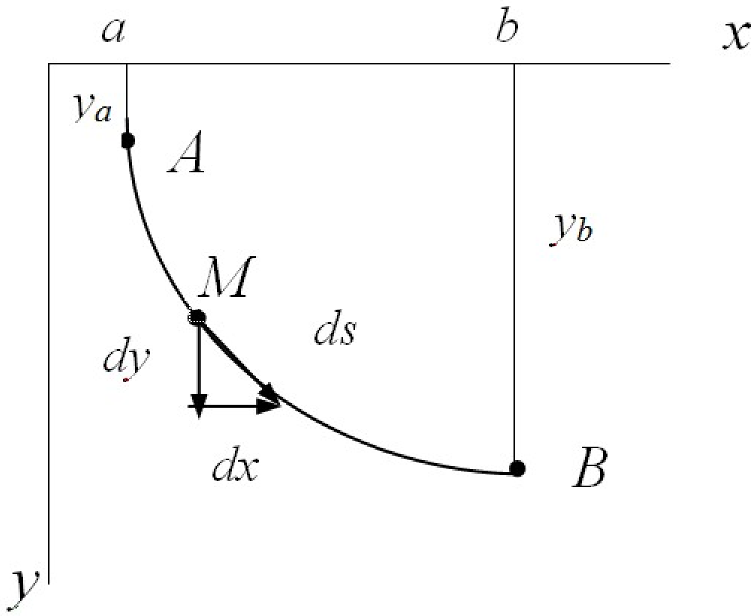

Figure 1: To justify the parameters of seed tube

But the speed of movement is the first time derivative of the path, i.e. $V = \dfrac{dS}{dt}$, in turn from a right triangle (Figure 1).

Taking into account these transformations can be written

$$V = \sqrt{2g(y_a - y)}; \quad \frac{dS}{dt} = \sqrt{2g(y_a - y)}; \quad \frac{dx\sqrt{1+(y')^2}}{dt} = \sqrt{2g(y_a - y)}.$$

Consequently, the differential equation of motion of the point M along the trajectory, the equation of which must be determined, is represented by the expression:

$$\frac{dx}{dt} = \frac{\sqrt{2g(y_a - y)}}{\sqrt{1+(y')^2}}. \qquad (4)$$

To get from this equation the time for which the material point will travel the full path along the trajectory between points *A* and *B*, it is necessary to solve it with respect to *dt* and integrate:

$$dt = \frac{\sqrt{1+(y')^2}}{\sqrt{2g(y_a - y)}}dx;$$

$$T = \int_a^b \frac{\sqrt{1+(y')^2}}{\sqrt{2g(y_a - y)}}dx = \frac{1}{\sqrt{2g}}\int_a^b \frac{\sqrt{1+(y')^2}}{\sqrt{y_a - y}}dx \quad (5)$$

Thus, it is necessary from all functions that satisfy conditions (1) (the curve must pass through the given points), choose one for which integral (5) takes the smallest value. In the calculus of variations, it is proved that, depending on the structure of the Euler equation, which is a second-order differential equation, the minimum of this integral must necessarily be on Euler extremals. And to determine the equation of the curve, it is necessary to integrate the Euler equation and, based on the initial conditions (1), determine arbitrary constants.

In this case, the integrand in (5) does not depend explicitly on *x*, therefore the Euler equation is an expression:

$$F - F'_{y'} \cdot y' = C_1, \qquad (6)$$

where $F = \frac{\sqrt{1+(y')^2}}{\sqrt{y_a - y}}$ – under the integral function of the functional (5).

Then according to (6) $\frac{\sqrt{1+(y')^2}}{\sqrt{y_a - y}} - \frac{\partial}{\partial y'}\left(\frac{\sqrt{1+(y')^2}}{\sqrt{y_a - y}}\right) \cdot y' = C_1$ and after differentiation we obtain the formula $\frac{\sqrt{1+(y')^2}}{\sqrt{y_a - y}} - \frac{y'}{\sqrt{y_a - y} \cdot \sqrt{1+(y')^2}} \cdot y' = C_1$, after converting which (reduction to the common denominator of the left side and abbreviations) we get the expression $\frac{1}{\sqrt{1+(y')^2} \cdot \sqrt{y_a - y}} = C_1$.

