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PARAMETER OPTIMIZATION USING COEFFICIENT OF VARIATION OF INTERVALS FOR ONE-SEED SOWING APPARATUS WITH HORIZONTAL DISK DURING MAIZE SEEDING

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Summary. The paper deals with the development of a model establishing the correlation between intervals variation coefficient between maize seeds during dotted sowing and three factors – height and diameter of seed duct as well as velocity of machine movement. An influence of each factor separately with the fixed values of the others has been determined with the help of this model and the optimization has been effected. The given material can be used while developing new sowing machines.

Key words: seeds, distribution, statistical data

Seeds distribution uniformity along the lines can be evaluated by the coefficients of intervals variation and is a major characteristic that has a substantial influence on crop capacity, labor expenditure on removing of „extra" plants and excessive consumption of sowing material [Basin 1987].

Sowing apparatus (SKNK-8 type) of seeding-machine with horizontal disks was used as a batcher; it was placed on a special frame above the belt of base designed stand. Three factors were varied: $x_1(D)$ – diameter of seed duct, $x_2(h)$ – height of seed duct, $x_3(v_0)$ – rotary velocity of a seeding disk rotation. Factors $x_1(D)$ and $x_2(h)$ were real by positioning of round metal tubes. Factor x_3 $(\tilde{v}_0)$ was real by changing of transmission relationship of drive mechanism (change sprockets stars).

Factors levels were varied according to central compositional rotatory uniform-planning of the second order for the three factors [Nalimov and Chernova 1965].

The moving speed of the stand belt was constant and equal to 2.0 m/s. Calculated interval between seeds was 200 mm with v_0 = 0.275 m/s. „Dneprovskaya-247" brand seeds of a third fraction were sowed using SKB-153B seeding disk with a 1.0 mm spacing gasket. Factors variation intervals were chosen according to technological efficiency condition of a batcher. The intervals are given in Table 1.

A coefficient of intervals between seeds in longitudinal direction variation Y was used as a criterion function. It is presented as decimal units:

$$Y = \frac{\sigma}{\nu_1}, \tag{1}$$

where:

σ, ν_1 – are standard and initial moment of intervals, correspondingly.

Table 1.Variation of intervals for factors x_1(D), x_2(h) and x_3(v_0) for a batcher of SKNK-8 seeding-machine

Characteristics	Factors		
	$x_1(D)$, mm	$x_2(h)$, mm	$x_3(v_0)$, m/s
Initial level, $x_i = 0$	60.0	350.0	0.275
Variation interval, I	23.8	59.5	0.134
Upper level, $x_i = 1$	83.8	409.5	0.409
Lower level, $x_i = -1$	36.2	290.5	0.141
Upper sprocket point, $x_i = 1.682$	100.0	450.0	0.5
Lower sprocket point, $x_i = -1.682$	20.0	250.0	0.05

During statistical data processing intervals of values were divided into different categories [Melnikov 1972]; the data were processed in this way: 1. x – real value of the interval. 2. m – real number of intervals in particular category interval. 3. xm 4. Σxm 5. Σm 6. $\nu_1 = \sum xm / \sum m$ 7. x_2 8. x_2m 9. Σx_2m 10. $\nu_2 = \sum x^2 m / \sum m$ (second initial moment) 11. ν_1^2 12. $\mu_2 = D = \nu_2 - \nu_1^2$ (dispersion – second central moment) 13. $\sigma = \sqrt{\mu_2} = \sqrt{D}$ 14. $Y = \upsilon = \sigma / \nu_1$. Sheppard's correction was used to minimize the influence of intervals grouping into categories on an error in selective dispersion (S_1^2) determination [Astanin 1986]:

$$S_1^2 = S^2 - h^2 / 12, \tag{2}$$

where:

S^2 – intervals dispersion without taking into account influence of category interval;
h – length of category interval.

Experimental data were processed using universally accepted method which is recommended for rotatory planning. The following criteria were determined: Kohren's G (which characterizes the uniformity of dispersions), Student's (which indicates the regression coefficients for regression magnitude) and Fisher's (which indicates the model adequacy). As a result, an adequate model was found as the secondary order regression:

$$Y = b_0 + b_3 x_3 + b_{23} x_2 x_3 + b_{33} x_3^2 \tag{3}$$

where:

b_0 = 0.7061; b_3 = -0.0685; b_{33} = 0.1027; b_{23} = 0.0462.

