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YIELD COMPONENTS OF TRITICALE AFTER APPLIED ELECTROMAGNETIC STIMULATION OF SEEDS

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Abstract

A field trial is conducted in Field Crops Institute (Bulgaria), in the period 2017-2019 on Pelic Verisols to evaluate the influence of three factors on yield triticale components: variety, electromagnetic seeds treatment and fertilization. Two Bulgarian varieties, two options of electromagnetic treatment and application of organic and mineral fertilizers are tested. The results show a positive effect of the electromagnetic treatment, the mineral and organic fertilizations. An increase the values of plant height, spike length, number of grains in a spike, grain weight and weigh of 1000 grains in the range of 0.4-6.6% for Colorit variety, and 1.5-9.2% for Boomerang variety is founded. Similar, significant effect of the fertilization on the spike length and the number of grains in a spike for Colorit variety, and for Boomerang variety both on the plant height and the grain weigh is established. No significant influence of the electromagnetic treatment and complex effect of the factors is reported. Based on the tested factors significant, positive correlations between different components of the yield for both the varieties are observed.

***Key words**: electromagnetic seeds treatment, mineral fertilizer, organic fertilizer, triticale, yield components.*

INTRODUCTION

The yield of cereals is determined by a number of biometric and weight parameters, which change under the influence of agronomic factors, varietal specifics and environmental conditions, predominant during the growing season. The main components of the yield are the number of spikes per unit area, the number of grains in spike and the thousand kernel weight. There are close relationships between the components of yield, which under certain conditions determine their optimal development.

The main question concerning the yield of cultivated plants is how the components of the yield change, what connections and dependencies are observed between them against the background of specific agrotechnical approaches and agrometeorological conditions. By now, at cereals are defined quite regularities, both between yield and its components, and between the components, after testing various agrotechnical factors.

The results of Fischer (2011) show that the variation in a grain yield in wheat is closely related with changes in a number of grains in spike, than with average weight of the grain. Pfeiffer et al. (1996) have founded when comparing wheat and triticale, that triticale forms a higher yield based of a larger number of grains per unit area and in class. Giunta and Motzo (2005) have reported that the higher yield of triticale compared to wheat, due to a larger number of spikes and grains per unit area. The comparative study of Méndez-Espinoza et al. (2019) found that the yield of triticale is explains by higher values of the thousand kernel weight and the number of grains in a spike and has a different physiological basis as higher photosynthetic rates. Bonchev (2020) has founded a high positive correlation of yield with plant height at varieties of common wheat.

Studies in cereals show that the components of the yield change to varying degrees under the influence of the applied factors. Biberdžić et al. (2010) have founded that the number of grains in a spike and the thousand kernel weight in triticale, show a different trend with increasing nitrogen fertilization and in barley they increase, respectively at 100 kg N/ha and 80 kg N/ha. Studies of Stefanova-Dobreva (2019) show that the length of spike, the number of grains in a spike and the weight of grains in a spike show a significant increase when fertilization with N_6P_6 and $N_{12}P_6$, depending of the variety.

Many scientists have established influence of environmental on the components of the yield. Đekić et al. (2016) have reported significant differences for the thousand kernel weight and the weight of grains in a spike in cereals in the years of study. Kendal & Sayar (2016) have established influence of environmental conditions on the height, the thousand kernel weight and the weight of grains in a triticale spike. The results obtained by Schwarte et al. (2006) show that the climatic conditions of the year affect the thousand kernel weight, the location of the experiment affects the number of grains in a spike, and the date of sowing affects the number of spike and tillers for unit area in triticale. Krusheva et al. (2018) have established that the climatic conditions of the year have the great influence on the number of grains in a spike and thousand kernel weight in triticale. In study by Hristov (2013) is founded that changes in the values of biometric indicators and the structural elements of triticale yield, follow those of yield, depending of the tillage systems tested and the fertilization options.

