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THE INFLUENCE OF EFFECTIVE MICROORGANISMS ON SOME CHARACTERISTICS OF DIFFERENT MAIZE

Vesna Stepić[1], Gorica Cvijanović[2], Marija Bajagić[3], Nenad Đurić[4], Vojin Đukić[5], Zlatica Mamlić[5], Gordana Dozet[2]

Abstract: The aim of the research was to determine the impact of the EM Aktiv preparation in the maize crop (ZP 427 and ZP 548) at 160, 120, 102 kg ha^{-1} N in 2017 at the location of the municipality of Vladimirovci. During the growing season, there was a pronounced water deficit. The preparation was applied in three variants: EM1 - control, EM2 - foliar 2 x 6 l ha^{-1} in the phenological stages of 5-7 leaves and after 15 days; EM3 - the preparation was introduced into the soil 7 days before sowing 30 l ha^{-1} + EM2. The mass of 1000 grains, the height of the yield and the nitrogen content in the grain were determined. Application of 160 kg ha^{-1} nitrogen had the greatest effect on the weight of 1000 grains, and 120 kg ha^{-1} N on grain yield in all treatments. The treatments had a positive effect on both traits. Higher values of the tested properties were found in the EM3 treatment. The applied factors did not have a statistically significant effect on the nitrogen content of maize grains.

Keywords: hybrids, fertilization, biostimulator, yield components

Introduction

Maize represents a strategically very important food plant species, and the demand for maize is growing. Predictions show that the need for this culture will double by 2050 in developing countries (Rosegrant et al., 2008).

The production of maize on a global level takes place in a way that affects the degradation of resources and elements of the environment, the increasing dependence on mineral fertilizers and pesticides, which leads to the production of greenhouse gases and a negative impact on climate change. Today,

[1]Municipal administration of municipalities, Vladimirovci Svetog Save 34 1522 Vladimirovci, Serbia
[2]University Megatrend, Faculty of Biofarming, Bl. Mihajla Pupuna 117 11 000 Novi Beograd, Serbia (cvijagor@yahoo.com)
[3]University of Bijeljina, Faculty of Agriculture, Pavlovića put bb, Bijeljina, Republika Srpska, BiH
[4]Institute for Vegetable Crops Karađorđeva 71, 11 420 Smederevska Palanka, Serbia
[5]Field and Vegetable Crops Institute, Maksima Gorkog 30, 21000 Novi Sad, Serbia

agricultural production emphasizes the management of ecological and biological processes in order to obtain acceptable crop yields and environmental protection. In recent years, there has been an increasing number of studies on the impact of different biostimulants within the fertilization program as a supplement to fertilization (Zamudio et al., 2018). Tejada et al. (2018) investigated the application of different types of foliar biostimulants in the maize crop and obtained positive results of agronomic characteristics and maize yield. Positive results were obtained by Cvijanović et al., (2007) in the examination of the application of diazotrophs on the yield of maize grains and the composition of the rhizosphere microflora. The aim of the work was to examine the influence of a microbiological preparation with effective microorganisms on the mass of 1000 grains, the height of the yield and the nitrogen content in the grains of different genotypes of maize in the dry year of 2017.

Materials and methods

Experimental research was conducted in 2017 on a private plot in the municipality of Vladimirci. The area of the elementary plot was 14 m^2. The plots were laid out according to the plan of divided plots in three repetitions. All agrotechnical measures were applied in optimal terms. (Factor A): to ensure the necessary amount of nitrogen on the entire plot, 30 t ha^{-1} of manure and 300 kg ha^{-1} of complete mineral NPK fertilizer of the formulation 15:15:15 were plowed in autumn. In the course of pre-sowing preparation and one top dressing, which was carried out in the phenological phase of plant development of 5-7 leaves, the following amounts of nitrogen were provided 160 kg ha^{-1}; 120 kg ha^{-1}; 102 kg ha^{-1}.

