# Parameter optimization dosator of the seeding of a sugar beet on the coefficient variation of intervals

*Victor Belodedov, Pavel Nosko, Grigoriy Boyko, Pavel Fil, Marina Mazneva*

Volodymyr Dahl East-Ukrainian National University, Lugansk, Ukraine

Summary. Results of multifactorial experiment by orthogonal planning for four factors: height and diameter of seed tube, rotary speed of seed disk and speed movement of seeder are presented. Experiment results were analyzed according to generally accepted methods. Adequate model was received. Influence of each factor on coefficient of variation intervals between seeds and optimal value of each factor were determined.

Key words. coefficient of variation intervals, sugar beet, influence of factors, optimization.

## INTRODUCTION

The coefficient variation of intervals between seeds is one from characteristic of quality sowing. It is controlled by agrotechnical demands. The level of harvest depends on the value of coefficient variation [5-20].

## OBJECTS AND PROBLEMS

The coefficient $y$ of variation intervals between seeds in longitudinal direction was calculated on the formula [4]:

$$y_5 = \sigma / v_1 , \qquad (1)$$

where: $\sigma$, $v_1$ – middle square deviation (standart) and first initial moment of intervals correspondingly.

By processing experimental data were divided on the classes [2-4]; the data were processed in this way:

1. $x$ — real value of the interval; 2. Real number of the intervals in given of class; 3. $xm$ ; 4. $\sum xm$ ; 5. $\sum m$ ; 6. $v_1 = \sum xm / \sum m$ ; 7. $x^2$ ; 8. $x^2 m$ ; 9. $\sum x^2 m$ ; 10. $v_2 = \sum x^2 m / \sum m$ (second initial moment); 11. $v_1^2$ ; 12. $\mu_2 = D = v_2 - v_1^2$ (dispersion – second central moment); 13. $\sigma = \sqrt{\mu_2} = \sqrt{D}$ ; 14. $y = v = \sigma / v_1$ .

Experiments were produced on the apparatus with vertical disc of the seeder of CCT-type, which was installed on the special framework over a ribbon of the stand of a generally accepted construction.

Four factors were varied: $x_1(h)$, $x_2(D)$ – altitude and diameter of a seed tube; $x_3(v_0)$; $x_4(v_\Lambda)$ – velocities of the twirl of a seed disc and movement the ribbon of the stand. Levels of the factors (tab.1) were varied according to the orthogonal planning of the second order for four factors [1-4].

**Table 1.** Intervals of a variation of the factors $x_1(h)$, $x_2(D)$, $x_3(v_0)$; $x_4(v_\Lambda)$ for CCT-type seeder dosator

| Characteristics | Factors | | | |
|---|---|---|---|---|
| | $x_1(h)$, мм | $x_2(D)$, мм | $x_3(v_0)$, м/с | $x_4(v_\Lambda)$, м/с |
| The basic level, $x_i$=0 | 425,0 | 60,0 | 0,350 | 2,000 |
| The interval of variation, I | 265,0 | 28,3 | 0,177 | 0,708 |
| The upper level, $x_i$=1 | 690,0 | 88,3 | 0,527 | 2,708 |
| The lower level, $x_i$=-1 | 160,0 | 31,7 | 0,173 | 1,292 |
| The upper star point, $x_i$=1,4142 | 800,0 | 100,0 | 0,600 | 3,000 |
| The lower star point, $x_i$=-1,4142 | 50,0 | 20,0 | 0,100 | 1,000 |

The seeds of sugar beet sort "Verhngachskaya-038" of fraction "4,5…5,5" mm by the disc H 125.04.006 of the seeder CCT-12A. Experimental data were treated accordingly with the generally accepted methods recommended for orthogonal planning: Kohren criterion (characterizing homogeneous of variances), Student criterion (causing the significance of regression coefficients) and Fisher criterion (pointing out on the adequacy of model) were defined. The adequate regression model of the second order with variables in a code designation is a result view:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_4x_4 + b_{12}x_1x_2 + b_{24}x_2x_4 + \\ + b_{34}x_3x_4 + b_{22}x_2^2 + b_{33}x_3^2, \qquad (2)$$

where $b_0 = 1{,}0517$; $b_1 = -0{,}076$; $b_2 = 0{,}0799$; $b_4 = -0{,}135$; $b_{12} = -0{,}0625$; $b_{24} = -0{,}0725$; $b_{34} = 0{,}0781$; $b_{22} = -0{,}086$; $b_{33} = -0{,}0885$.