In modern agriculture is observed trend to apply intensive technological solutions, but it is interesting to follow the changes of the yield components when applying environmental approaches of impact. In research by Ivanova et al. (2008) soil pollutants are analyzed: chemical, heavy metals, pesticides, etc. and the advantages are indicated of the use of manure over chemical ones. The quality of the seeds is crucial for the amount of harvest obtained. Thus scientists looking for solutions for improvement of their sowing qualities. Now tests continue of different methods for pre-sowing treatment of seed material, one of them is exposing to an electromagnetic field. This ecological method allows to reduce the quantities of the mineral fertilizers used and successfully competes with the use of chemicals for disease control (Belitskaya et al., 2013).

It's known, that increase of yield is possible when applying of definite parameters of the electromagnetic field–voltage between the electrodes, seed exposure time, stay time of the seeds from treatment to sowing. Furthermore, any agricultural crop has own optimum of these parameters, in which the yield is expected to increase. In Spain Flórez et al. (2014) and Martinez et al. (2017) have conducted a number of studies on pre-sowing magnetic treatment of triticale seeds. The parameters of the magnetic field are indicated, with which the seeds are treated. In Bulgaria has been studied and the positive impact has been established of electromagnetic seed pre-sowing treatments for triticale Muhova et al. (2016) on some laboratory parameters and on germination rate and mean germination time (Sirakov et al., 2016). Results for electromagnetic treatment of triticale seeds and their influence on the lengths and numbers of root and the lengths of the sprouts of the triticale Colorit variety, are also indicated by Sirakov et al. (2019).

The high productivity of the modern triticale varieties makes it preferred alternative culture. Due to high genetic yield potential, adaptability to environmental conditions and disease resistance, triticale is included to different systems of agriculture. The trend for the use of triticale is to be included as a useful ingredient in the food industry, respectively in the diet of humans. These benefits of triticale explain the wide interest to the culture and need to conduct of extensive research to increase yield.

The purpose of the research is to establish the effect of electromagnetic stimulation of triticale seeds on the components of yield, against the background of applied organic and mineral fertilization.

MATERIALS AND METHODS

During the period 2017-2019 on conventional field, three-factor experiment was conducted by the method of perpendicular arrangement of degrees of the tested factors in four replications. The experimental plot was 18 m^2 in size and the sowing rate was 550 seeds per m^2. The soil (PellicVertisols) is low to medium provided with mineral nitrogen, with low content of mobile phosphates and good supply of potassium. The sowing of triticale was carried out on 9.11.17 and 30.11.18 after the predecessor of sunflower. Before sowing phosphorus fertilizer and certified organic fertilizer were applied with subsequent cultivation in autumn. Then the soil was treated with disc harrow. In the spring was imported nitrogen fertilizer. During the growing season pest, weed and diseases were managed with insecticide, herbicides and fungicide.

Table 1. Temperature and precipitation conditions during the triticale vegetation

Years	Months									Σ
	X	XI	XII	I	II	III	IV	V	VI	
Temperature sums (°C) average for period 1928–2013										
1928-13	*396.7*	*215.9*	*61.1*	*-4.4*	*49.4*	*188.9*	*357.9*	*511.5*	*630.7*	*2137.7*
2017–2019										
2017/18	388.0	244.9	125.6	65.2	97.8	200.5	471.0	584.8	646.9	2827.7
2018/19	434.0	225.3	20.7	53.8	113.1	292.6	335.2	533.4	681.5	2689.6
Precipitation (mm) average for period 1928–2013										
1928-13	*37.5*	*43.3*	*54.0*	*44.3*	*37.7*	*37.0*	*45.2*	*64.1*	*65.4*	*428.5*
2017–2019										
2017/18	80.0	48,2	38.9	23.3	109.0	83.4	8.7	62.2	87.9	541.6
±	+42.5	+4.9	–15.1	–21.0	+71.3	+46.4	–36.5	–1.9	+22.5	+146.6
2018/19	25.4	82.3	46.9	28.9	24.5	3.3	51.4	21.4	123.2	383.9
±	–12.1	+39.0	–7.1	–15.4	–13.2	–33.7	+6.2	–42.7	+57.8	-41.1

