Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi
International Journal of Innovative Approaches in Agricultural Research 2019, Vol. 3 (3), 466-479
https://doi.org/10.29329/ijiaar.2019.206.12

Original article

Study on the Effect of Presowing Electromagnetic Treatment on the Number and Lengths of Roots and Lengths of Sprouts of Triticale Seeds the Cultivar Colorit [1]

Kiril Sirakov [a], Ana Stoilova [b], Ivan Palov [a] & Angelina Muhova [b, *]

[a] Department ESEO, University of Ruse, 8, Studentska Street, 7017 Ruse, Bulgaria.
[b] Field Crops Institute, 1, Georgi Dimitrov, bul., 6200 Chirpan, Bulgaria

Abstract

On triticale seeds the cultivar Colorit pre-sowing electromagnetic treatments with screw device were performed and established the values of laboratory parameters: number of roots and lengths of roots and sprouts.

There were established the equations of regression. The surfaces and lines of response of these parameters were built. On their basis there were established the values of controllable factors that could affect beneficially on the development of laboratory parameters number and length of roots and length of sprouts, namely: voltage between the electrodes of screw processing device (factor $\overset{o}{x}_1$) U=(4.3...5.4) kV, exposure duration (factor $\overset{o}{x}_2$) τ =(28...54)s, and length of staying of seeds from treatment to their sowing (factor $\overset{o}{x}_3$) T≈(14...22) days.

Keywords: Triticale seeds, The cultivar Colorit, Pre-sowing electromagnetic treatments, Number of roots, Lengths of roots and sprouts, Surfaces and lines of response.

Received: 22 August 2018 * **Accepted:** 10 July 2019 * **DOI:** https://doi.org/10.29329/ijiaar.2019.206.12

* **Corresponding author:**

Angelina Muhova, Field Crops Institute, 1, Georgi Dimitrov, bul., 6200 Chirpan, Bulgaria.
Email: muhova.angelina@gmail.com

[1] A part of this study was presented at the International Agricultural, Biological and Life Science Conference, Edirne, Turkey, September 2-5, 2018.

INTRODUCTION

Research results of other authors on the pre-sowing electromagnetic treatments of triticale seed were not found in the specialized literature. Our laboratory results obtained from such treatments of triticale seeds the cultivars: Boomerang, Colorit and Respect were presented (Muhova et al., 2016; Sirakov et al., 2016). Research were continued to obtain the surfaces and lines of response of number of roots, lengths of roots and sprouts after pre-sowing electromagnetic treatments of triticale seeds, the cultivar Colorit.

Aim of the study: after analysis of the resulting surfaces and lines of response of studied laboratory parameters to determine the optimum values of controllable factors of pre-sowing electromagnetic treatments of triticale seeds, the cultivar Colorit.

Material and Methods

The objects of this study were the surfaces and lines of response of number of roots N_{root}, their lengths ℓ_{root} and lengths of sprouts ℓ_{spr} of seeds of the Bulgarian triticale cultivar Colorit.

Seeds were pre-sowing electromagnetically treated with device (Patent for the invention in Bulgaria, №30631, Device for pre-sowing electrical treatments of seedling material. A 01C 1/00, A01 N 21/00).

As controllable factors of pre-sowing treatment were selected: the voltage between the electrodes - U, kV, duration of exposure - τ,s and duration of staying - T, days of seeds from the treatment to their sowing in laboratory conditions (Muhova et al., 2016; Sirakov et al., 2016).

The processing of the results obtained for the number of grown roots N_{root}, the lengths of roots ℓ_{root} and sprouts ℓ_{spr} and construction the surfaces and lines of their response was performed with the software Statistics 8 (https://support.software.dell.com/statistica/8.0/release-notes-guides).

Based on the established equations - models (Muhova et al., 2016), there were found the effects (Yi, in percentage to the control - %/control) of the impact of pre-sowing electromagnetic treatments on the observed parameters.

For this purpose for each monitored parameter three cases were discussed. In these cases, one of the controllable factors of impact was excluded.

Thus, at the interaction of the remaining two factors, the equation of the surface and lines of response of the concrete parameter was obtained.