Influence of each factor separately on the response function was defined at levels of other factors, equal 0 and ±1,4142; the equation (2) takes a view:

when $x_2 = x_3 = x_4 = -1{,}4142$;

$y_{1.1} = 0{,}7919 + 0{,}0124$;

when $x_2 = x_3 = x_4 = 0$;

$y_{1.2} = 1{,}0517 - 0{,}076x_1$;

when $x_2 = x_3 = x_4 = 1{,}4142$;

$y_{1.3} = 0{,}6359 - 0{,}1644x_1$;

when $x_1 = x_3 = x_4 = -1{,}4142$;

$y_{2.1} = 1{,}3294 + 0{,}2708x_2 - 0{,}086x_2^2$;

when $x_1 = x_3 = x_4 = 0$;

$y_{2.2} = 1{,}0517 + 0{,}0799x_2 - 0{,}086x_2^2$;

when $x_1 = x_3 = x_4 = 1{,}4142$;

$y_{2.3} = 0{,}7324 - 0{,}111x_2 - 0{,}086x_2^2$;

when $x_1 = x_3 = x_4 = -1{,}4142$;

$y_{3.1} = 0{,}7952 - 0{,}1105x_3 - 0{,}0885x_3^2$;

when $x_1 = x_2 = x_4 = 0$;

$y_{3.2} = 1{,}1205 - 0{,}0885x_3^2$;

when $x_1 = x_2 = x_4 = 1{,}4142$;

$y_{3.3} = 0{,}493 + 0{,}1105x_3 - 0{,}0885x_3^2$;

when $x_1 = x_3 = x_3 = -1{,}4142$;

$y_{4.1} = 0{,}5722 - 0{,}143x_4$;

when $x_1 = x_2 = x_3 = 0$;

$y_{4.2} = 1{,}0517 - 0{,}135x_4$;

when $x_1 = x_2 = x_3 = 1{,}4142$;

$$y_{4.3} = 0{,}5832 - 0{,}127x_4. \qquad (3)$$

Values of functions $y_{1.1} - y_{4.3}$ according (3) are computed on the points $x_i = 0$; $\pm 1$; $\pm 1{,}4142$; calculation data are presented in tab.2.

**Table 2.** The sequence calculation of functions $y_{1.1} - y_{4.3}$

| $x_i$ | $x_i^2 - 0{,}8$ | $0{,}0124x_1$ | $y_{1.1} = 0{,}7919 + (3)$ | $0{,}076x_1$ | $y_{1.2} = 1{,}0517 - (5)$ | $0{,}1644x_1$ | $y_{1.3} = 0{,}6359 - (7)$ | $0{,}2708x_2$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| -1,4142 | 1,2 | -0,0175 | 0,7744 | -0,1075 | 1,1592 | -0,2325 | 0,8684 | -0,3830 |
| -1,0 | 0,2 | -0,0124 | 0,7795 | -0,0760 | 1,1277 | -0,1644 | 0,9003 | -0,2708 |
| 0 | -0,8 | 0 | 0,7919 | 0 | 1,0517 | 0 | 0,6359 | 0 |
| 1,0 | 0,2 | 0,0124 | 0,8043 | 0,0760 | 0,9757 | 0,1644 | 0,4715 | 0,2708 |
| 1,4142 | 1,2 | 0,0175 | 0,8094 | 0,1075 | 0,9442 | 0,2325 | 0,4034 | 0,3830 |