Three factors were tested: two Bulgarian varieties of triticale–Boomerang and Colorit; organic certified fertilizer Lumbrical at a rates of 2,200 kg/ha and mineral fertilizers $N_{120}P_{60}$; pre-sowing electromagnetic treatment (EMT) with conditionally accepted options E0, E1 and E2. After preliminary laboratory test, were theoretically determined the values of the controllable factors of electromagnetic impact–voltage between the electrode space–U (kV), seed exposure time–τ (s), time from treatment to sowing T (days), in which it is expected increasing the seed germination and mean germination rate of seeds of both varieties, respectively expected increase in yield. The values of the controllable factors as follow: E1–U = 5.2 kV, τ = 24 s, T = 14 days; E2–U = 5.0 kV, τ = 50 s, T = 7 days. The option E0 is without electromagnetic influence. Plant samples (10 spikes) were collected from two plot at full maturity phase for processing.

To define significant influence of factors on data from the two harvest years 2018 and 2019, analysis of variance was applied separately for varieties with ANOVA (Penchev et al., 1989-1991). The coefficients of simple linear correlation of Pearson (r) were established with Statistika 13.

Table 1 shows the data from the meteorological station in Chirpan, regarding the temperature sum and the quantity of precipitation by months. According to Table 1, during the growing season of triticale the temperature sums are higher compared to the multiannual period (2009.7°C), respectively for 2017/18 is 2824.7°C or 815.0°C more, and in 2018/19 is 2689.6°C or 679.9°C higher. Regarding precipitation: in 2017/18 the amount of precipitation is 146.6 mm more, and in 2018/19 is about average for the period 1928-2013 (395.0 mm) - 383.9 mm. This data characterize the two harvest years as warmer, and 2017/18 and as more humid, compared to typical weather conditions.

RESULTS AND DISCUSSIONS

The results of analysis of variance for yield components for both varieties are shown on Table 2 and Table 3. The data from the statistical analysis for Colorit variety show no significant differences in the values for plant height (PH), length spike (LS), weight of grains in spike (WGS) and thousand kernel weight (TKW) (Table 2A). Highest values for LS, number of grains in spike (NGS) and WGS was reported for E1+$N_{120}P_{60}$ option respectively, 5.6%, 16.6% and 5.7% more and for TKW for E2 option - 3.7% over the control option. The value for NGS is statistically significant at probability P = 5.0%. There is a trend to reduce PH values for E1 and E2 options compared to E0, but when applying mineral fertilizer the values increased by 10.5 and 10.2%, respectively.

Table 2. Influence of the factors on the components of yield for Colorit variety for 2017/19 period

A. Influence of electromagnetic treatment and fertilization

Factors and levels	Plant height (cm)	Length spike (cm)	Number of grains in spike	Weight of grain in spike (g)	Thousand-kernel weight (g)
E0	100.8	10.8	62.0	2.63	39.96
E0+L	101.0 ^{ns}	10.6 ^{ns}	59.7 ^{ns}	2.41 ^{ns}	38.39 ^{ns}
E0+$N_{120}P_{60}$	106.7 ^{ns}	11.3 ^{ns}	69.3 ^{ns}	2.57 ^{ns}	37.05 ^{ns}
E1	97.5 ^{ns}	10.4 ^{ns}	62.4 ^{ns}	2.73 ^{ns}	41.30 ^{ns}
E1+L	97.2 ^{ns}	10.6 ^{ns}	65.6 ^{ns}	2.63 ^{ns}	39.41 ^{ns}
E1+$N_{120}P_{60}$	105.6 ^{ns}	11.4 ^{ns}	72.3*	2.78 ^{ns}	36.62 ^{ns}
E2	96.8 ^{ns}	10.8	63.7 ^{ns}	2.75 ^{ns}	41.42 ^{ns}
E2+L	97.8 ^{ns}	10.8	62.8 ^{ns}	2.71 ^{ns}	40.38 ^{ns}
E2+$N_{120}P_{60}$	102.5 ^{ns}	11.4 ^{ns}	66.1 ^{ns}	2.73 ^{ns}	40.47 ^{ns}
LSD (%)					
5.0	10.5	0.9	9.9	0.39	5.66
1.0	14.1	1.3	13.3	0.52	7.64
0.1	18.8	1.7	17.7	0.69	10.18