Results and Discussion

The planning matrix of the experiment by the plan B3 used in treatment and the results obtained from the laboratory tests of stated above parameters are shown in Table 1. Using the obtained, according

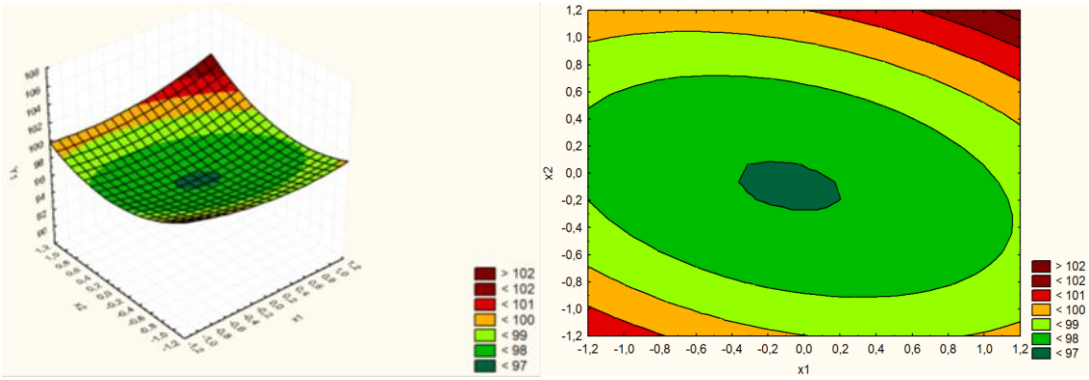
to Muhova et al. (2016), regression equations for the number of roots N_{root}, lengths of roots ℓ_{root}, and sprouts ℓ_{spr}, below, in table form are shown their coefficients - Table 2. These coefficients have been rounded to the third decimal place. Based on the equations, whose coefficients are shown in Table 2, the surfaces and lines of response were obtained for triticale seeds the cultivar Colorit in the following cases:

Case 1 for the number of roots N_{root} of triticale seeds, the cultivar Colorit:

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

$$(1)\quad \hat{Y}_{C1.\,N\,root} = 96{,}969 + 0{,}199\,\overset{o}{x}_1 + 0{,}393\,\overset{o}{x}_2 + 0{,}745\,\overset{o}{x}_1\,\overset{o}{x}_2 + 0{,}764\,\overset{o}{x}_1^2 + 1{,}758\,\overset{o}{x}_2^2$$

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



a) b)

Figure 1. Surface (a) and lines (b) of response of the emerged roots Nroot of triticale seeds the cultivar Colorit at exclusion impact of the factor $\overset{o}{x}_3$ (T)

Values of the emerged 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. In this and in accordance with Fig.1, the zones colored in light red to dark brown show that at such values of controllable factors stimulation the number of emerged roots is possible. According to case of Figures 1a and 1b after pre-sowing electromagnetic treatment at $\overset{o}{x}_1$ = (-1.2…-0.8), $\overset{o}{x}_2$ = (-1.2...-1.0) and $\overset{o}{x}_1$ = (0.1…1.2), $\overset{o}{x}_2$ = (0.9...1.2) it is expected the number of roots to increase. According to Figure 1,

where fields are dark green and light green for example, at $\overset{o}{x_1}$ = (-1.2...1.2) and $\overset{o}{x_2}$ = (-0.85...0.75) it is expected the pre-sowing impact to be depressing.

The analysis of the corresponding surface and lines of response of N_{root} for the cultivar Boomerang (Muhova et al., 2016) showed that there the response surface was with convex center while here - for the cultivar Colorit it is concave - Figure 1. This indicates that if for the cultivar Colorit the average levels of controllable factors are use, than the result of pre-sowing treatment would be depressing. This can be attributed to the varietal characteristics of both triticale cultivars - Boomerang and Colorit.

Table 1. The matrix of planning the experiment by plan B3 and research results (in 2015) on the number of roots Nroot, lengths of roots ℓroot and lengths of sprouts ℓspr of triticale seeds, the cultivar Colorit

Variant No.	**Controllable factors**						**Colorit**		
	U		**τ**		**T**		**N_{root}**	**ℓ_{root}**	**ℓ_{spr}**
	-	**kV**	**-**	**s**	**-**	**Days**	**%/control**	**%/control**	**%/control**
1	1	5	1	50	1	21	101.3	88.9	97.5
2	-1	1	1	50	1	21	107.3	93.2	90.0
3	1	5	-1	10	1	21	107.3	84.6	95.8
4	-1	1	-1	10	1	21	99.3	95.4	100.4
5	1	5	1	50	-1	7	103.3	106.1	101.0
6	-1	1	1	50	-1	7	89.4	129.6	99.8
7	1	5	-1	10	-1	7	95.4	125.4	98.7
8	-1	1	-1	10	-1	7	101.3	120.0	94.0
9	1	5	0	30	0	14	89.4	91.1	93.5
10	-1	1	0	30	0	14	97.4	114.6	103.3
11	0	3	1	50	0	14	97.4	88.9	88.8
12	0	3	-1	10	0	14	91.4	106.1	88.8
13	0	3	0	30	1	21	105.3	101.8	97.5
14	0	3	0	30	-1	7	97.4	113.6	97.5

