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Vigour variability in hybrid kernels of triticale with *Aegilops* under the influence of biostimulation

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A b s t r a c t. The influence of a variable magnetic field of 30 mT magnetic induction and frequency f = 50 Hz, at different exposure times (8, 15, 30, 60 and 120 s), as well as an electric field of 5 kV cm^{-1} intensity and the same frequency and exposure times on kernel vigour of triticale with *Aegilops* hybrids and triticale (cv. Tewo), were studied. The aim of the research has been to choose suitable parameters for kernel biostimulation and find the application for results in further studies. The following methods for vigour evaluation have been used: germination ability, sprout length, germ necroses using the topographic tetrasolin method, electric conductivity of exudates from kernels and α-amylase activity. Positive effects of variable magnetic and electric fields on kernel vigour have been found. Grains subjected to an electric rather than a magnetic field have been characterized as having higher vigour. The best exposure time for kernels in a magnetic field was 60 s and in an electric field 30 s. The cross-combination produced using *Ae. crassa* 4x was characterized as having higher vigour than that obtained with *Ae. juvenalis* 6x. Tewo cultivar had a higher power and ability of germination than hybrid lines.

K e y w o r d s: biostimulation, kernel vigour, triticale, *Aegilops*

INTRODUCTION

Increasing crop yields without chemical application can be achieved by breeding new varieties better utilizing local conditions, or improvement of crop physiological activity by means of different types of stimulation. Pietruszewski [13], as well as Pietruszewski and Kornarzyński [14], studied pre-sowing stimulation of grains. Subjecting wheat kernel to magnetic and electric field operations, they found that it germinated faster, more uniformly and gave higher yields than the control material. Moreover, that method, as an ecological one, may find wide practical applications [12].

Nowadays, genes responsible for improvement of breeding and performance traits are introduced into cultivated varieties, among others used there is the method of crossbreeding with wild forms. Resistance of triticale towards diseases and stresses can be elevated after crossbreeding with *Aegilops* [3].

Analysis of kernel vigour makes it possible to evaluate potential possibilities of plant development, its productivity, and its yielding.

The aim of this study was to choose suitable parameters for hybrid (triticale with *Aegilops*) kernel biostimulation and to study their impact on the vigour of the material studied, as well as an application for further research as a result.

MATERIAL AND METHODS

Kernels of the following plants were studied: triticale cv. Tewo and two hybrid triticale with *Aegilops* lines: {*Ae. crassa* 4x × [(Lanca × L 506/79) × CZR 142/79]} × Presto and *Ae. juvenalis* 6x × [(Lanca × L 506/79) × CZR 142/79] [3,4].

A variable magnetic field of 30 mT magnetic induction and frequency f = 50 Hz, at different exposure times (8, 15, 30, 60 and 120 s), as well as a variable electric field of 5 kV cm^{-1} intensity with the same frequency and exposure times, were used to biostimulate.

The following methods were applied to evaluate the kernel's vigour: germination ability (PN-79/R-65950),

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sprout length using the filter paper method [11], germ necroses using the topographic tetrasolin method - TTC test [10], electric conductivity of exudates from kernels [8] and α-amylase activity [5]. All tests were done in three replications. Statistical analysis was made using variance analysis and multiple Tukey intersections. Triple orthogonal cross-classification was also applied.

RESULTS AND DISCUSSION

On the basis of statistical analysis results, significant differentiation of germination ability of kernels depending on a line ($p = 0.01$) and a field ($p = 0.01$) was found (Table 1). Among lines studied, CZR 490P was characterized as having a significantly higher germination ability. Triticale cv. Tewo showed the highest value of that trait. The results of our own study revealed the increase of kernel germination ability to be about 2% under the influence of the variable electric field. Basov [1] drew similar conclusions, finding an increase of wheat kernel germination ability by 10-18% compared to control. Also Miszczenko [9] proved a higher (by 12-16%) germination ability of wheat kernels treated with an electromagnetic field.

Higher vigour is apparent in kernels subjected to an electric field action (mean germination ability 94.9%) rather than to a magnetic one (mean value 91.8%). Along with the increase in exposure time, the kernel's germination ability increased too, although differences were statistically insignificant. Also Pietruszewski and Skwarek [15] found that the germination ability of buckwheat grains depended on the time they were treated with a magnetic field. Kordas *et al.* [6] observed a positive effect of similar biostimulation - they found an increase of winter wheat germination ability by 10.8% and that of oat by 12.1%, on average.