B. Influence of electromagnetic treatment

Factors and levels	Plant height (cm)	Length spike (cm)	Number of grains in spike	Weight of grain in spike (g)	Thousand kernel weight (g)
E0	102.8	10.9	63.7	2.54	38.47
E1	100.1 ^{ns}	10.8 ^{ns}	66.4 ^{ns}	2.71 ^{ns}	39.11 ^{ns}
E2	99.0 ^{ns}	11.0 ^{ns}	64.2 ^{ns}	2.73 ^{ns}	40.75 ^{ns}
LSD (%)					
5.0	6.0	0.5	5.7	0.22	3.27
1.0	8.2	0.7	7.7	0.30	4.41
0.1	10.9	1.0	10.2	0.40	5.87

C. Influence of fertilization

Factors and levels	Plant height (cm)	Length spike (cm)	Number of grains in spike	Weight of grain in spike (g)	Thousand kernel weight (g)
0	98.3	10.7	62.4	2.70	40.89
L	98.7 ^{ns}	10.7	62.7 ^{ns}	2.58 ^{ns}	39.39 ^{ns}
$N_{120}P_{60}$	104.9*	11.4*	69.2*	2.69 ^{ns}	38.05 ^{ns}
LSD (%)					
5.0	6.0	0.5	5.7	0.22	3.27
1.0	8.2	0.7	7.7	0.30	4.41
0.1	10.9	1.0	10.2	0.40	5.87

*significant at probability P = 0.1%; ns - no significant; L - Lumbrical; LSD - low significant differences.

Although, that the values of all tested components were statistically no significant under the influence of the EMT, from the results of Table 2B it can be found that for E1 and E2 options the PH values were lower than E0, and for WGS and TKW higher for E2 option by 7.5% and 5.9%, respectively compared to E0. The results for LS and NGS were highest for E2 and E1 options, respectively 0.9% and 4.7% compared to E0.

According to Table 3C, mineral fertilization has statistically significant influence for the PH, LS and NGS - 5.6%, 6.5% and 10.8%, respectively compared to the control option. They were not established significant differences for WGS and TKW. Higher, but no significant values for PH and NGS after application of organic fertilizer are reported– 0.4 and 1.0%, respectively compared to the control option.

In contrast from Colorit variety, yield components under the influence of EMT and fertilization for Boomerang variety showed highest values for different options of EMT and fertilization (Table 3A). The values for PH and WGS showed highest results for E2+$N_{120}P_{60}$ option - 7.0% and 8.5% above E0, respectively. The PH is significant at probability P = 5.0%. The value of LS was influenced most favourably for E0+$N_{120}P_{6}$ - 3.6%, and NGS for E1+$N_{120}P_{60}$ option - 9.2% above E0. WGS showed highest, but no significant value for E2

Table 3 Influence of the factors on the yield components for Boomerang variety for 2017/19 period

A. Influence of electromagnetic treatment and fertilization

Factors and levels	Plant height (cm)	Length spike (cm)	Number of grains in spike	Weight of grain in spike (g)	Thousand-kernel weight (g)
E0	108.0	11.1	54.6	2.58	45.88
E0+L	108.4 ns	10.4 ns	55.0 ns	2.51 ns	43.94 ns
E0+$N_{120}P_{60}$	113.0 ns	11.5 ns	60.3 ns	2.63 ns	43.43 ns
E1	106.1 ns	10.8 ns	55.4 ns	2.49 ns	43.81 ns
E1+L	108.2 ns	10.5 ns	50.8 ns	2.34 ns	42.78 ns
E1+$N_{120}P_{60}$	113.2 ns	11.2 ns	59.6 ns	2.72 ns	43.47 ns
E2	105.4 ns	10.4 ns	56.5 ns	2.63 ns	47.39 ns
E2+L	107.8 ns	10.3 ns	50.2 ns	2.52 ns	44.56 ns
E2+$N_{120}P_{60}$	115.6*	11.3 ns	59.5 ns	2.80 ns	45.32 ns
LSD (%)					
5.0	7.4	11.0	9.2	0.35	3.63
1.0	10.0	10.8 ns	12.5	0.47	4.91
0.1	13.4	10.6 ns	16.6	0.63	6.53