Table 2. Regression coefficients of equations for the number of roots N_{root}, lengths of roots ℓ_{root}, and lengths of sprouts ℓ_{spr} of triticale seeds, the cultivar Colorit

Studied parameters	b_0	b_1	b_2	b_3	b_{12}	b_{13}	b_{23}	b_{11}	b_{22}	b_{33}
Nroot	94.247	0.199	0.398	3.378	0.745	-0.745	0.745	-0.869	0.124	7.078
ℓroot	101.317	-5.679	-2.464	-13.071	-2.813	0.402	1.473	1.541	-3.817	6.362
ℓspr	93.786	-0.116	-0.058	-0.981	1.082	-0.361	-2.091	4.579	-4.940	3.714

Case 2 for the number of roots N_{root} of triticale seeds, the cultivar Colorit:

Here, the factor $\overset{o}{x_2}$ - exposure time τ was excluded. Thus, at the interaction of the factors $\overset{o}{x_1}$ and $\overset{o}{x_3}$ the following equation of the surface and lines of response for the number of roots N_{root} of triticale seeds the cultivar Colorit was obtained for the case 2:

(2) $\hat{Y}_{C2.\,N\,root} = 94{,}294 + 0{,}199\,\overset{o}{x_1} + 3{,}378\,\overset{o}{x_3} - 0{,}745\,\overset{o}{x_1}\,\overset{o}{x_3} - 0{,}841\,\overset{o}{x_1^2} + 7{,}107\,\overset{o}{x_3^2}$

Case 3 for the number of roots N_{root} of triticale seeds the cultivar Colorit:

Here, the factor $\overset{o}{x_1}$ - applied voltage U between the electrodes was excluded. Thus, at the interaction of the factors $\overset{o}{x_2}$ and $\overset{o}{x_3}$ the following equation of the surface and lines of response for the number of roots N_{root} was obtained for the case 3:

(3) $\hat{Y}_{C3.\,N\,root} = 93{,}912 + 0{,}397\,\overset{o}{x_2} + 3{,}378\,\overset{o}{x_3} + 0{,}745\,\overset{o}{x_2}\,\overset{o}{x_3} - 0{,}076\,\overset{o}{x_2^2} + 6{,}877\,\overset{o}{x_3^2}$

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

From the analysis of resulting surfaces and lines of response of emerged roots N_{root} of triticale seeds the cultivar Colorit can be found what would be their effects $\hat{Y}_{Ci.\,N\,root}$ on the number of roots - depressing or stimulating with the relevant areas of action.

Zones of activity of the electromagnetic field - depressing or stimulating defined with respective values of controllable factors are shown in Table. 3. Therein are also reflected the effects of their interactions when factors were on their mid-level - 0. Easier passing of relative in natural units can be performed using the data in Table 4.

Table 3. Zones of the controllable factors whose interactions $\hat{Y}_{C\,i.\,N\,root}$ stimulate or suppress the number of roots of triticale seeds, the cultivar Colorit

Effect $\hat{Y}_{C\,i.\,N\,root}$ of the electromagnetic treatment controllable factors interaction					
At mid-level of the factors		Stimulating		Depressing	
x_j^o	$\hat{Y}_{C\,i.\,N\,root}$, %/ control	at x_j^o	$\hat{Y}_{C\,i.\,N\,root}$, %/ control	at x_j^o	$\hat{Y}_{C\,i.\,N\,root}$, %/ control
Case 1 - removed factor x_3^o					
$x_1^o = 0$ $x_2^o = 0$	97.0	$x_1^o = (0{,}65 \ldots 1{,}2)$ $x_2^o = (0{,}95 \ldots 1{,}2)$	above 101	$x_1^o = (-0{,}8 \ldots 0{,}8)$ $x_2^o = (-0{,}6 \ldots 0{,}4)$	below 98
Case 2 - removed factor x_2^o					
$x_1^o = 0$ $x_3^o = 0$	94.3	$x_1^o = (-1{,}2 \ldots 0{,}8)$ $x_3^o = (1{,}1 \ldots 1{,}2)$	above 106	$x_1^o = (-1{,}2 \ldots 1{,}2)$ $x_3^o = (-0{,}9 \ldots 0{,}5)$	below 98
Case 3 - removed factor x_1^o					
$x_2^o = 0$ $x_3^o = 0$	93.9	$x_2^o = (-1{,}2 \ldots 1{,}2)$ $x_3^o = (1{,}05 \ldots 1{,}2)$	above 106	$x_2^o = (-1{,}2 \ldots 1{,}2)$ $x_3^o = (-1{,}0 \ldots 0{,}5)$	below 98