When the electric field was applied it caused a greater inhibition of mould development on Petri dishes, in comparison with the application of a magnetic field.

Significant differentiation of sprout length depending on line ($p = 0.01$) was observed (Table 2). Unfortunately, sprout length decreased in comparison with material not subjected to biostimulation. Line CZR 490P appeared to be the one with the highest value of the above trait (10.0 cm, on average). Among exposure times applied, the highest sprout length was achieved at 60 s.

On a basis of TTC test results, significant differences of vigour between lines ($p = 0.01$) and exposure times ($p = 0.05$) were found (Table 3). The highest vigour was shown by line

Table 1. Mean values of germination ability (%) for level combination of: variety (A_i), field (B_j) and exposure time (C_k)

A_i	B_j	C_k (s)						$\overline{A_i \times B_j}$*
		C_1=0	C_2=8	C_3=15	C_4=30	C_5=60	C_6=120	
A_1 CZR490P	B_1	92.7	80.7	95.7	91.3	98.0	88.7	91.2
	B_2	92.7	99.0	96.7	98.3	97.3	99.3	97.2
$\overline{A_1C_k}$		92.7	89.8	96.2	94.8	97.7	94.0	$\overline{A_1}$=94.2
A_2 CZR350	B_1	91.0	88.7	89.7	87.0	87.3	87.0	88.4
	B_2	91.0	92.3	87.3	93.7	92.3	89.7	91.1
$\overline{A_2C_k}$		91.0	90.5	88.5	90.3	89.8	88.3	$\overline{A_2}$=89.8
A_3 Tewo	B_1	95.3	96.0	95.3	97.3	95.7	95.3	95.8
	B_2	95.3	96.3	95.0	97.7	97.3	96.3	96.3
$\overline{A_3C_k}$		95.3	96.2	95.2	97.5	96.5	95.8	$\overline{A_3}$=96.1
$\overline{C_k}$		93.0	92.2	93.3	94.2	94.7	92.7	

$LSD_A = 3.01$, $LSD_B = 2.05$, $LSD_C = 5.21$, $LSD_{AB} = 5.21$, $LSD_{AC} = 11.18$.

Field	Time						$\overline{B_j}$*
	C_1	C_2	C_3	C_4	C_5	C_6	
B_1	93.0	88.4	93.6	91.9	93.7	90.3	91.8
B_2	93.0	95.9	93.0	96.6	95.7	95.1	94.9

$LSD_{BC} = 8.52$, *dash over the letters stands for mean value from other factors, B_1- magnetic field, B_2 - electric field.

T a b l e 2. Mean values of sprout length (cm) for level combination of: variety (A_i), field (B_j) and exposure time (C_k)

A_i	B_j	C_k (s)						$\overline{A_i \times B_j}$*
		C_1=0	C_2=8	C_3=15	C_4=30	C_5=60	C_6=120	
A_1	B_1	10.4	10.9	9.8	8.7	10.1	10.9	10.1
CZR490P	B_2	10.4	9.3	10.1	10.2	10.4	9.0	9.9
$\overline{A_1C_k}$		10.4	10.1	10.0	9.4	10.2	10.0	$\overline{A_1}$=10.0
A_2	B_1	9.0	8.1	8.5	8.0	9.4	8.0	8.5
CZR350	B_2	9.0	8.8	9.3	9.6	9.6	8.5	9.1
$\overline{A_2C_k}$		9.0	8.5	8.9	8.7	9.5	8.3	$\overline{A_2}$=8.8
A_3	B_1	9.6	8.6	8.8	9.1	9.6	9.4	9.2
Tewo	B_2	9.6	10.3	9.0	9.6	9.6	8.6	9.4
$\overline{A_3C_k}$		9.6	9.5	8.9	9.4	9.6	9.0	$\overline{A_3}$=9.3
$\overline{C_k}$		9.7	9.3	9.2	9.2	9.8	9.1	

LSD_A = 0.62, LSD_B = 0.42, LSD_C = 1.07, LSD_{AB} = 1.07, LSD_{AC} = 2.29.

