STUDYING THE EFFECT OF PRE-SOWING ELECTROMAGNETIC TREATMENT ON THE LENGTHS OF ROOTS AND SPROUTS OF TRITICALE SEEDS THE CULTIVAR BOOMERANG

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Abstract. *After pre-sowing electromagnetic treatments, with screw device, of triticale seeds, cultivar Boomerang, laboratory studies on the number of roots and lengths of roots and sprouts were carried out. Regression equations were found. The surfaces and lines of response of the studied parameters were built. On their basis they were established the values of controllable factors that would have beneficial effects on the development of laboratory parameters number and lengths of the roots, lengths of the sprouts, namely: voltage between the electrodes of the screw device (factor* $\overset{\circ}{x}_1$ *) U=(4.5...5.4)kV, exposure time (factor* $\overset{\circ}{x}_2$ *)* τ*=(22...54)s, and duration of staying of seeds from the treatment to their sowing in laboratory conditions (factor* $\overset{\circ}{x}_3$ *) T=(14...18) days.*

Keywords: *triticale seeds, cultivar Boomerang, pre-sowing electromagnetic treatments, number of roots, lengths of the roots and sprouts.*

Introduction. Triticale is an attractive culture due to its productive capacity and high output quality, competitiveness in terms of weeds and tolerance to drought [2,3,7]. Areas tend to steadily increase in all corners the world, especially in Europe.

In our country many new triticale varieties were created and introduced in production. Very high productive capacity it was established for the cultivar Boomerang, as a result of a more sustainable response to stressful growing conditions [1].

Currently, there is an increased interest in researches in the field of agro-ecological systems using tolerant technologies to the environment. The issue of implementation of the energy simulation is extremely topical as an opportunity to search for alternative, environmentally friendly methods and technologies to increase yields of major field crops.

The conduction of laboratory examinations promotes the effectiveness of studies using electromagnetic fields in the plant crops. After the initial researches [9], work on the establishment the effect of pre-sowing electromagnetic treatments of triticale seeds, the cultivar Boomerang, was continued with mathematical processing of the obtained laboratory data - finding the regression equations and construction of the surfaces and lines of response of the laboratory parameters: number of roots, lengths of the roots and sprouts of the triticale seeds, the cultivar Boomerang.

Aim of the study: after analyzing the data obtained from the laboratory tests, surfaces and lines of response of the indicated laboratory parameters, to determine the optimal values of controllable factors of the pre-sowing electromagnetic treatments of triticale seed, the cultivar Boomerang.

Object and methodology. Object of the study were the surfaces and lines of response of number of the roots $\mathbf{N_{root}}$, lengths of the roots $\boldsymbol{\ell_{root}}$ and lengths of the sprouts $\boldsymbol{\ell_{spr}}$ of triticale seeds of the Bulgarian cultivar Boomerang.

According to the methodology described in [9] the seeds were pre-sowing electromagnetic treated with the device [8] trough a symmetrical compositional plan B3 [5].

The controllable factors of treatment were: voltage between the electrodes - U,kV, exposure time τ,s and duration of staying T days, from the seeds treatment to their sowing in laboratory conditions.

Processing of the results obtained for the number of roots $\mathbf{N_{root}}$, lengths of the roots ℓ_{root} and of the sprouts $\boldsymbol{\ell_{spr}}$, and construction the surfaces and lines of their response were performed using the software Statistics 8 [4].

Effects (Y_i, in %/control) of the pre-sowing electromagnetic treatments impact on the monitored parameters were obtained by their established equations - models shown in [6].

For the purpose of the study for each parameter three cases were discussed. In these cases, one of the controllable factors was excluded. Thus, at the interaction of the remaining two ones, the equation of the surface and lines of response of the concrete parameter was obtained.

Results and discussion. Plan of the experiment through the symmetrical compositional plan B3 and the results obtained from the laboratory tests of stated above parameters are shown in Table 1.