B. Influence of electromagnetic treatment

Factors and levels	Plant height (cm)	Length spike (cm)	Number of grains in spike	Weight of grain in spike (g)	Thousand-kernel weight (g)
E0	109.8	11.0	56.6	2.57	44.36
E1	109.1 ns	10.8 ns	55.3 ns	2.52 ns	43.85 ns
E2	109.6 ns	10.6 ns	55.4 ns	2.65 ns	45.75 ns
LSD (%)					
5.0	4.3	0.6	5.3	0.20	2.10
1.0	5.8	0.8	7.2	0.27	2.83
0.1	7.7	1.0	9.6	0.36	3.77

C. Influence of fertilization

Factors and levels	Plant height (cm)	Length spike (cm)	Number of grains in spike	Weight of grain in spike (g)	Thousand-kernel weight (g)
0	106.5	10.8	55.5	2.57	45.69
L	108.1 ns	10.4 ns	52.0 ns	2.45 ns	44.26 ns
$N_{120}P_{60}$	113.9**	11.3*	59.8 ns	2.72 ns	44.01 ns
LSD (%)					
5.0	4.3	0.6	5.3	0.20	2.10
1.0	5.8	0.8	7.2	0.27	2.83
0.1	7.7	1.0	9.6	0.36	3.77

*, **significant at probability P = 0.1 and P = 1.0%; ns - no significant; L - Lumbrical; LSD - low significant differences.

+$N_{120}P_{60}$ option - 8.5% more. Like of Colorit variety TKW was highest, but no significant for E2 option - 3.3% to E0.

According to Table 3B, EMT does not influence significant on the values of the studied components. The results for WGS and TKW were highest for E2 option - 3.1% to E0. It is observed reduction of the values of LS and NGS under the influence of E1 and E2 options compared to E0.

The results of the effect of fertilization (Table 3C) showed that mineral fertilization has statistically significant effect for PH and LS, the values are 6.9% and 5.6% more than control option. It is reported increase the value of PH by 1.5%, after application of organic fertilizer. From the results presented on Table 2B and Table 3B should be summarized, that for both triticale varieties the values for WGS and TKW were highest for E2 treatment. This means, that the EMT has a positive impact on these indicators, which mainly express spike productivity in cereals. In study by Belitskaya et al. (2013) also is established, that under the influence of electromagnetic stimulation increased field germination is obtained, it is improved the initial development of root, length of sprouts, the yield components for triticale - PH, WGS and TKW exceed the control. In study by Tibirkov et al. (2012) is established, that TKW has highest value after EMT in wheat seeds, compared to the control option. Different results have received Zhalnin et al. (2016). Their research establishes no significant influence of electromagnetic field on TKW in spring wheat.

Table 4. Effect of electromagnetic treatment and fertilization on the plant height

Source of variation	df	SS	η (%)	MS	F criteria	P value
Colorit						
Options	8	440.5313	23.88	55.06641	1.058545	0.42001
A	2	92.59375	5.0	46.29688 ^{ns}	0.889968	0.57476
B	2	332.5938	18.0	166.2969 ^{ns}	3.196736	0.05542
A×B	4	15.34375	0.8	3.835938 ^{ns}	7.373849E-02	0.98663
Error	27	1404.563	76.1	52.02083	-	-
Boomerang						
Options	8	401.0938	36.15086	50.13672	1.910897	0.09949
A	2	2.75	0.2	1.375 ^{ns}	5.240637E-02	0.94898
B	2	369.875	33.2	184.4375**	7.0296	0.00378
A×B	4	29.46875	2.7	7.367188 ^{ns}	0.280791	0.88738
Error	27	708.4063	63.8	26.23727	-	-