Field	Time						$\overline{B_j}$*
	C_1	C_2	C_3	C_4	C_5	C_6	
B_1	9.7	9.2	9.0	8.6	9.7	9.4	9.3
B_2	9.7	9.5	9.5	9.8	9.8	8.7	9.5

LSD_{BC} = 1.72. Explanations as in Table 1.

T a b l e 3. Mean values of TTC test (%) for level combination of: variety (A_i), field (B_j) and exposure time (C_k)

A_i	B_j	C_k (s)						$\overline{A_i \times B_j}$*
		C_1=0	C_2=8	C_3=15	C_4=30	C_5=60	C_6=120	
A_1	B_1	92.6	96.0	98.0	98.0	100.0	100.0	97.4
CZR490P	B_2	92.6	94.0	96.0	92.0	94.0	86.0	92.4
$\overline{A_1C_k}$		92.6	95.0	97.0	95.0	97.0	92.6	$\overline{A_1}$=95.6
A_2	B_1	94.0	100.0	94.0	100.0	98.0	100.0	97.6
CZR350	B_2	94.0	94.0	96.0	98.0	96.0	96.0	95.6
$\overline{A_2C_k}$		94.0	97.0	95.0	99.0	97.0	98.0	$\overline{A_2}$=96.6
A_3	B_1	96.0	82.0	88.0	90.0	100.0	96.0	92.0
Tewo	B_2	96.0	96.0	96.0	96.0	94.0	98.0	96.0
$\overline{A_3C_k}$		96.0	89.0	92.0	93.0	97.0	97.0	$\overline{A_3}$=94.0
$\overline{C_k}$		94.2	93.6	94.6	95.6	97.0	96.0	

LSD_A = 0.96, LSD_B = 0.65, LSD_C = 1.66, LSD_{AB} = 1.66, LSD_{AC} = 3.57.

Field	Time						$\overline{B_j}$*
	C_1	C_2	C_3	C_4	C_5	C_6	
B_1	94.2	92.6	93.4	96.0	99.4	98.6	95.8
B_2	94.2	94.6	96.0	95.4	94.6	93.4	94.8

LSD_{BC} = 5.44. Explanations as in Table 1.

CZR 350 (96.6%, on average). Magnetic biostimulation was more advantageous (95.8%) than electric (94.8%) and 60 s was the best exposure time (97%).

Evaluation of magnetic and electric fields effects on electric conductivity of exudates showed significant differentiation depending on plant material studied, the type of field, and the exposure time (p = 0.01) (Table 4). Line CZR 490P had the lowest conductometric values, and so had the highest vigour (30 μS cm^{-1} g^{-1}); cv. Tewo showed the highest electric conductivity (64.8 μS cm^{-1} g^{-1}, on average). Lower conductometric values were found after the electric field treatment when compared with the magnetic one. Fifteen seconds was the most advantageous exposure time, however, the difference was insignificant compared to 30 s. Many authors studied electric conductivity as an indication of kernel's vigour, but nobody evaluated the influence of fields on conductometric values. Zdradzisz and Urbaniak [18] applied a method of electric conductivity measurement of exudates to predict spring wheat kernel's vigour. They found a negative correlation between the results of conductometric measurements and germination ability. This dependence direction was consistent with results presented by Tulo [17] and those achieved in our own studies.

An increase of α-amylase activity was observed in kernels biostimulated using magnetic and electric fields. Lebedev *et al.* [7] and Fiedurek *et al.* [2] confirmed a similar action using wheat kernels. On the basis of statistical analysis of own results, significant differentiation of that trait value depending on line, field and exposure time (p = 0.01) was found (Table 5). The highest amylolytic values were characterized as cv. Tewo (456.9 j.e.), lower - CZR 490P line (425.4 j.e.) and CZR 350 line (397.0 j.e.). Grain treated with an electric field had a higher amylolytic activity (428.7 j.e.) than that subjected to magnetic field action. The highest α-amylase activity was observed in kernels after 30 s of exposure (454.9 j.e.), the lowest - after 60 s (421.3 j.e.).

CONCLUSIONS

1. A positive influence of variable magnetic and electric fields, applied after harvest, on kernel's vigour was observed.