Based on the obtained in [6] regression equations of the number of roots $\mathbf{N_{root}}$, lengths of the roots $\boldsymbol{\ell_{root}}$ and sprout $\boldsymbol{\ell_{spr}}$, below in tabular form their coefficients b_i are shown - Table 2. These coefficients have been rounded to the third decimal place.

Table 1. Plan of the experiment and results from laboratory researches (in 2015) of the number of roots $\mathbf{N_{root}}$, lengths of the roots $\boldsymbol{\ell_{root}}$ and lengths of the sprouts $\boldsymbol{\ell_{spr}}$ of triticale seed cultivar Boomerang

Variant No.	Controllable factors						BOOMERANG		
	U		τ		T				
	-	kV	-	s	-	Days	$\mathbf{N_{root}}$	$\boldsymbol{\ell_{root}}$	$\boldsymbol{\ell_{spr}}$
1	1	5	1	50	1	21	109.4	81.4	104.5
2	-1	1	1	50	1	21	83.0	88.2	96.5
3	1	5	-1	10	1	21	101.9	84.3	102.7
4	-1	1	-1	10	1	21	94.3	87.3	107.6
5	1	5	1	50	-1	7	103.8	121.6	105.2
6	-1	1	1	50	-1	7	100.0	104.9	97.7
7	1	5	-1	10	-1	7	94.3	133.3	104.5
8	-1	1	-1	10	-1	7	98.1	111.8	100.8
9	1	5	0	30	0	14	107.5	80.4	102.7
10	-1	1	0	30	0	14	100.0	92.2	105.8
11	0	3	1	50	0	14	103.8	76.5	103.3
12	0	3	-1	10	0	14	101.9	75.5	101.4
13	0	3	0	30	1	21	100.0	96.1	104.5
14	0	3	0	30	-1	7	101.9	92.2	99.0

Table 2. Regression coefficients b_i of the equations for: the number of roots $\mathbf{N_{root}}$, lengths of the roots $\boldsymbol{\ell_{root}}$ and lengths of the sprouts $\boldsymbol{\ell_{spr}}$ of triticale seeds cultivar Boomerang

Studied parameters	b_0	b_1	b_2	b_3	b_{12}	b_{13}	b_{23}	b_{11}	b_{22}	b_{33}
Number of roots – $\mathbf{N_{root}}$	104.717	4.151	0.943	-0.943	3.302	4.245	-1.887	-0.943	-1.887	-3.774
Lengths of the roots - $\boldsymbol{\ell_{root}}$	77.390	1.667	-1.961	-12.647	-1.103	-6.050	2.083	8.885	-1.409	16.728
Lengths of the sprouts - $\boldsymbol{\ell_{spr}}$	102.951	1.113	-0.990	0.866	2.088	-1.005	-0.851	1.276	-0.580	-1.199

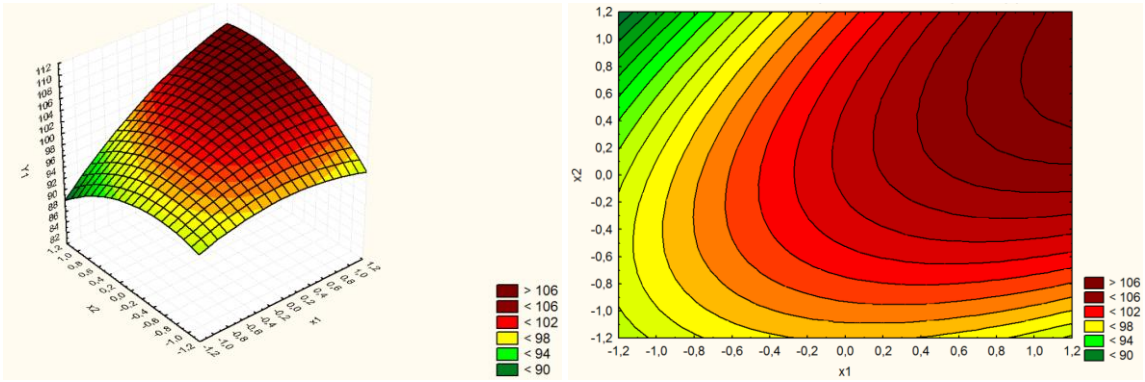
Calculated and shown below equations of the surfaces and lines of response of the mentioned laboratory parameters were obtained in the following cases for the triticale seeds, the cultivar Boomerang:

Case 1 for the number of roots $\mathbf{N_{root}}$ of the triticale seeds, the cultivar Boomerang:

Here, the factor $\overset{\circ}{x}_3$ - duration of staying T until sowing was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_1$ and $\overset{\circ}{x}_2$ the resulting equation of the surface and lines of response of the number of the emerged roots $\mathbf{N_{root}}$ was of the following type:

$$\hat{Y}_{B1.\,N\,root} = 103.266 + 4.151\overset{\circ}{x}_1 + 0.943\overset{\circ}{x}_2 + 3.302\overset{\circ}{x}_1\overset{\circ}{x}_2 - 1.814\overset{\circ}{x}_1^2 - 2.758\overset{\circ}{x}_2^2 \quad (1)$$

Constructed surface and lines of response of the number of the emerged roots $\mathbf{N_{root}}$, for the case 1 are shown in Figure 1.



a) *b)*

Fig.1. Surface (a) and lines (b) of response of the roots of triticale seeds, the cultivar Boomerang, at exclusion impact of the factor $\overset{\circ}{x}_3$ *(T).*

Values of $\hat{Y}_{N\,root}$ (of the grown roots) according to the model (1), in %/control are indicated in digital form along the vertical axis in Figure 1a and in color expression on the right side of both figures. The zones colored from light red to dark brown show that at such values of the controllable factors stimulation the number of roots is possible. For the case of Figures 1a and 1b after pre-sowing electromagnetic treatment at $\overset{\circ}{x}_1$ =(0.75...1.2) and $\overset{\circ}{x}_2$ =(0.3...1.2) it is expected the number of roots to increase.

Case 2 for the numbers of roots $\mathbf{N_{root}}$ *of the triticale seeds, the cultivar Boomerang:*

Here, the factor $\overset{\circ}{x}_2$ - exposure time τ was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_1$ and $\overset{\circ}{x}_3$ the following equation of the surface and lines of response for the number of roots $\mathbf{N_{root}}$ was obtained for the case 2:

$$\hat{Y}_{B2.\,N\,root} = 103.991 + 4.151\overset{\circ}{x}_1 - 0.943\overset{\circ}{x}_3 + 4.245\overset{\circ}{x}_1\overset{\circ}{x}_3 - 1.379\overset{\circ}{x}_1^2 - 4.209\overset{\circ}{x}_3^2 \qquad (2)$$

Case 3 for the number of roots of the triticale seeds the cultivar Boomerang:

Here, the factor $\overset{\circ}{x}_1$ - applied voltage U between the electrodes was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_2$ and $\overset{\circ}{x}_3$ the following equation of the surface and lines of response for the number of roots $\mathbf{N_{root}}$ was obtained for the case 3:

$$\hat{Y}_{B3.\,N\,root} = 104.354 + 0.943\overset{\circ}{x}_2 - 0.943\overset{\circ}{x}_3 - 1.887\overset{\circ}{x}_2\overset{\circ}{x}_3 - 2.105\overset{\circ}{x}_2^2 - 3.991\overset{\circ}{x}_3^2 \qquad (3)$$

The surfaces and lines of response – number of roots $\mathbf{N_{root}}$ for the cases 2 and 3 are not shown here.

Analysis of the resulting surfaces and lines of response for the roots of the triticale seeds the cultivar Boomerang helps to establish the values of controllable factors that determine the zones where it is expected depressing or stimulating effects of the pre-sowing cultivation.