From Figure 1 and Table 3 can be concluded that, if the factors x_1^o, x_2^o and x_3^o are on their zero levels, i.e. U=3kV, τ=30s and T=14 days, it is expected depressing impact on the number of roots to (94...97)% /control.

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

x_1^o = (0.65…0.8), т.е. U=(4.3…4.6)kV;

x_2^o = (0.95…1.2), т.е. τ=(49…54)s;

$\overset{o}{x_3}$ = (1.05…1.2) т.е. T≈(14…22) days.

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

Factors	**-1**	**0**	**+1**	**Value of the factor for the step 0.1 division**
$\overset{o}{x_1}$	1 kV	3kV	5kV	0.2 kV
$\overset{o}{x_2}$	10 s	30 s	50 s	2 s
$\overset{o}{x_3}$	7days	14 days	21 days	0.7days

From Figure 1b it can be found that by using the values of the upper level (+1) of controllable factors, the parameter of optimization number of roots N_{root} should be increased by (1...2)%, i.e. to the number of roots of control seeds this increase will be (101...102)% /control.

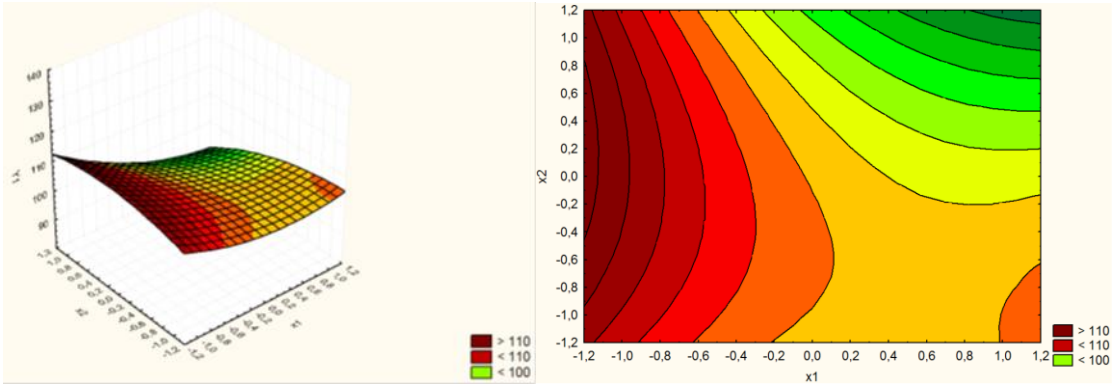
According to the regression equations, whose coefficients b_i are shown in Table 2, the surface and lines of response - length of the roots - ℓ_{root} of electromagnetically treated triticale seeds, the cultivar Colorit, were built in the following cases:

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

Here, the factor $\overset{o}{x_3}$ - duration of staying T until sowing was excluded. Thus, at the interaction of the factors $\overset{o}{x_1}$ and $\overset{o}{x_2}$ the equation of the surface and lines of response for ℓ_{root} was of the following type for the case 1:

$$(4)\ \hat{Y}_{C1.\lambda root} = 103{,}764 - 5{,}679\,\overset{o}{x_1} - 2{,}463\,\overset{o}{x_2} - 2{,}813\,\overset{o}{x_1}\,\overset{o}{x_2} + 3{,}008\,\overset{o}{x_1^2} - 2{,}349\,\overset{o}{x_2^2}$$

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



a) b)

Figure 2. Surface (a) and lines (b) of response of lengths of the roots ℓ_{root} of triticale seeds, the cultivar Colorit, at exclusion impact of the factor $\overset{o}{x_3}$ *(T)*

And here, the values of $\hat{Y}_{Ci.\lambda root}$ (the lengths ℓ_{root} of emerged roots) of the model (4), in% /control, are indicated in digital form along the vertical axis of Fig.2a and in color expression on the right of both Figs. In that, areas colored light red to dark brown indicate that at such values of controllable factors it provides stimulation the lengths of roots. For the case of Fig. 2a and Fig. 2b after pre-sowing electromagnetic treatment $\overset{o}{x_1}$ = (- 1.2...0.1) and $\overset{o}{x_2}$ = (- 1.2...1.2) it is expected an increasing in root lengths above 100% /control.