To integrate this equation, we introduce the parameter *t* according to the formula: $y_a - y = r(1 - Cos\, t)$, where $r = 1/4gC_1^2$. Then after some transformations we get:

$$\frac{1}{\sqrt{1+(y')^2}} = C_1\sqrt{y_a - y} = \sqrt{\frac{1-Cost}{2}};$$

$$1+(y')^2 = \frac{2}{1-Cost}; \qquad (y')^2 = \frac{1+Cost}{1-Cost} = \frac{Sin^2 t}{(1-Cost)^2};$$

$$\frac{dy}{dx} = \frac{S\,\text{int}}{1-Cost}; \qquad \text{dx} = \frac{\text{1-Cost}}{\text{Sint}}\,dy = r(1-Cost)dt;$$

$$x = r(t - S\,\text{int}) + C_2.$$

In the last expression, if we substitute the initial conditions, then $C_2=0$ and then together with the expression for y we get:

$$\begin{aligned} x &= r(t - S\,int) \\ y &= r(1 - Cost) \end{aligned} \qquad (7)$$

Formulas (7) are parametric equations of the cycloid, a line that is described by a point of a circle of radius *r* rolling along a horizontal straight line without sliding (Figure 2).

Figure 2 shows cycloid arcs and the circles that form them with conditional radii equal to 1, 2, 3. In this case, each generator circle rolls along the *x* axis from below.

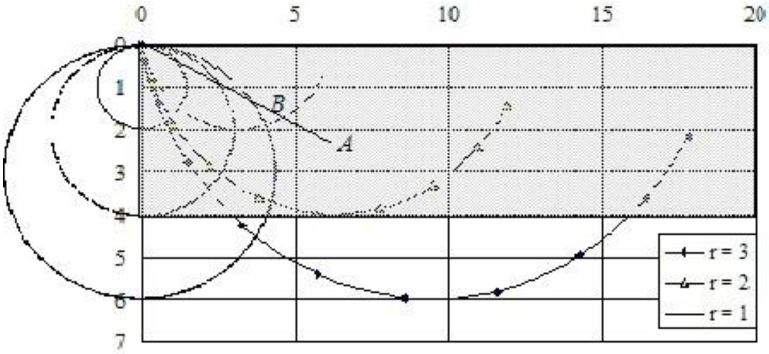

Figure 2: Cycloid arcs for varying radius of the circle

If we solve the second equation of system (7) with respect to t and substitute it into the first equation of this system, then we obtain the function *x = f(y)*, which is determined by the expression:

$$x = 2rk\pi \pm (r \cdot arcCos\frac{r-y}{r} - \sqrt{y(2r-y)}), \qquad (8)$$

where *k* – any integer.

Thus, the line of the fastest descent of seed flow from the sowing machine to the opener is the cycloid arc, therefore, the seed line of the seeder must be in the form of a cycloid, but the radius of the circle generator must be chosen so that the cycloid arch passes through the specified points.

Due to the fact that the seed lines of any planter are placed in a limited space (between the sowing unit and the opener), the variational problem is solved under conditions of constraints. The restriction zone in Figure 2 is highlighted by shading. It is clear that if the coordinates of the lowest point of the vas deferens do not fall outside the restricted area (a cycloid with a radius of a forming circle *r = 1* and *r = 2*), then the desired line is the cycloid arc. If these coordinates are outside the zone of limitations, then the solution of the variational problem only partially meets the requirements of the fastest descent line (a cycloid with a radius of the circle *r = 3*).

In this case, as applied to the multi-vibrating sowing apparatus of a vibrodiscrete type, the coordinates of each seed of the seed line are known, since the width of the spacing, the position of each opener, the location of the sowing apparatus and the seed hopper are known.

Consequently, each arc of a cycloid must therefore be located in space in order to necessarily pass through points with given coordinates, i.e. it is necessary to know the radius of the forming circle, which would ensure the specified requirements.

In some cases, a graphical method is proposed to determine this radius. For this, any auxiliary cycloid is conducted (for example, with a radius r = 1 Figure 2) and the points through which the desired cycloid must pass are connected by a straight line OA. It was established that the ratio of the straight line segments OB and OA exactly correspond to the ratio of the diameters of the cycloid forming circles passing through points B and A, i.e. it can be written that

$$\frac{OB}{OA} = \frac{D_B}{D_A}, \quad D_A = 2R_A = \frac{OA \cdot D_B}{OB}, \quad R = \frac{OA \cdot D_B}{2OB},$$

where D_A, D_B – respectively, the diameter of the generatrix of a cycloid circle passing through point *A*, and the diameter of the generatrix of a cycloid circle passing through point *B*.

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However, it is possible to determine the radius of the generatrix of a circle, in which the arc of the first cycloid passes through a given point in a different way, based on the fact that the coordinates of this point are known from the planter's layout scheme. For this, it is necessary to exclude the radius from the parametric equations (7), that is, for example, from the first equation, find the radius using the formula

$$r = \frac{x}{(t - S\,int)} \qquad (9)$$

and substitute its value in the second equation.