| $0{,}086x_2^2$ | $y_{2.1} = 1{,}3294 + (9) - (10)$ | $0{,}0799x_2$ | $y_{2.2} = 1{,}0577 + (12) - (10)$ | $0{,}111x_2$ | $y_{2.3} = 0{,}7324 - (14) - (10)$ | $0{,}1105x_3$ | $0{,}0885x_3^2$ | $y_{3.1} = 0{,}7952 - (16) - (17)$ |
|---|---|---|---|---|---|---|---|---|
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0,1032 | 0,8432 | -0,1130 | 0,8355 | -0,157 | 0,7862 | -0,1563 | 0,1062 | 0,8453 |
| 0,0172 | 1,0414 | -0,0799 | 0,9546 | -0,111 | 0,8262 | 0,1105 | 0,0177 | 0,8880 |
| -0,0688 | 1,3982 | 0 | 1,1205 | 0 | 0.8012 | 0 | -0,0708 | 0,8660 |
| 0,0172 | 1,5830 | 0,0799 | 1,1144 | 0,111 | 0,6042 | 0,1105 | 0,0177 | 0,6670 |
| 0,1032 | 1,6092 | 0,1130 | 1,0615 | 0.157 | 0,4722 | 0,1562 | 0,1062 | 0,5328 |

| $y_{3.2} = 1{,}1205 - (17)$ | $y_{3.3} = 0{,}493 + (16) - (17)$ | $0{,}143x_4$ | $y_{4.1} = 0{,}5722 - (21)$ | $0{,}135x_4$ | $y_{4.2} = 1{,}0517 - (23)$ | $0{,}127x_4$ | $y_{4.3} = 0{,}5832 - (25)$ |
|---|---|---|---|---|---|---|---|
| 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| 1,0143 | 0,2306 | -0,2022 | 0,7744 | -0,1909 | 1,2426 | -0,1796 | 0,7212 |
| 1,1028 | 0,3648 | -0,1430 | 0,7152 | -0,1350 | 1,1867 | 0,1270 | 0,7102 |
| 1,1913 | 0,5638 | 0 | 0,5722 | 0 | 1,0517 | 0 | 0,5832 |
| 1,1028 | 0,5858 | 0,1430 | 0,4292 | 0,1350 | 0,9167 | 0,1270 | 0,4132 |
| 1,0143 | 0,5430 | 0,2022 | 0,3700 | 0,1909 | 0,8609 | 0,1796 | 0,4036 |

According to the tab.2 is built graphs, presented on the fig.1. From tab.2 and fig.1 is visible, that coefficient variation intervals between the seeds of sugar beet by sowing apparatus seeder CCT-type from factors $x_1(h)$, $x_4(v_\Lambda)$ was depended straight-line, but from factors $x_2(D)$, $x_3(v_0)$ — corvilinely; by that a response is diminishes by increase factors $x_1(h)$, $x_4(v_\Lambda)$ (the lines $y_{1.2}, y_{1.3}$, $y_{4.1} - y_{4.3}$); behind exclusion function $y_{1.1}$, which is increases by growing up the factor $x_1(h)$ ($x_2 = x_3 = x_4 = -1{,}4142$). Coefficient variation increases by growing factor $x_2(D)$ — the lines $y_{2.1}, y_{2.2}$, however by $x_1 = x_3 = x_4 = 1{,}4142$ function $y$ is diminishes with increase the diameter of seed tube (line ). The increase of velocity $x_3(v_0)$ of the twirl of a seed disc was stipulated the decrease the response $y$ (by $x_1 = x_2 = x_4 = -1{,}4142$; the line $y_{3.1}$) and increase $y$ (by $x_1 = x_2 = x_4 = 1{,}4142$; the line $y_{3.3}$), but also the presence of a maximum $y_{max} = 1{,}1913$ (by $x_1 = x_2 = x_4 = 0$; the line $y_{3.2}$, the column 19, tab. 2).