Where, in Figure 2 dark green and light green fields are, for example at $\overset{o}{x_1}$ = (0.2...1.2) and $\overset{o}{x_2}$ = (0.2...1.2) it is expected pre-sowing electromagnetic impact to be depressing.

Diverging genetic qualities and here they affected the shapes of surface and lines of response of lengths ℓ_{root} of emerged roots. In contrast to their shape shown in Figure 2, at the similar testing for the cultivar Boomerang the shape was concave (Muhova et al., 2016).

Case 2 for the lengths of roots ℓ_{root} of triticale seeds the cultivar Colorit:

Here, the factor $\overset{o}{x_2}$ - duration of the electromagnetic impact τ was excluded. Thus, at the interaction of the factors $\overset{o}{x_1}$ and $\overset{o}{x_3}$ the following equation of the surface and lines of response for the length of roots ℓ_{root} of triticale seeds the cultivar Colorit was obtained for the case 2:

(5) $\hat{Y}_{C2.\lambda root} = 99{,}849 - 5{,}679\,\overset{o}{x_1} - 13{,}071\,\overset{o}{x_3} + 0{,}402\,\overset{o}{x_1}\,\overset{o}{x_3} + 0{,}659\,\overset{o}{x_1^2} + 5{,}481\,\overset{o}{x_3^2}$

Case 3 for the lengths of roots ℓ_{root} of triticale seeds the cultivar Colorit:

Here, the factor $\overset{o}{x_1}$ - applied voltage U between the electrodes was excluded. Thus, at the interaction of the factors $\overset{o}{x_2}$ and $\overset{o}{x_3}$ the following equation of the surface and lines of response for the lengths of roots ℓ_{root} of triticale seeds the cultivar Colorit was obtain for the case 3:

(6) $$\hat{Y}_{C3.\lambda root} = 101{,}909 - 2{,}464\,\overset{o}{x_2} - 13{,}071\,\overset{o}{x_3} + 1{,}473\,\overset{o}{x_2}\,\overset{o}{x_3} - 3{,}462\,\overset{o}{x_2^2} + 6{,}717\,\overset{o}{x_3^2}$$

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

Zones of electromagnetic field action - stimulating or depressing identified with respective values of controllable factors are shown in Table. 5. There are also reflected and the effects of these interactions when factors $\overset{o}{x_i}$ were of their mid-level - 0.

From figure 2 and Table 5 it can be concluded that if the factors $\overset{o}{x_1}$, $\overset{o}{x_2}$ and $\overset{o}{x_3}$ are on their zero levels i.e. U=3kV, τ=30s and T=14 days, it can expected slightly depressing impact and it so that the lengths of emerged roots are a little smaller than 100% /control.

According to Fig.2, Table 4 and Table 5, it can be established that a stimulating effect on the lengths of roots ℓ_{root} could be expected by treating the seeds with factors having the following values:

$\overset{o}{x_1}$ = (-0.8…-1.2), т.е. U=(0.6…1.4)kV;

$\overset{o}{x_2}$ = (-1.2…1.1), т.е. τ=(8…52)s;

$\overset{o}{x_3}$ = (-0.9…-1.2) т.е. T≈(8…6) days.

According to the regression equations, whose coefficients are shown in Table 2, the surfaces and lines of response - lengths of the sprouts ℓ_{spr} of electromagnetically treated triticale seed, the cultivar Colorit, were built in the following cases:

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

Here, the factor $\overset{o}{x_3}$ - duration of staying T to seed sowing was excluded. Thus, at the interaction of the factors $\overset{o}{x_1}$ and $\overset{o}{x_2}$, the equation of the surface and lines of response for the ℓ_{spr} was prepared of the following type for the case 1:

(7) $\hat{Y}_{C1.\,\lambda spr} = 95{,}215 - 0{,}115\,\overset{o}{x}_1 - 0{,}056\,\overset{o}{x}_2 + 1{,}082\,\overset{o}{x}_1\,\overset{o}{x}_2 + 5{,}436\,\overset{o}{x}_1^2 - 4{,}083\,\overset{o}{x}_2^2$

On Figure 3 are shown constructed by equation (7) surface and lines of response - length of the sprouts ℓ_{spr} of triticale seeds the cultivar Colorit.