**significant at probability P = 1.0%; ns - no significant; A - electromagnetic treatment; B - fertilization.

Table 5. Effect of electromagnetic treatment and fertilization on the length of spike

Source of variation	df	SS	η (%)	MS	F crieria	P value
Colorit						
Options	8	5.038574	31.26	0.6298218^{ns}	1.534754	0.19151
A	2	0.2802735	1.74	0.1401367^{ns}	0.341486	0.71834
B	2	4.350586	27.00	2.175293*	5.300767	0.01136
A×B	4	0.4077149	2.53	0.1019287^{ns}	0.2483805	0.90712
Error	27	11.08008	68.74	0.4103733	-	-
Boomerang						
Options	8	6.601563	33.85	0.8251953^{ns}	1.726839	0.13736
A	2	0.7084961	3.63	0.3542481^{ns}	0.7413147	0.51000
B	2	5.283692	27.10	2.641846**	5.52844	0.00973
A×B	4	0.609375	3.12	0.1523438^{ns}	0.3188011	0.86307
Error	27	12.90234	66.15	0.4778646	-	-

$^{*,\,**}$significant, respectively at probability P = 0.1 and P = 1.0%; ns - no significant; A - electromagnetic treatment; B - fertilization.

Table 6. Effect of electromagnetic treatment and fertilization on the number of grains in spike

Source of variation	df	SS	η (%)	MS	F crieria	P value
Colorit						
Options	8	492.9531	28.31	61.61914^{ns}	1.332923	0.26951
A	2	65.85938	3.78	32.92969^{ns}	0.712323	0.50362
B	2	340.625	19.56	170.3225*	3.684138	0.03748
A×B	4	86.46875	4.97	21.61719^{ns}	0.467151	0.76120
Error	27	1248.172	71.67	46.22859	-	-
Boomerang						
Options	8	368.211	25.20	46.02637	1.136795	0.37139
A	2	2.242188	0.15	1.121094	2.768964e-02	0.97339
B	2	300.336	20.55	150.168*	3.708964	0.03675
A×B	4	65.63281	4.49	16.4082	0.4052625	0.80470
Error	27	1093.172	74.80	40.48785	-	-

*significant at probability P = 0.1%; ns - no significant; A - electromagnetic treatment; B - fertilization.

On the other components of the yield for both triticale varieties, different effects of EMT options were observed. Nizharadze (2016) has received similar results.

The analysis of variance showed significant effect of fertilization for PH, LS, NGS and WGS for Boomerang variety (Tables 4, 5, 6 and 7). No significant effects of

Table 7. Effect of electromagnetic treatment and fertilization on the weight of grain in spike

Source of variation	df	SS	η (%)	MS	F criteria	P value
Colorit						
Options	8	0.4247742	18.19	5.309677e-02	0.7501617	0.64904
A	2	0.2706909	11.59	0.1353455	1.912188	0.16565
B	2	0.1082764	4.64	5.413819e-02	0.764875	0.52084
A×B	4	4.580689e-02	1.96	1.145172e-02	0.1617922	0.95349
Error	27	1.911072	81.81	7.078043e-02		
Boomerang						
Options	8	0.6035461	28.00	7.544327e-02	1.312917	0.27864
A	2	0.1078339	5.00	5.391693e-02	0.9383003	0.59394
B	2	0.4190674	19.44	0.2095337*	3.646453	0.03861
A×B	4	0.0766449	3.56	1.916122e-02	0.3334571	0.85343
Error	27	1.551483	72.00	5.746234e-02	-	-

*significant at probability P =0.1%; ns - no significant; A - electromagnetic treatment; B - fertilization.