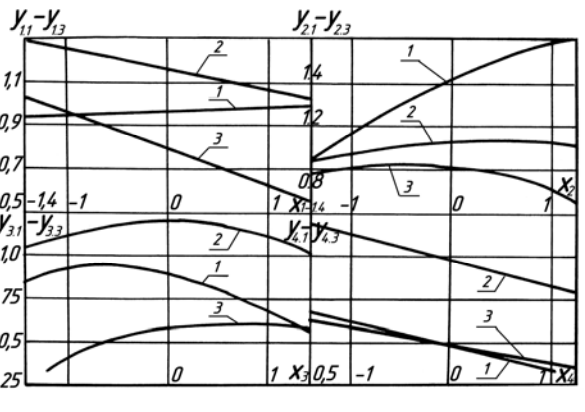

**Fig. 1.** Graphs of functions $y_{1.1} - y_{4.3}$ (the coefficient variation of intervals)

Optimization of the parameters the dosator with vertical disc on the coefficient variation intervals

The minimum importance function of response on the matrix of scheduling is observed in the experiment №9: $y'_{min} = 0{,}68$; $x_1 = x_2 = x_3 = -1$; $x_4 = 1$. We make the matrix for calculation of $y_{min}$ by means of quantization of independent variables [2-4], tab.3.

The tab. 3 is constructed as follows: in the column 2 independent arguments $x_i$ and their productions on the coefficients of regress are located; in heading — the coefficients of regress and their numerical importance. In line 1 conditions of experience and minimum importance of the function response $y'_{min}$ from the matrix of planning are represented; further in even lines (2, 4) importance of arguments are represented, and in odd – their productions on corresponding coefficients of regress. In the right extreme column (12) the importance of function $\hat{y}$, foretell by the equation of regress, are placed. From it is visible, that minimum of the function response was placed in the line 5 ($\hat{y}$=0,2306); therefore by the coordinates of a special point S factorial space take conditions of line 4 tab. 3:

$$y_S = 0{,}2306;\ x_{1S} = x_{2S} = x_{4S} = 1{,}4142;\quad x_{3S} = -1{,}4142. \qquad (4)$$

The two-dimensional sections of the function $y$, necessary for research of "almost stationary" area, was carried out on the factors $x_2, x_3$ with using regress (2). Characteristic equation has the view [2-4]:

$$f(B) = \begin{vmatrix} b_{22} - B & 0{,}5b_{23} \\ 0{,}5b_{23} & b_{33} - B \end{vmatrix} = \begin{vmatrix} 0{,}086 - B & 0 \\ 0 & -0{,}0885 - B \end{vmatrix} = = 0{,}0076 + 0{,}086B + 0{,}0885B + B^2 = = B^2 + 0{,}1745B + 0{,}0076 = 0. \qquad (5)$$

**Table 3.** Calculation of the response $y_{min}$ minimum

| № | $b_0$ 1,0517 | $b_1$ -0,076 | $b_2$ 0,0799 | $b_3$ 0 | $b_4$ -0,0625 | $b_{12}$ -0,0725 | $b_{24}$ +0,0781 | $b_{34}$ 0,0781 | $b_{22}$ -0,086 | $b_{33}$ -0,0885 | $\hat{y}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | $x_i$ | -1 | -1 | -1 | 1 | | | | | | 0,68 |
| 2 | $x_i$ | 1,4142 | -1,4142 | -1,4142 | 1,4142 | -2 | -2 | -2 | 1,2 | 1,2 | |
| 3 | $b_i x_i$ | -0,1075 | -0,113 | 0 | -0,191 | 0,135 | -0,145 | -0,1562 | -0,1032 | -0,1062 | 0,5546 |
| 4 | $x_i$ | 1,4142 | 1,4142 | -1,4142 | 1,4142 | 2 | 2 | -2 | 1,2 | 1,2 | |
| 5 | $b_i x_i$ | -0,1075 | 0,113 | 0 | -0,191 | -0,125 | -0,145 | -0,1562 | -0,1032 | -0,1062 | 0,2306 |
| 6 | $x_i$ | 1,4142 | -1,4142 | 1,4142 | 1,4142 | -2 | -2 | 2 | 1,4142 | 1,4142 | |
| 7 | $b_i x_i$ | -0,1075 | -0,113 | 0 | -0,191 | 0,135 | 0,145 | 0,1562 | -0,1032 | -0,1062 | 0,867 |