The separate influence of every factor on the response function is determined when another factor value is equal to ± 1.682 and 0.

Then equation (3) becomes:

when x_3 = -1,682:

$Y_{2.1}$ = 0.7061 + 0.0685 · 1.682 + 0.1027 · 2.829 – 0.0462 · 1.682 x_2 = 1.1118 – 0.0777x_2;

when x_3 = 0;

$Y_{2.2}$ = 0.7061;

when x_3 = 1.682;

$Y_{2.3}$ = 0.7061 – 0.1152 + 0.2905 + 0.0777x_2 = 0.8814 + 0.0777x_2;

when x_2 = -1.682;

$Y_{3.1}$ = 0.7061 – 0.0685x_3 + 0.1027x_3^2 - 0.0462 · 1.682x_3 = 0.7061–0.1462x_3 + 0.1027x_3^2;

when x_2 = 0;

$Y_{3.2}$ = 0.7061 – 0.0685x_3 + 0.1027x_3^2;

when x_2 = 1.682;

$Y_{3.3}$ = 0.7061–0.0685x_3+0.1027x_3^2+0.0462·1.682x_3 = 0.7061+0.0092x_3+ 0.1027x_3^2 (4)

Values of functions $Y_{2.1}$–$Y_{3.3}$ from (3) are calculated by points x_i = ± 1.682; ± 1; 0; data of the calculations are given in Table 2.

Table 2. Calculation sequence for functions $Y_{2.1} – Y_{3.3}$

x_i	x_i^2	0.0777x_2	$Y_{2.1}$ = = 1.1118 – (3)		$Y_{2.3}$ = = 0.8814 + (3)	0.1462x_3
1	2	3	4	5	6	7
-1.682	2.829	-0.1307	1.2425		0.7507	-0.2459
-1	1	-0.0777	1.1895		0.8027	-0.1462
0	0	0	1.1118	$Y_{2.2}$ = = 0.7061	0.8814	0
1	1	0.0777	1.0341		0.9591	0.1462
1.682	2.829	0.1307	0.9811		1.0121	0.2459
0.1027x_3^2	$Y_{3.1}$ = = 0.7061 – – (7) + (8)	0.0685x_3	$Y_{3.2}$ = = 0.7061 – – (10) + (8)	0.0092x_3	$Y_{3.3}$ = = 0.7061 + + (12) + (8)	
8	9	10	11	12	13	
0.2905	1.2425	-0.1152	1.1118	-0.0155	0.9811	
0.1027	0.955	-0.0685	0.8773	-0.0092	0.7996	
0	0.7061	0	0.7061	0	0.7061	
0.1027	0.6626	0.0685	0.7403	0.0092	0.818	
0.2905	0.7507	0.1152	0.8814	0.0155	1.0121	

The plots were constructed according to Table 2 data. The plots are presented in Fig. 1. It is evident from the plots that the response (coefficient of intervals variation) depends on factor $x_2(h)$ linearly: when $x_3(v_0) = 0$ the response is constant ($Y_1 = 0.7061$; curve $Y_{2.2}$), when $x_3 = -1.682$ the response decreases with $x^2(h)$ increasing, and when $x_3 = 1.682$ the response increases on the contrary (curves $Y_{2.1}$ and $Y_{2.3}$). The response depends on $x_3(v_0)$ factor curvilinearly when the minimal value $x_3(v_0)$ = 0..1 (curves $Y_{3.1}$–$Y_{3.3}$).

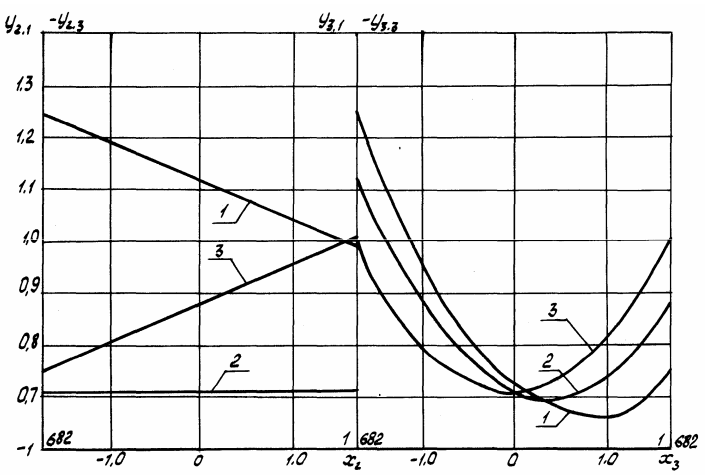

Fig. 1. Plot of $Y_{2.1}$–$Y_{2.3}$ dependence (coefficient of intervals variation)