Table 8. Effect of electromagnetic treatment and fertilization on the thousand kernel weight

Source of variation	df	SS	η (%)	MS	F criteria	P value
Colorit						
Options	8	97.41797	19.17	12.17725	0.8006728	0.60821
A	2	33.44922	6.58	16.72461	1.099669	0.34834
B	2	48.58985	9.56	24.29492	1.597429	0.21972
A×B	4	15.37891	3.03	3.844727	0.2527968	0.90449
Error	27	410.6367	80.8253	15.20877	-	-
Boomerang						
Options	8	56.63281	25.07	7.079102	1.129206	0.37591
A	2	23.28125	10.31	11.64063	1.856826	0.17401
B	2	19.78906	8.76	9.894531	1.578302	0.22357
A×B	4	13.5625	6.00	3.390625	0.5408475	0.70980
Error	27	169.2656	74.93	6.269098	-	-

ns - no significant; A - electromagnetic treatment; B - fertilization.

fertilization and EMT were founded on the thousand kernel weight (Table 8). It was established close effect of the fertilization on both varieties of triticale, respectively 27.0 and 27.1% of the variance for LS and 19.5 and 20.6% for NGS. The greatest effect of fertilization was reported on the PH for Boomerang variety - 33.2% of the total variation. For yield components for both varieties no significant effect of EMT was found. This gives basis to note that the significant values to E0 for NGS and PH, shown in Table 2A and Table 3A, are due to of the positive influence of mineral fertilization.

From Table 9 can to be fined, that in both varieties of triticale the established correlation coefficients show linear, positive relationships between some of the components studied, but differences are observed. For Colorit variety can to affirm, that there are statistically significant dependencies between all investigated components. High correlations were found between NGS and WGS (r = 0.775), between WGS and TKW (r = 0.869). For Boomerang variety there are no correlations between LS and the other components, PH low correlated with WGS (r = 0.335) and LS (r = 0.454).

CONCLUSIONS

It is established similar, significant effects of fertilization on the length of a spike and the number of grains in a spike for both varieties of triticale, and for Boomerang variety on the plants height and the weight of the grains in spike. Not confirmed the effect of electromagnetic pre-sowing seed treatment, but is reported positive impact on some components of the yield, expressed with higher values compared to the control option.

Table 9. Correlation coefficients between the components of grain yield

	PH	SL	NGS	WGS	TKW
Colorit					
PH	1				
LS	0.631***	1			
NGS	0.552***	0.674***	1		
WGS	0.446***	0.691***	0.775***	1	
TKW	0.334*	0.564***	0.426***	0.869***	1
Boomerang					
PH	1				
LS	0.454***	1			
NGS	0.260	0.265	1		
WGS	0.335*	0.187	0.855***	1	
TKW	0.1456	0.049	0.534***	0.688***	1

*, ***significant, respectively at probability, $\alpha = 0.05$ and $\alpha = 0.01$; n = 35 observations; PH - Plant height; SL - Spike length; NGS - Number of grain per spike; WGS - Weight of grains per spike; TKW - Thousand kernel weight.

For Colorit variety is received an increase for the following yield components: for the length of a spike, the number of grains in a spike and the weight of the grains in a spike for E1 option and applied mineral fertilizer $N_{120}P_{60}$, respectively 5.6, 16.6 and 5.7%; for the length of a spike, the weight of the grains in a spike and the thousand kernel weight at separately application of E2 option, respectively 0.9, 7.5 and 5.9%; for the number of grains in a spike for E1 option–4.7%.

For Boomerang variety highest values are received for the following yield components: for the plant height and the weight of the grains in a spike for E2 option and applied mineral fertilizer $N_{120}P_{60}$ - 7.0 and 8.5%; for the weight of the grains in a spike and the thousand kernel weight when applying separately E2 option - 3.1%.

When applying organic fertilizer in both varieties of triticale, the increase in values of some components of the yield is within 0.4 and 1.5%, and after mineral fertilization from 5.6 to 10.8%.

Positive correlations are established between all yield components for the variety Colorit, and for Boomerang variety between the plant height and the length of a spike, as well as interdependence between the number of grains in a spike, the weight of the grains in a spike and the thousand kernel weight.

Pre-sowing electromagnetic treatment is a promising ecological method for stimulating effect on triticale seeds. It is necessary conducting field experiments with electromagnetically treated seeds.

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