Such data together with the zones of activity are shown in Table 3. Therein are also reflected the effects of these interactions when the factors $\overset{\circ}{x}_j$ were on there mid levels - 0.

For easier transition from relative in natural units the data in Table 4 are used.

From figure 1 and Table 3 it can be concluded that, if the factors $\overset{\circ}{x}_1$, $\overset{\circ}{x}_2$ and $\overset{\circ}{x}_3$ are on their zero levels, i.e. U=3kV, τ=30s and T=14 days, it is expected the number of roots to the control ones to increase within (103.3...104.4) %/control.

From figure 1 and Tables 3 and with the help of Table 4 it can be found that a stimulating effect on the number of roots $\mathbf{N_{root}}$ it could be expected by treating the seeds with factors having the following values:

Table 3. Zones of the controllable factors whose interactions $\hat{Y}_{Bi.\,N\,root}$ stimulate or suppress the growth of roots of triticale seed, the cultivar Boomerang

Effect $\hat{Y}_{Bi.\,N\,root}$ of the electromagnetic treatment controllable factors interaction					
At a mid-level of the factors		Stimulating		Depressing	
$\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,N\,root}$ %/control	at $\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,N\,root}$ %/control	At $\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,N\,root}$ %/control
Case 1 – exclusion the factor $\overset{\circ}{x}_3$					
$\overset{\circ}{x}_1 = 0$ $\overset{\circ}{x}_2 = 0$	103.3	$\overset{\circ}{x}_1 = (0.75 \dots 1.2)$ $\overset{\circ}{x}_2 = (0.3 \dots 1.2)$	above 106	$\overset{\circ}{x}_1 = (-0.75 \dots -1.2)$ $\overset{\circ}{x}_2 = (0.5 \dots 1.2)$	below 98
Case 2 - exclusion the factor $\overset{\circ}{x}_2$					
$\overset{\circ}{x}_1 = 0$ $\overset{\circ}{x}_3 = 0$	103.9	$\overset{\circ}{x}_1 = (0.7 \dots 1.2)$ $\overset{\circ}{x}_3 = (0 \dots 0.75)$	above 106	$\overset{\circ}{x}_1 = (-0.5 \dots -1.2)$ $\overset{\circ}{x}_3 = (0.6 \dots 1.2)$	below 98
Case 3 - exclusion the factor $\overset{\circ}{x}_1$					
$\overset{\circ}{x}_2 = 0$ $\overset{\circ}{x}_3 = 0$	104.4	$\overset{\circ}{x}_2 = (-0.6 \dots 1.2)$ $\overset{\circ}{x}_3 = (-0.8 \dots 0.4)$	above 104	$\overset{\circ}{x}_2 = (0.6 \dots 1.2)$ $\overset{\circ}{x}_3 = (0.9 \dots 1.2)$ $\overset{\circ}{x}_2 = (-0.8 \dots -1.2)$ $\overset{\circ}{x}_3 = (-0.8 \dots -1.2)$	below 98

Table 4. Controllable factors of the pre-sowing electromagnetic treatment of triticale seeds the cultivar Boomerang in relative and natural units

Factors	-1	0	+1	Value of the factor for the step 0,1 division
$\overset{\circ}{x}_1$	1 kV	3kV	5kV	0.2 kV
$\overset{\circ}{x}_2$	10 s	30 s	50 s	2 s
$\overset{\circ}{x}_3$	7 days	14 days	21 days	0.7 days

$\overset{\circ}{x}_1$ = (0.75…1.2), or U= (4.5…5.4)kV ;

$\overset{\circ}{x}_2$ = (0.3…1.2), or τ= (36…54)s;

$\overset{\circ}{x}_3$ = (0.0…0.4), or. T ≈ (14…17) days.

From figure 1b it may be noted that when using the above values of controllable factors, the parameter of optimization number of roots N_{root} should be increased by (4...6) %, i.e. to the number of roots of control seeds and that increase will be (104...106) %/control.