2. Grains treated with an electric rather than a magnetic field were characterized as having higher vigour.

3. Germination ability due to variable electric field operation increased by about 2%.

T a b l e 4. Mean values of electric conductivity (μS cm^{-1} g^{-1}) of exudates from grain for level combination of: variety (A_i), field (B_j) and exposure time (C_k)

A_i	B_j	C_k (s)						$\overline{A_i \times B_j}$*
		C_1=0	C_2=8	C_3=15	C_4=30	C_5=60	C_6=120	
A_1 CZR490P	B_1	32.5	30.0	28.1	30.6	29.0	36.3	31.1
	B_2	32.5	30.6	30.6	28.4	30.3	28.7	30.2
$\overline{A_1C_k}$		32.5	30.3	29.4	29.5	29.7	32.5	$\overline{A_1}$=30.6
A_2 CZR350	B_1	55.4	57.4	57.5	57.9	55.5	57.8	57.0
	B_2	55.4	57.0	53.2	57.1	56.2	60.1	56.4
$\overline{A_2C_k}$		55.4	57.2	55.4	57.5	55.8	58.9	$\overline{A_2}$=56.7
A_3 Tewo	B_1	65.3	65.9	64.4	61.6	63.9	67.3	64.7
	B_2	65.3	61.3	62.7	63.0	64.8	71.9	64.8
$\overline{A_3C_k}$		65.3	63.6	63.6	62.3	64.4	69.6	$\overline{A_3}$=64.8
$\overline{C_k}$		51.1	50.4	49.4	49.8	50.0	53.7	

LSD_A = 0.36, LSD_B = 0.25, LSD_C = 0.63, LSD_{AB} = 0.63, LSD_{AC} = 1.35.

Field	Time						$\overline{B_j}$*
	C_1	C_2	C_3	C_4	C_5	C_6	
B_1	51.1	51.1	50.0	50.0	49.5	53.8	51.0
B_2	51.1	49.6	48.8	49.5	50.4	53.5	50.5

LSD_{BC} = 1.03. Explanations as in Table 1.

T a b l e 5. Mean values of α-amylase activity (j.e. /1 min x 100 grains) for level combination of: variety (A_i), field (B_j) and exposure time (C_k)

A_i	B_j	C_k (s)						$\overline{A_i \times B_j}$*
		C_1=0	C_2=8	C_3=15	C_4=30	C_5=60	C_6=120	
A_1	B_1	390.4	381.9	458.1	465.9	432.8	417.6	424.2
CZR490P	B_2	390.4	387.7	448.0	503.7	393.3	434.4	426.3
$\overline{A_1C_k}$		390.4	384.8	453.1	484.8	413.1	426.0	$\overline{A_1}$=425.4
A_2	B_1	351.7	429.3	397.9	398.7	389.3	365.6	388.8
CZR350	B_2	351.7	398.1	433.9	434.4	413.6	400.3	405.3
$\overline{A_2C_k}$		351.7	413.7	415.9	416.5	401.5	382.9	$\overline{A_2}$=397.0
A_3	B_1	374.1	473.9	469.6	448.3	488.5	502.1	459.4
Tewo	B_2	374.1	473.3	449.3	478.4	410.4	540.8	454.4
$\overline{A_3C_k}$		374.1	473.6	459.5	463.3	449.5	521.5	$\overline{A_3}$=456.9
$\overline{C_k}$		372.1	424.0	442.8	454.9	421.3	443.5	456.9

LSD_A = 5.41, LSD_B = 3.68, LSD_C = 9.36, LSD_{AB} = 9.36, LSD_{AC} = 20.07.

Field	Time						$\overline{B_j}$*
	C_1	C_2	C_3	C_4	C_5	C_6	
B_1	372.1	428.4	441.9	437.6	436.9	428.4	424.2
B_2	372.1	419.7	443.7	472.2	405.8	458.5	428.7

LSD_{BC} = 15.31. Explanations as in Table 1.

4. 60 s appeared to be the most advantageous exposure time in a magnetic field and 30 s in an electric one.

5. Crossbreeding combination CZR 490P produced using *Ae. crassa* 4x was characterized as having higher vigour than CZR 350 (obtained as a result of crossbreeding with *Ae. juvenalis* 6x).

6. Standard cv. Tewo was characterized as having a higher germination ability and α-amylase activity than hybrid lines.

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