In this case, after some transformations, we obtain the expression:

$$\frac{y}{x} = \frac{(1 - Cost\,)}{(t - S\,int)} \qquad (10)$$

The left side of this equation is known, since the coordinates of the point through which the cycloid arc must pass are known. The argument *t* of the right side of this equation varies in the range $0 \le t \le 2\pi$. Therefore, giving different values to the argument t from the specified range, it is necessary to find such a value that satisfies equation (10). After that, you can determine the radius of the generatrix of a cycloid circle passing through a given point using formula (9), since the values of *x* and *t* become known.

For example, let's define the parameters of seed lines of seeders of the type SZP-3,6 and SZ-3,6, in which the C_i coulters are arranged in two rows and the distance between the rows is 350 mm. The sowing unit *B* (Figure 3) of the vibro-discrete type is placed in the center between these rows, and the row spacing is 150 mm. The distance between the sowing apparatus and the openers vertically (zone of limitations), in this case, the value on the ordinate axis is *y = 450 mm*.

To determine the radii of the forming circles, it is necessary to know the coordinates on the abscissa axis for each opener, therefore it is necessary to establish the length of segments BC_1, BC_2, BC_3, BC_4, and BC_5 taking into account the dimensions indicated on the diagram.

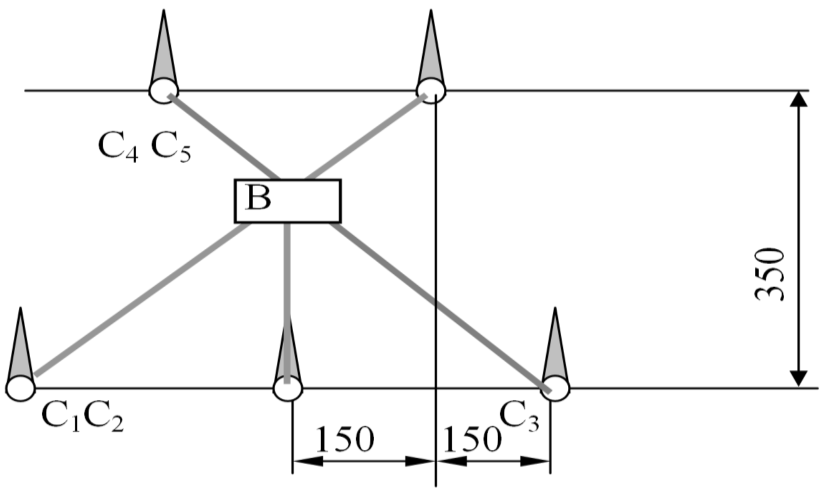

Figure 3: Diagram for determining the coordinates of the location of the openers (top view)

$BC_2 = x_2 = 350/2 = 175;$

$$BC_1 = BC_3 = x_{13} = \sqrt{175^2 + 300^2} = 345;$$

$$BC_4 = BC_5 = x_{45} = \sqrt{175^2 + 150^2} = 230.$$

Then, in accordance with equations (10) and (9), we obtain:

$$\frac{y}{x_2}=\frac{450}{175}=2.57=\frac{1-Cost}{t-S\,int};\;\; t_2=1{,}12;\;\; r_2=\frac{x_2}{t_2\text{ - }Sint_2}=0{,}796;$$

$$\frac{y}{x_{13}}=\frac{450}{345}=1.30=\frac{1-Cost}{t-S\,int};\;\; t_{13}=2{,}00;\;\; r_{13}=\frac{x_2}{t_{13}\text{ - }Sint_{13}}=0{,}317;$$

$$\frac{y}{x_{45}}=\frac{450}{230}=1.96=\frac{1-Cost}{t-S\,int};\;\; t_{45}=1{,}427;\;\; r_{45}=\frac{x_2}{t_{45}\text{ - }Sint_{45}}=0{,}526;$$

At a known radius of the generatrix of a circle, according to formulas (7), an arc of a cycloid is established, which represents the trajectory of the seed flow with the shortest descent time from the sowing apparatus to the vomer. These cycloids, as applied to the coulters in question, are shown in Figure 4. In the figure, the dashed lines show the coordinates of the coulters, which exactly correspond to those set out above in the diagram (Figure 3), which confirms the sufficient accuracy of the seeder parameters of the seeder.