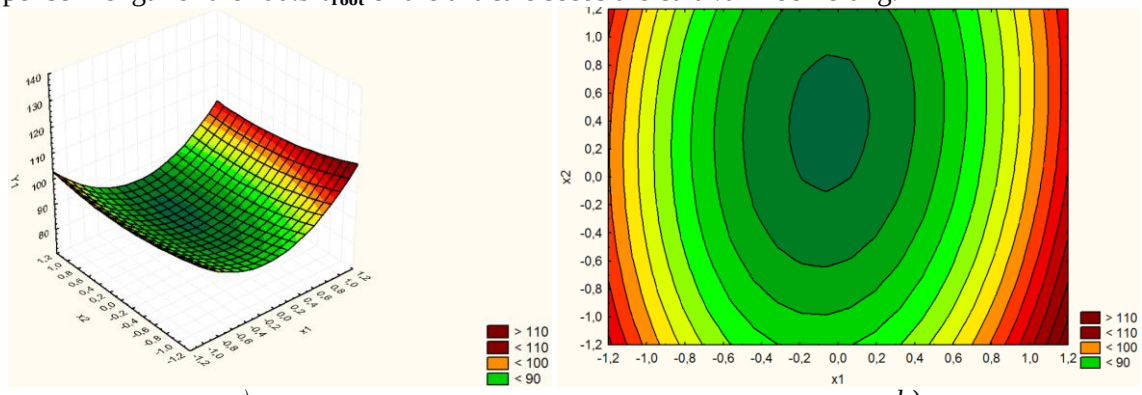
According to the regression equations, whose coefficients are shown in Table 2, the surface and lines of response - length of the roots - ℓ_{root} of electromagnetic treated triticale seeds, the cultivar Boomerang, were built in the following cases:

Case 1 for the lengths of roots ℓ_{root} of the triticale seeds the cultivar Boomerang:

Here, the factor $\overset{\circ}{x}_3$ - duration the staying T until the seed sowing was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_1$ and $\overset{\circ}{x}_2$ the equation of the surface and lines of response for ℓ_{root} was of the following type for the case 1:

$$\hat{Y}_{B1.\,\ell\,root} = 83.824 + 1.667\overset{\circ}{x}_1 + 1.961\overset{\circ}{x}_2 - 1.103\overset{\circ}{x}_1\overset{\circ}{x}_2 + 12.745\overset{\circ}{x}_1^2 + 2.451\overset{\circ}{x}_2^2 \quad (4)$$

In Figure 2 are presented the built in accordance with equation (4), surface and lines of response - length of the roots ℓ_{root} of the triticale seeds the cultivar Boomerang.



a) *b)*

Fig. 2. Surface (a) and lines (b) of response of the lengths of roots ℓ_{root} of the triticale seeds, the cultivar Boomerang, at exclusion impact of the factor $\overset{\circ}{x}_3$ (T).

Case 2 for the lengths of roots $\boldsymbol{\ell_{root}}$ of the triticale seeds cultivar Boomerang:

Here, the factor $\overset{\circ}{x}_2$ - duration of the electromagnetic impact τ was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_1$ and $\overset{\circ}{x}_3$ the following equation of the surface and lines of response for the length of roots ℓ_{root} of the triticale seeds of the cultivar Boomerang was obtained for the case 2:

$$\hat{Y}_{B2.\,\ell root} = 76.848 + 1.667\,\overset{\circ}{x}_1 - 12.647\,\overset{\circ}{x}_3 - 6.005\,\overset{\circ}{x}_1\,\overset{\circ}{x}_3 + 8.560\,\overset{\circ}{x}_1^2 + 16.403\,\overset{\circ}{x}_3^2 \quad (5)$$

Case 3 for the lengths of roots $\boldsymbol{\ell_{root}}$ of the triticale seeds the cultivar Boomerang:

Here, the factor $\overset{\circ}{x}_1$ - applied voltage U between the electrodes was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_2$ and $\overset{\circ}{x}_3$ the following equation of the surface and lines of response for the lengths of roots $\boldsymbol{\ell_{root}}$ of the seeds of the triticale cultivar Boomerang was obtain for the case 3:

$$\hat{Y}_{B3.\,\ell root} = 80.807 - 1.961\,\overset{\circ}{x}_2 - 12.647\,\overset{\circ}{x}_3 + 2.083\,\overset{\circ}{x}_2\,\overset{\circ}{x}_3 + 0.641\,\overset{\circ}{x}_2^2 + 18.778\,\overset{\circ}{x}_3^2 \quad (6)$$

The surfaces and lines of response - lengths of the roots ℓ_{root} for the cases 2 and 3 are not shown here.

From the analysis of the resulting surfaces and lines of response at the interactions of individual factors it can be found what would be their effects on the lengths of roots $\hat{Y}_{Bi.\,\ell root}$ - stimulating or depressing ones.

Such data, with the zones of actions are shown in Table 5. There they are also reflected the effects of these interactions when the factors $\overset{\circ}{x}_i$, $\overset{\circ}{x}_2$ and $\overset{\circ}{x}_3$ are on their mid levels - 0.

From figure 2 and Table 5 it can be concluded that, if the factors $\overset{\circ}{x}_1$, $\overset{\circ}{x}_2$ and $\overset{\circ}{x}_3$ are on their zero levels it is expected suppressive effect - to (76.9...83.8) %/control of the pre-sowing electromagnetic treatment on the lengths of roots.

Of Figure 2 and Table 5, using the data in Table 4, it can be found that a stimulating effect on the lengths of roots ℓ_{root} could be expected by treating the seeds with factors having the following values:

$\overset{\circ}{x}_1$ = (1.1…1.2), i.e. U= (5.2…5.4) kV;

$\overset{\circ}{x}_2$ = (-1.2…-1.1), i.e. τ= (6…8) s;

$\overset{\circ}{x}_3$ = (-1.2…-1.0), i.e. T≈ (5.6…7) days.

Table 5. Zones of the controllable factors, whose interactions stimulate or suppress the lengths of roots ℓ_{root} of triticale seed, the cultivar Boomerang

Effect $\hat{Y}_{Bi.\,\ell root}$ of the electromagnetic treatment controllable factors interaction					
At a mid-level of the factors		Stimulating		Depressing	
$\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,\ell root}$ %/control	at $\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,\ell root}$ %/control	at $\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,\ell root}$ %/control
Case 1 – exclusion the factor $\overset{\circ}{x}_3$					
$\overset{\circ}{x}_1 = 0$ $\overset{\circ}{x}_2 = 0$	83.8	$\overset{\circ}{x}_1 = (1.1 \dots 1.2)$ $\overset{\circ}{x}_2 = (-1.1 \dots -1.2)$	above 110	$\overset{\circ}{x}_1 = (-0.9 \dots 0.9)$ $\overset{\circ}{x}_2 = (-1.2 \dots 1.2)$	below 98
Case 2 - exclusion the factor $\overset{\circ}{x}_2$					
$\overset{\circ}{x}_1 = 0$ $\overset{\circ}{x}_3 = 0$	76.9	$\overset{\circ}{x}_1 = (0.85 \dots 1.2)$ $\overset{\circ}{x}_3 = (-0.9 \dots -1.2)$	above 120	$\overset{\circ}{x}_1 = (-1.2 \dots 1.2)$ $\overset{\circ}{x}_3 = (-0.7 \dots 1.2)$	below 98
Case 3 - exclusion the factor $\overset{\circ}{x}_1$					
$\overset{\circ}{x}_2 = 0$ $\overset{\circ}{x}_3 = 0$	80.8	$\overset{\circ}{x}_2 = (-1.2 \dots 1.2)$ $\overset{\circ}{x}_3 = (-1.0 \dots -1.2)$	above 120	$\overset{\circ}{x}_2 = (-1.2 \dots 1.2)$ $\overset{\circ}{x}_3 = (-0.7 \dots 1.2)$	below 98