Values of $\hat{Y}_{C\,i.\,\lambda spr}$ (of the lengths of sprouts) of the model (7), in% /control, are indicated in digital form along the vertical axis of Figure 3a and in color expression on the right of both Figs. In that, the zones colored light red to dark brown indicate that at such values of

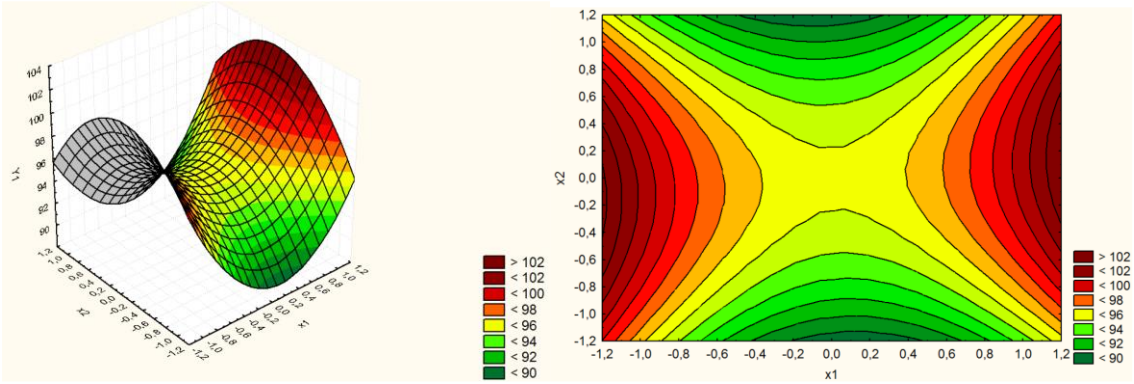
Table 5. Zones of the controllable factors, whose interactions stimulate or suppress the lengths of roots ℓ_{root} of triticale seed, the cultivar Colorit

Effect $\hat{Y}_{C\,i.\,\lambda root}$ of the interaction of controllable factors of the electromagnetic treatment					
At a mid-level of the factors		**Stimulating**		**Depressing**	
$\overset{o}{x}_j$	$\hat{Y}_{C\,i.\,\lambda root}$, %/control	at $\overset{o}{x}_j$	$\hat{Y}_{C\,i.\,\lambda root}$, %/control	at $\overset{o}{x}_j$	$\hat{Y}_{C\,i.\,\lambda root}$, %/control
Case 1 - removed factor $\overset{o}{x}_3$					
$\overset{o}{x}_1 = 0$ $\overset{o}{x}_2 = 0$	103.8	$\overset{o}{x}_1 = (-0{,}8 \ldots -1{,}2)$ $\overset{o}{x}_2 = (-1{,}2 \ldots 1{,}2)$	above 110	$\overset{o}{x}_1 = (0{,}0 \ldots 1{,}2)$ $\overset{o}{x}_2 = (0{,}5 \ldots 1{,}2)$	below 98
Case 2 - removed factor $\overset{o}{x}_2$					
$\overset{o}{x}_1 = 0$ $\overset{o}{x}_3 = 0$	99.9	$\overset{o}{x}_1 = (-1{,}2 \ldots 0{,}5)$ $\overset{o}{x}_3 = (-0{,}75 \ldots -1{,}2)$	above 120	$\overset{o}{x}_1 = (-1{,}1 \ldots 1{,}2)$ $\overset{o}{x}_3 = (-0{,}3 \ldots 1{,}2)$	below 98
Case 3 - removed factor $\overset{o}{x}_1$					
$\overset{o}{x}_2 = 0$ $\overset{o}{x}_3 = 0$	101.9	$\overset{o}{x}_2 = (-1{,}2 \ldots 1{,}1)$ $\overset{o}{x}_3 = (-0{,}9 \ldots -1{,}2)$	above 120	$\overset{o}{x}_2 = (-1{,}2 \ldots 1{,}2)$ $\overset{o}{x}_3 = (0{,}1 \ldots 1{,}2)$	below 98

controllable factors it provides stimulation the lengths of emerged sprouts. For the case of Fig.1a and Fig.1b after pre-sowing electromagnetic treatment at $\overset{o}{x_1}$ = (0.65... 1.2), $\overset{o}{x_2}$ = (-1.1...1.2) and $\overset{o}{x_1}$ = (-0.6...-1.2), $\overset{o}{x_2}$ = (-1.2...1.1) it is expected the length of sprouts to increase about 102% /control.