PARAMETER OPTIMIZATION FOR SOWING APPARATUS

The minimal value of the function $\bar{y}'_{=}$ = 0.59 of matrix of experiment planning with $x_1 = x_3 = 0$; $x_2 = 1.682$. Parameter optimization by independent variables quantization of matrix is given in Table 3, from which it is evident that it is not possible to lower the response (lines 3 and 5); therefore the values of the factors from line 1 in Table 3 are taken as coordinates of a particular point of factor space:

$$y_S = 0.7061; \quad x_{1S} = x_{3S} = 0; \quad x_{2S} = 1.682 \tag{5}$$

Table 3. Response function y_{min} minimal value determination

№	b_0 0.7061	x_1 0	x_2 0	x_3 -0.0685	x_{33} 0.1027	x_{23} 0.0462	$\hat{y}$
1	x_i	0	1.682	0			0.7061
2	x_i	0	-1.682	1.682	2.829	-2.829	
3	$b_i x_i$ 0.7061	0	0	-0.1152	0.2905	-0.1307	0.7507
4	x_i	0	1.682	-1.682	2.829	-2.829	
5	$b_i x_i$ 0.7061	0	0	0.1152	0.2905	-0.1307	0.9811

Two-dimensional cross section surface of response in „almost stationary" area with factors x_2, x_3 is implemented by the model:

characteristic equation becomes [Nalimov and Chernova 1965]:

$$f(B) = \begin{vmatrix} 0-B & 0{,}5b_{23} \\ 0.5b_{23} & 0-B \end{vmatrix} = B^2 - 0.25b_{23}^2 = 0; \tag{6}$$

From this:

$$B_{23} = \pm 0{,}5b_{23}; \quad B_{22} = 0.5b_{23} = 0.5 \cdot 0.0462 = 0.5 \cdot 0.231 = 0.1075; \quad B_{33} = -0.0231. \tag{7}$$

Angle of coordinate axes rotation:

$$\mathrm{tg}2\alpha = \frac{b_{23}}{b_{22} - b_{33}} = \frac{0.0462}{0 - 0.1027} = -0.45; \tag{8}$$

$$2\alpha = \mathrm{arctg}(-0{,}45) = -24.23°; \quad \alpha = -12.115°$$

In a canonical form it appears as:

$$Y - 0.7061 = 0.0231X_2^2 - 0.0231X_3^2 \tag{9}$$

Therefore:

$$X_2 = \pm\sqrt{\frac{Y}{0.0231} - 30.567 + X_3^2}; \tag{10}$$

Coordinates of a new center S are (1.682; 0); signs of coefficients B_{22}, B_{33} are different (B_{22} = 0.0231; B_{33} = -0.0231), so curves of equal exit are hyperbolas; and a response surface is a hyperbolic paraboloid. Hyperbolas cordinates are found using (10), having exit y = 0.7; 0.725; 0.75; 0.775. The calculation sequence is presented in Table 4.

Table 4. Calculation sequence for coordinates of curves of equal exit in „almost stationary" area of response function $Y_1 = f(x_2, x_3)$

$\pm X_3$	X_3^2	$-30.567 + X_3^2$	$Y = 0.7$	$\pm X_2$	$Y = 0.725$
1	2	3	4	5	6
2.0	4	-26.567	$S = \frac{y}{0{,}231} = 30.3$	1.93	$S = \frac{y}{0{,}231} = 31.39$
1.5	2.25	-28.317		1.41	
1	1	-29.567		0.86	
0.5	0.25	-30.317		-	
0	0	-30.567		-	

$\pm X_2$	$Y = 0.75$	$\pm X_2$	$Y = 0.775$	$\pm X_2$
7	8	9	10	11
2.19	$S = \frac{y}{0{,}231} = 32.46$	2.43	$S = \frac{y}{0{,}231} = 33.55$	2.6
1.75		2.04		2.29
1.35		1.7		1.99
1.04		1.46		1.8
1.01		1.38		1.73

New center S with coordinates X_2 = 1.682; X_3 = 0 is designated in the old coordinate system x_2ox_2 (Fig. 2), and the coordinate system X_2SX_3 is turned by angle α = –12.12° (clockwise). From Figure 2 it is evident that response Y increases with moving along X_2 axis in the decreasing direction.