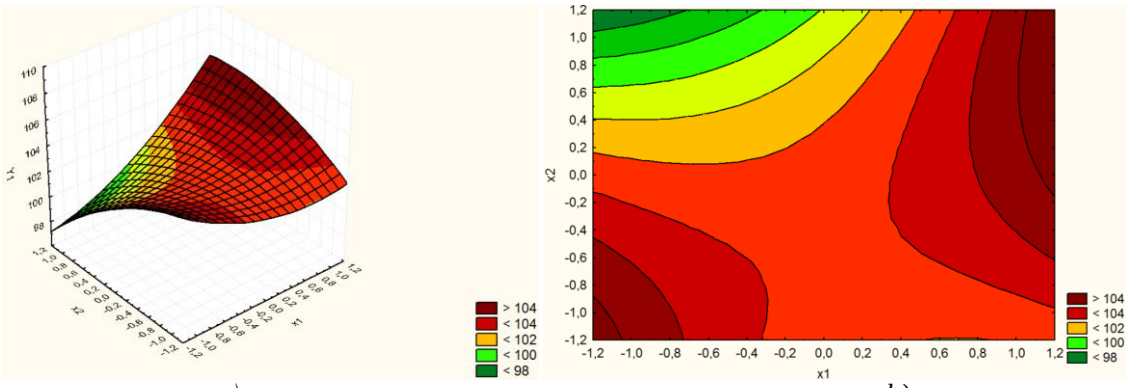
According to the regression equations, their coefficients are given in Table 2, the surfaces and lines of response - lengths of the sprouts ℓ_{spr} of the electromagnetic treated triticale seed, the variety Boomerang, were built in the following cases:

Case 1 for the lengths of sprouts ℓ_{spr} of triticale seeds the variety Boomerang:

Here, the factor $\overset{\circ}{x}_3$ - duration of the stay T to sowing was excluded. Thus, at the interaction of the factors $\overset{\circ}{x}_1$ and $\overset{\circ}{x}_2$, the equation of the surface and lines of response for the ℓ_{spr} was prepared of the following type for the case 1:

$$\hat{Y}_{B1.\,\ell spr} = 102.490 + 1.113\overset{\circ}{x}_1 - 0.990\overset{\circ}{x}_2 + 2.088\overset{\circ}{x}_1\overset{\circ}{x}_2 + 0.999\overset{\circ}{x}_1^2 - 0.857\overset{\circ}{x}_2^2 \quad (7)$$

In Figure 3 are shown built through equation (7) surfaces and lines of response - lengths of the sprouts ℓ_{spr} of the triticale seeds, the cultivar Boomerang.



a) *b)*

Fig. 3. Surface (a) and lines (b) of response of the lengths of sprout ℓ_{spr} of triticale seeds, the variety Boomerang, at exclusion impact of the factor $\overset{\circ}{x}_3$ (T).

Case 2 for the lengths of sprouts ℓ_{spr} of the triticale seeds, the variety Boomerang:

Here, the factor $\overset{\circ}{x}_2$ - duration of the electromagnetic impact τ was excluded. Then, at the interaction of the factors $\overset{\circ}{x}_1$ and $\overset{\circ}{x}_3$ the following equation of the surface and the lines of response for the lengths of sprouts $\ell_{\mathbf{spr}}$ of the triticale seeds the cultivar Boomerang was obtained for the case 2:

$$\hat{Y}_{B2.\,\ell\,spr} = 102.728 + 1.113\overset{\circ}{x}_1 + 0.866\overset{\circ}{x}_3 - 1.005\overset{\circ}{x}_1\overset{\circ}{x}_3 + 1.142\overset{\circ}{x}_1^2 - 1.332\overset{\circ}{x}_3^2 \quad (8)$$