Where dark green, light green and yellow fields are, is expected the pre-sowing impact to be suppressing.

A comparison of the surface and lines of response ℓ_{spr} the cultivars - Colorit, Figure 3 and Boomerang (Sirakov et al., 2017) showed that they differ in shape, due to their genetic features.



a) b)

Figure 3. Surface (a) and lines (b) of response of the lengths of sprout ℓ_{spr} of triticale seeds, the cultivar Golorit, at exclusion impact of the factor $\overset{o}{x_3}$ *(T)*

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

Here, the factor $\overset{o}{x_2}$ - duration of the electromagnetic impact τ was excluded and at the interaction of the factors $\overset{o}{x_1}$ and $\overset{o}{x_3}$ the following equation of the surface and lines of response of the lengths of sprouts ℓ_{spr} of triticale seeds, the cultivar Colorit was obtained for the case 2:

(8) $\hat{Y}_{C2.\,\lambda spr} = 91{,}886 - 0{,}115\,\overset{o}{x_1} - 0{,}981\,\overset{o}{x_3} - 0{,}361\,\overset{o}{x_1}\,\overset{o}{x_3} + 3{,}439\,\overset{o}{x_1^2} + 2{,}574\,\overset{o}{x_3^2}$

Case 3 for the lengths of sprout ℓ_{spr} of triticale seeds, the variety Colorit:

Here, the factor $\overset{o}{x_1}$ - applied voltage U between the electrodes was excluded. Then, at the interaction of factors $\overset{o}{x_2}$ and $\overset{o}{x_3}$ the following equation of the surface and lines of response of the lengths of sprouts ℓ_{spr} of triticale seeds, the variety Colorit was obtained for the case 3:

$$(9)\quad \hat{Y}_{K3.\lambda кълн} = 95{,}547 - 0{,}058\,\overset{o}{x_2} - 0{,}981\,\overset{o}{x_3} - 2{,}091\,\overset{o}{x_2}\,\overset{o}{x_3} - 3{,}883\,\overset{o}{x_2^2} + 4{,}771\,\overset{o}{x_3^2}$$

Table 6. Zones of controllable factors whose interactions $\hat{Y}_{C\,i.\,\lambda spr}$ stimulate or suppress the lengths of sprouts ℓ_{spr} of triticale seed, the cultivar Colorit

Effect $\hat{Y}_{C\,i.\,\lambda spr}$ of the interaction of controllable factors of the electromagnetic treatment					
At a mid-level of the factors		**Stimulating**		**Depressing**	
$\overset{o}{x_j}$	$\hat{Y}_{C\,i.\,\lambda spr}$, %/control	at $\overset{o}{x_j}$	$\hat{Y}_{C\,i.\,\lambda spr}$, %/ control	at $\overset{o}{x_j}$	$\hat{Y}_{C\,i.\,\lambda spr}$, %/ control
Case 1 - removed factor $\overset{o}{x_3}$					
$\overset{o}{x_1} = 0$ $\overset{o}{x_2} = 0$	95.2	$\overset{o}{x_1} = (-1{,}1 \ldots -1{,}2)$ $\overset{o}{x_2} = (-0{,}7 \ldots 0{,}4)$	above 102	$\overset{o}{x_1} = (-1{,}1 \ldots 1{,}1)$ $\overset{o}{x_2} = (-1{,}2 \ldots 1{,}2)$	below 98
		$\overset{o}{x_1} = (1{,}15 \ldots 1{,}2)$ $\overset{o}{x_2} = (-0{,}4 \ldots 0{,}6)$			
Case 2 - removed factor $\overset{o}{x_2}$					
$\overset{o}{x_1} = 0$ $\overset{o}{x_3} = 0$	91.9	$\overset{o}{x_1} = (-1{,}15 \ldots -1{,}2)$ $\overset{o}{x_3} = (-1{,}15 \ldots -1{,}2)$	above 101	$\overset{o}{x_1} = (-1{,}0 \ldots 1{,}1)$ $\overset{o}{x_3} = (-0{,}8 \ldots 1{,}1)$	below 98

Case 3 - removed factor $\overset{o}{x_1}$					
$\overset{o}{x_2} = 0$ $\overset{o}{x_3} = 0$	95.6	$\overset{o}{x_2} = (-0{,}1 \ldots 0{,}7)$ $\overset{o}{x_3} = (-1{,}1 \ldots -1{,}2)$	above 102	$\overset{o}{x_2} = (-1{,}2 \ldots 1{,}2)$ $\overset{o}{x_3} = (-0{,}6 \ldots 0{,}8)$	below 98

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

Zones of the electromagnetic field action - stimulating or depressing identified with respective values of controllable factors are shown in Table 6. There are also reflected the effects of these interactions when the factors $\overset{o}{x_i}$ were of their mid-level - 0.