The roots equation (2, 3):

$$B_{23} = -0{,}08725 \pm \sqrt{0{,}0076126 - 0{,}0076} = = -0{,}08725 \pm 0{,}08725; \quad (6)$$

$$B_{22} = 0; \; B_{33} = -0{,}1745 .$$

The corner of turn coordinate axes:

$$\mathrm{tg}2a = b_{23}/(b_{22} - b_{33}) = 0/(-0{,}086 + 0{,}0885) = 0. \quad (7)$$

The initial form has the view:

$$Y - Y_S = B_{22}X_2^2 + B_{33}9X_3^2; \; Y - 0{,}2306 = -0{,}1745X_3^2. \quad (8)$$

From here:

$$X_3 = \sqrt{Y/(-0{,}1745) + 1{,}3215} . \quad (9)$$

The coordinates of the new centre $S(-1{,}4142;-1{,}4142)$; as coefficients $B_{22} = 0$, $B_{33} < 0$ ($B_{33} = -0{,}1745$), that the lines of an equal exit – the straights, but a surface of response is the stationary rise [2-4]. The coordinates of the lines of an equal exit were determined according (9) by an $y = 0{,}1;\ 0{,}15;\ 0{,}2$ and 0,2306; the sequence of calculation is presented in tab. 4.

**Table 4.** The sequence of calculation coordinates lines of equal exit for function Y

| Y | $X_3(\pm)$ | Y | $X_3(\pm)$ | Y | $X_3(\pm)$ | Y | $X_3(\pm)$ |
|---|---|---|---|---|---|---|---|
| 0,2306 | 0 | 0,2 | 0,42 | 0,15 | 0,68 | 0,1 | 0,865 |

In old system of coordinates $x_2 0 x_3$ (fig. 2) the square with the sides $2 \cdot 1{,}4142$ is construction and new centre $S(-1{,}4142;-1{,}4142)$ is mark with axes $X_2, X_3$, which are parallel the axes $0x_2$, $0x_3$ (corner $\alpha = 0$ on the (7)). From fig. 2 is evidently, that a response diminishes by the movement along of axe $X_3$.

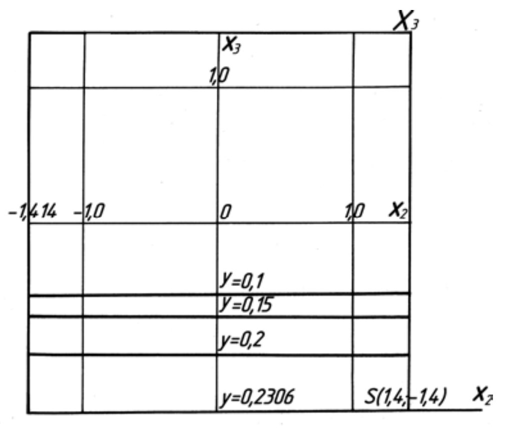


**Fig. 2.** Two-dimensional sections of "almost stationary" area of function Y (coefficient variation of intervals) by factors $X_2, X_3$ when $x_1 = x_4 = 1{,}4142$ (lines of an equal exit (straight) are shown)

CONCLUSIONS

1. The coefficient Y of variation an intervals between seeds in longitudinal direction was calculated on the formula:

$$Y_5 = \sigma / v_1, \quad (1)$$

where: $\sigma$, $v_1$ — middle square deviation (standart) and first initial moment of intervals correspondingly.

An experiments were produced on the apparatus with vertical disc of the seeder of CCT-type, which was installed on the special framework over a ribbon of the stand of a generally accepted construction.

Four factors were varied: $x_1(h)$, $x_2(D)$ — altitude and diameter of a seed tube; $x_3(v_0)$; $x_4(v_\Lambda)$ — velocities of the twirl of a seed disc and movement the ribbon of the stand. Levels of the factors (tab.1) were varied according to the orthogonal planning of the second order for four factors.