Case 3 for the lengths of sprout $\ell_{\mathbf{spr}}$ of the triticale seeds, the variety Boomerang:

Here, the factor $\overset{\circ}{x}_1$ - applied voltage U between the electrodes was excluded. Then, at the interaction of factors $\overset{\circ}{x}_2$ and $\overset{\circ}{x}_3$ the following equation of the surface and lines of response of the lengths of sprouts $\ell_{\mathbf{spr}}$ of the triticale seeds the variety Boomerang was obtained for the case 3:

$$\hat{Y}_{B3.\,\ell\,spr} = 103.441 - 0.990\overset{\circ}{x}_2 + 0.866\overset{\circ}{x}_3 - 0.851\overset{\circ}{x}_2\overset{\circ}{x}_3 - 0.286\overset{\circ}{x}_2^2 - 0.904\overset{\circ}{x}_3^2 \quad (9)$$

The surfaces and lines of response - lengths of sprouts $\ell_{\mathbf{spr}}$ in the cases 2 and 3 are not shown here.

The data showing the effects on the lengths of sprouts $\ell_{\mathbf{spr}}$ and the zones of actions, according to the case 3 are shown in Table 6. There in the effects of these interactions when the factors $\overset{\circ}{x}_i$ are on their mid-levels – 0 are also reflected.

Table 6. Zones of controllable factors whose interactions stimulate or suppress the lengths of sprouts ℓ_{spr} of the triticale seed, the cultivar Boomerang

Effect $\hat{Y}_{Bi.\,\ell\,spr}$ of the electromagnetic treatment controllable factors interaction					
At mid-level of the factors		Stimulating		Depressing	
$\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,\ell\,spr}$ %/control	at $\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,\ell\,spr}$ %/control	at $\overset{\circ}{x}_j$	$\hat{Y}_{Bi.\,\ell\,spr}$ %/control
Case 1 – exclusion the factor $\overset{\circ}{x}_3$					
$\overset{\circ}{x}_1 = 0$ $\overset{\circ}{x}_2 = 0$	102.5	$\overset{\circ}{x}_1 = (0.7 \ldots 1.2)$ $\overset{\circ}{x}_2 = (-0.3 \ldots 1.2)$	above 104	$\overset{\circ}{x}_1 = (0.6 \ldots -1.2)$ $\overset{\circ}{x}_2 = (1.0 \ldots 1.2)$	below 98
Case 2 – exclusion the factor $\overset{\circ}{x}_2$					
$\overset{\circ}{x}_1 = 0$ $\overset{\circ}{x}_3 = 0$	102.7	$\overset{\circ}{x}_1 = (0.9 \ldots 1.2)$ $\overset{\circ}{x}_3 = (0.6 \ldots -0.6)$	above 105	$\overset{\circ}{x}_1 = (-0.4 \ldots -1.2)$ $\overset{\circ}{x}_3 = (-1.1 \ldots -1.2)$	below 98
Case 3 – exclusion the factor $\overset{\circ}{x}_1$					
$\overset{\circ}{x}_2 = 0$ $\overset{\circ}{x}_3 = 0$	103.4	$\overset{\circ}{x}_2 = (-0.4 \ldots -1.2)$ $\overset{\circ}{x}_3 = (0.0 \ldots 1.2)$	above 105	There is no	

Conclusions. There were found values of the controllable factors that could affect beneficial on the development of the laboratory parameters number and length of the roots, length of the sprouts, namely: voltage between the electrodes of the screw device (factor $\overset{\circ}{x}_1$) U=(4.5... 5.4) kV, exposure time (factor $\overset{\circ}{x}_2$) τ=(22...54)s and duration of the seeds stay from the treatment to their sowing (factor $\overset{\circ}{x}_3$) T=(14...18) days.

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