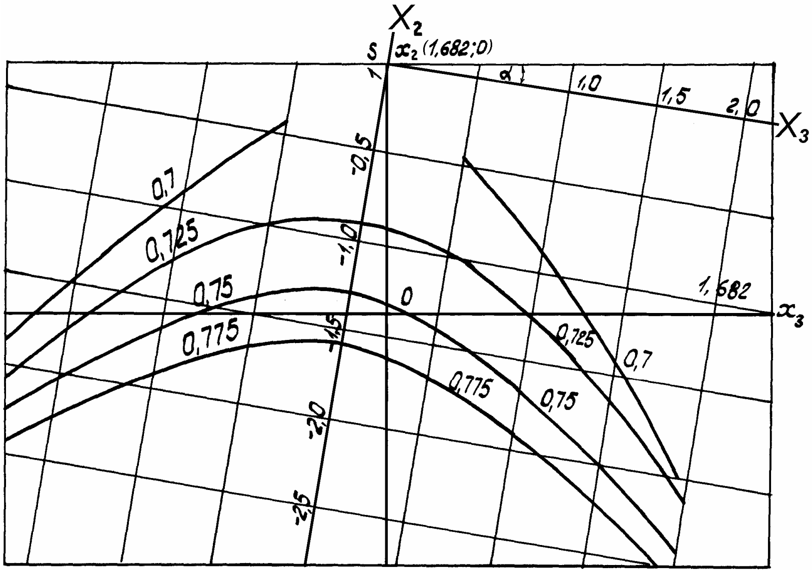

Fig. 2. Two-dimensional cross sections of „almost stationary" area of response function $y_1 = f(x_2, x_3)$ (variation coefficient) along x_2, x_3 with $x_{1S} = 0$ (curves of equal exit-hyperbolas are shown)

CONCLUSIONS

1. The regression coefficients were obtained as a result of experimental data processing. The significant coefficients are b_0 = 0.7061; b_3 = -0.0685; b_{33} = 0.1027 and b_{23} = 0.0462. Therefore the mathematical model is (3):

$$y_1 = b_0 + b_3x_3 + b_{23}x_2x_3 + b_{33}x_3^2$$

2. The separate factors on response y_1 were researched with the values of another factor equal to $\pm$1.682 and 0 (functions $Y_{2.1}$–$Y_{3.3}$, (4)); the plots of these functions are shown in Figure 1, it is evident that the response depends linearly on factor $x_2(h)$: when $x_3(v_0)$ = 0 the response is constant ($Y_{2.2}$ = 0.7061; curve $Y_{2.2}$), when x_3 = -1.682 the variation coefficient decreases when x_2(h) increases, and when x_3 = 1.682, it increases (curves $Y_{2.1}$, $Y_{2.3}$). The response depends curvilinearly on $x_3(v_0)$ factor when the involving minimal value ranges $x_3(v_0)$ = 0…1 (curves $Y_{3.1}$–$Y_{3.3}$).

3. The minimal value of intervals variation coefficient was determined using planning matrix: $\overline{Y}'_{\min}$ = 0.59 ($\hat{Y}$ = 0.7061) when $x_1 = x_3 = 0$; x_2 = 1.682; since lowering the

value by arguments quantization failed (Table 3), the values of the factors from line 1 in Table 3 have been taken as coordinates of particular point *S* of factor space: $Y_S = 0.7061$; $x_{1S} = x_{3S} = 0$; $x_{2S} = 1.682$. Coefficients B_{22}, B_{33} of the canonical form were found by solving characteristic equation (6); the coordinates (Table 4) of the linear equal exit (hyperbolas) were found using (10); two-dimensional surface cross section of „almost stationary" area of response are shown in Figure 2; from which it is evident that response *y* increases with moving along X_2 axis in the decreasing direction.

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