From Figure 3 and Table 6 may be noted that if the factors $\overset{o}{x_1}$, $\overset{o}{x_2}$ and $\overset{o}{x_3}$ are at their zero levels it is expected suppressing impact of pre-sowing electromagnetic treatment. Then the lengths of sprouts will be in the range of (92...96)% /control. In the same position it was found a stimulating effect of pre-sowing electromagnetic treatment on the length of spouts - (102...104)% /control (Sirakov et al., 2018).

From Figure 3, Table 3 and Table 6 It can be found that a stimulating effect on the length of sprouts ℓ_{spr} could be expected after electromagnetic treatment of triticale seed, the cultivar Colorit with controllable factors having the following values:

$\overset{o}{x_1}$ = (-1.15…-1.2), i.e. U=(0.6…0.7)kV or $\overset{o}{x_1}$ = (1.15…1.2), i.e. U=(5.3…5.4)kV;

$\overset{o}{x_2}$ = (-0.1…0.6), i.e. τ=(28…42)s;

$\overset{o}{x_3}$ = (-1.15…-1.2), i.e. T≈(5…6) days.

The analysis of the resulting values of controllable factors that are expected to stimulate the number N_{root} of roots, i.e. the factors affecting beneficially respectively the lengths ℓ_{root} of roots and lengths ℓ_{spr} of sprouts gives grounds as suitable for complex stimulation of triticale seeds, the cultivar Colorit to offer these values:

- Voltage between the electrodes: U=(4.3...5.4) kV;

- Duration of impact: τ=(28...54) s;

- Length of staying from seed treatment to their sowing: T≈(14...22) days.

Conclusions

1. After pre-sowing electromagnetic treatments with a modified screw device and research in laboratory conditions the surfaces and lines of response for the number of roots, lengths of roots and sprouts of triticale seeds the cultivar Colorit were constructed and their regression equations were found.

2. There were found the values of controllable factors that could affect beneficially the development of laboratory parameters number and length of roots, length of sprouts, namely: voltage between the electrodes of the screw device (factor $\overset{o}{x_1}$) U=(4,3...5,4) kV, exposure duration (factor $\overset{o}{x_2}$) τ=(28...54) s, and length of staying of seeds from treatment to their sowing (factor $\overset{o}{x_3}$) T≈(14...22) days. It was found that at the same values of controllable factors it is obtained a different impact on the triticale seeds the cultivar Colorit compared with those of the cultivar Boomerang.

REFERENCES

Terziev, P., I. Palov, St. Stefanov and R. Radev. Patent for an invention in Bulgaria, №30631

Device for pre-sowing electrical treatments of seedling material A 01C 1/00, A01 N 21/00.

Statistics 8 https: support.software.dell.com/statistica/8.0/release-notes-guides - software product.

Sirakov, K., A. Stoilova, A. Muhova, I. Palov and S. Stefanova-Dobreva (2017). Study the effect of pre-sowing electromagnetic treatments on laboratory germination vigor and germination of seeds of bulgarian triticale varieties. International Scientific and Practical Conference "WORLD SCIENCE", Proceedings of the III International Scientific and Practical Conference "Topical Problems of Modern Science and Possible Solutions“, 10 (14): Vol.6., Dubai, UAE, p. 31-40.

Muhova, A., K. Sirakov, A.Stoilova, S. Stefanova-Dobreva and I. Palov (2016). Study the effects of pre-sowing electromagnetic treatment of some laboratory parameters on triticale seeds. International Scientific and Practical Conference "WORLD SCIENCE", Proc. III International Scientific and Practical Conference "Topical Problems of Modern Science and Possible Solutions“,10 (14),Vol.6, Dubai, UAE, p. 40-45.

Sirakov, K., A. Stoilova, I. Palov and A. Muhova (2018). Studying the effect of pre-sowing electromagnetic treatment on the lengths of roots and sprouts of triticale seeds the cultivar Boomerang. International Scientific and Practical Conference "Scientific and Practical Results in 2017 Prospects for Their Development", 1 (29): Vol.2, Dubai, UAE, p. 10-17.