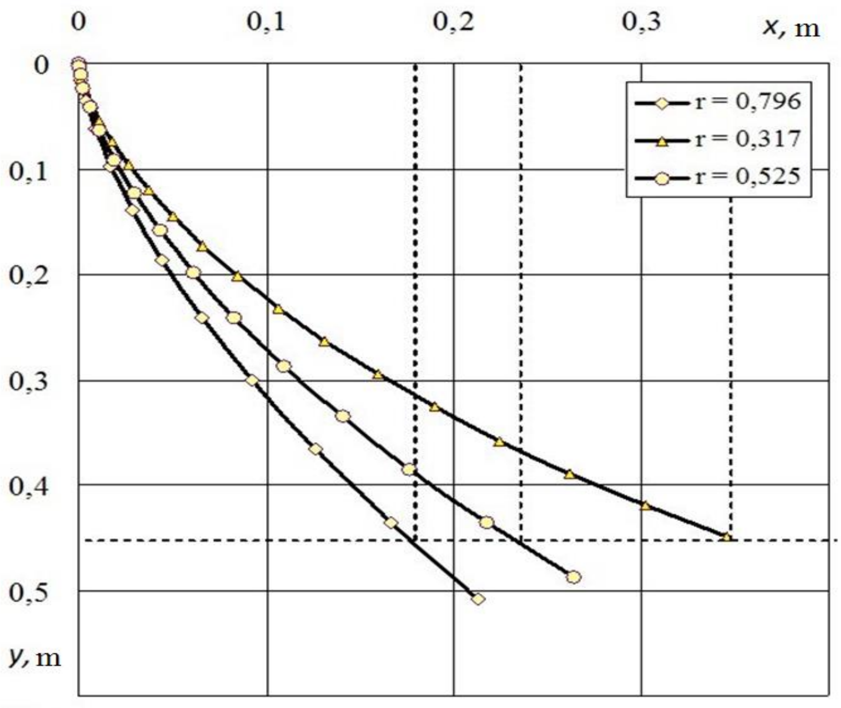

Figure 4: Form of seed tubes of the sowing system of seeders of the type SZ-3.6 and SZP-3.6

CONCLUSION

Thus, the results of the research allow to note the following:

- parameters of seed lines affect the quality of work of the seeder system of the seeder. At the same time, it is necessary to choose such a form of a seed tube, which ensures the most rapid descent of the seed flow from the sowing apparatus to the opener;
- the line of the fastest descent of seeds from the sowing machine to the vomer is the cycloid arc, therefore, the seed line of the seeder must be in the form of a cycloid, but the radius of the cycloid forming circle must pass through the given points;
- the developed method allows determining parameters of seed lines that meet the specified requirements for any type of seeders;

- the radii of cycloid forming circles for seed pipes of the SZ-3.6 and SZP-3.6 type seeders are 0.317, 0.525 and 0.796 m. Taking into account the adopted position of the sowing unit relative to the seeders' openers.

REFERENCES

[1] Kosolapov, E.L. The influence of the position of the seed tube rack on the distribution of seeds. Kosolapov, A.N. Kirov. // Mechanization and electrification of agriculture №6, 1982. - p. 47-48.

[2] Ovsyannikov, S.A. perfection of technological process of the mechanized crops of seeds of grain crops by machine with an electromagnetic dosing system of seeding rates: the dissertation of a candidate of technical sciences: 05.20.01 / S.A. Ovsyannikov. - Stavropol, 2000. - 206 p.

[3] Bespamyatnova, N.M. Scientific and methodological bases of adaptation of tillage and sowing machines / N.M. Bespamyatnova. - Rosto-on-Don: Terra, 2002. - 176 p.

[4] Olsson N.O. Development of a new model grain drill: Canadian Agricaltural Endineering, 1971. 13. №1. P. 2-3.

[5] Guo, P. Y. Preliminary studies of a modified slot opener for direct drilling seeds / P. Y. Guo, M. A. Choudhary // New Zealand Journal of Experimental Agriculture, 1985. V. 13. - P. 85-95.

[6] Cbaorakam L, Koike M., Takigawa T. Field Evaluation of Slot Openers for Minimum Tillage Japan. Soc. Agr, Mach., 2007; Vol.69.N 6. P. 65-74.

[7] Nîshimura Y., Hayashi K., Gotoh T. Development of a precision direct drill seeder for direct sowing of r.ce on paddy field Japan.Soc.Agr.Mach., 2001; Vol.63,N 6. P. 122-130.

[8] Schechter, R. Variational method in engineering calculations / R. Schechter - M .: Mir, 1971. - 289 p.

[9] Korn, G. Math Handbook. For scientists and engineers. Definitions, theorems, formulas / G. Korn, T. Korn .. - M .: Nauka, 1970. - 720 p.