2. After implementation of the experiments on the matrix of orthogonal planning of the second order for four factors and processing of data experiments according with the methods of orthogonal planning the adequate regression model of the second order with variables in a code designation was received:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_4x_4 + b_{12}x_1x_2 + b_{24}x_2x_4 + + b_{34}x_3x_4 + b_{22}x_2^2 + b_{33}x_3^2, \quad (2)$$

where: $b_0 = 1{,}0517$; $b_1 = -0{,}076$; $b_2 = 0{,}0799$; $b_4 = -0{,}135$; $b_{12} = -0{,}0625$; $b_{24} = -0{,}0725$; $b_{34} = 0{,}0781$; $b_{22} = -0{,}086$; $b_{33} = -0{,}0885$.

3. Influence of each factor on the coefficient of variation an intervals between seeds in longitudinal direction was defined by an levels of other factors, equal ±1,4142 and 0; it was presented in the equations (3), tab. 2 and fig. 1. From them it is visible, that the response was depended from the factors $x_1(h)$, $x_4(v_\Lambda)$ straightlinely, but from factors $x_2(D)$, $x_3(v_0)$ — corvilinely; by that a response is diminishes by increase factors $x_1(h)$, $x_4(v_\Lambda)$ — the lines $y_{1.2}, y_{1.3}$, $y_{4.1} - y_{4.3}$; behind exclusion function $y_{1.1}$, which is increases by growing up the factor $x_1(h)$ ($x_2 = x_3 = x_4 = -1{,}4142$). Coefficient variation increases by growing factor $x_2(D)$ — the lines $y_{2.1}, y_{2.2}$; however by $x_1 = x_3 = x_4 = 1{,}4142$ function Y is diminishes with increase the diameter of seed

tube (line $y_{2.3}$). The increase of factor $x_3(v_0)$ was stipulated the decrease the response $y$ (by $x_1 = x_2 = x_4 = -1{,}4142$; the line $y_{3.1}$) and increase $y$ (by $x_1 = x_2 = x_4 = 1{,}4142$; the line $y_{3.3}$), but also the presence of a maximum $y_{max} = 1{,}1913$ (by $x_1 = x_2 = x_4 = 0$; the line $y_{3.2}$, the column 19, tab. 2).

4. The coordinates of special point factorial space were determined by quantization of the independent variables (tab.3); from it is visible, that minimum of the function response was placed in the line 5 ($\hat{y}$=0,2306); therefore by the coordinates of the special point $S$ factorial space is take conditions of line 4 tab. 3:

$$y_S = 0{,}2306;\ x_{1S} = x_{2S} = x_{4S} = 1{,}4142; \quad x_{3S} = -1{,}4142. \tag{4}$$

The two-dimensional sections of the function $y$ was carried out on the factors $x_2, x_3$ with using of model (2).

The coordinates of the new centre $S(-1{,}4142;-1{,}4142)$; as coefficients $B_{22} = 0$, $B_{33} < 0$ ($B_{33} = -0{,}1745$), that the lines of an equal exit – the straights, but a surface of response is the stationary rise. The coordinates of lines equal exit (tab. 4) were defined from initial form (9), it was presented on the fig. 2; from it is evidently, that a response diminishes by the movement along axe $X_3$.

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## ПАРАМЕТРИЧЕСКАЯ ОПТИМИЗАЦИЯ ВЫСЕВА САХАРНОЙ СВЕКЛЫ ПО КОЭФФИЦИЕНТУ ВАРИАЦИИ ИНТЕРВАЛОВ

*Виктор Белодедов, Павел Носко, Григорий Бойко, Павел Филь, Марина Мазнева*

А н н о т а ц и я. Представлены результаты многофакторного эксперимента, поставленного по матрице ортогонального планирования для четырех факторов: высоты и диаметра семяпровода, а также скорости вращения высевающего диска и движения ленты стенда. Результаты экспериментов обработаны в соответствии с методикой, характерной для ортогонального планирования, получена адекватная математическая модель процесса, по которой установлено влияние факторов и оптимальные условия высева.

К л ю ч е в ы е с л о в а. Коэффициент вариации интервалов, влияние факторов, оптимизация.