Two hybrids (factor B) of the toothed yellow grain type were sown, the selection of the Maize Research Institute Zemun Polje ZP 427 and ZP 548. Various treatments were applied with the preparation EM Aktiv (trade name) (Factor C). Treatments: EM1 - no treatment, EM2 - EM Aktiv was used during the growing season 2 x 6 l ha^{-1} in the phenological stages of 5-7 leaves and after 15 days; EM3 - EM Aktiv was introduced into the soil 7 days before sowing, 30 l ha^{-1} + EM2.

EM Aktiv is a liquid preparation containing a mixture of highly effective strains of lactic acid fermentation bacteria, sulfate-reducing bacteria, fungi, yeasts and actinomycetes. These microbes produce a large amount of biostimulatory compounds such as hormones, indole-3 acetic acid, organic acids, antibiotics and B vitamins.

The water regime during the vegetation period was very unfavorable (360.3 mm). 55.2 mm of rain was recorded in April, and 90.2 mm in May, which was more than the conditional-optimal needs for the initial stages of maize growth. In the month of June, only 14.8 mm of rain fell, which is almost six times less than the conditionally optimal needs (90 mm). In July, 49.3 mm of water precipitation fell, which was insufficient, and the dry period continued in August, as 25.5 mm fell, which is four times less than the conditional-optimal needs. In September, 83.7 mm fell, which was 3.74 mm more than needed.The average air temperature in the growing season was 18.3°C. The month of April had an average temperature of 11.5°C, which is lower than optimal needs. In May, the average temperatures were at the level of the required temperatures, while in June the average daily temperatures of 22.7°C were 2.7°C higher, which with a small amount of precipitation of only 14.8 mm was an unfavorable period for the development of generative organs in maize. In August, the average mean daily temperatures were at the optimal level of 23°C, but the period of water deficit continued, so it can be said that the conditions for maize fertilization were unfavorable.

Total proteins were determined by the method micro–Kjeldalh Laboratory for soil and agroecology at the Institute of Crop and Vegetable Farming Novi Sad. To evaluate data we used descriptive statistics and analysis of variance (ANOVA) u programu DSAASTAT Three-way ANOVA was used to test effects of mineral nitrogenin fertylizer, genotype, treatment and growing season. All results were calculated at a significance level LSD of 0.01 and 0.05.

Results and discussion

Based on the processed results, the average weight of 1000 maize grains was determined to be 222.75 g (Table 1).

Table 1. Mass of 1000 grains of maize (g)

N kg ha^{-1} (A)	Genotypes (B)	Treatments (C)			x̄ AB	x̄ A
		EM1	EM2	EM3		
160	427	281.45	282.57	281.55	281.86	282.27
	548	281.98	283.36	282.73	282.69	
x̄ AC		281.72	282.97	282.14		
120	427	201.72	203.32	202.67	202.57	200.46
	548	200.59	196.41	198.03	198.34	
x̄ AC		201.15	199.87	200.35		

102	427	170.25	206.29	196.58	191.04	185.53
	548	191.02	169.71	179.29	180.01	
x̄ AC		180.64	188.00	187.94		
x̄ BC	427	217.80	230.73	226.94	225.16	x̄ B
	548	224.53	216.50	220.02	220.35	
x̄ C		221.17	223.61	223.48		
Average					222.75	

	A*	B^{ns}	AB^{ns}	C^{ns}	AC*	BC**	ABC**
F test	0.00	0.33	0.59	0.22	0.01	0.00	0.00
LSD 0.01	12.28	11.07	19.17	3.17	4.49	4.48	7.76
LSD 0.05	16.40	16.77	29.05	4.29	7.36	6.07	10.52

Fertilization and the interaction of fertilization with treatments significantly influenced the differences in yield ($p<0.05$). Statistically, hybrids had the lowest grain mass at fertilization with 102 kg ha^{-1} (185.53 g). Hybrids and treatments did not have significant differences in the weight of 1000 grains, while the interaction of hybrids and treatments had a statistically significant effect on the differences in the weight of 1000 grains. The highest mass of 1000 grains was determined in the interaction of hybrid ZP 427 with both treatments (216.50-220.02 g).

The average yield of maize grains was 3.57 t ha^{-1} (Table 2). Statistically significant differences in yield were determined under the influence of fertilization and the interaction of fertilization with treatments ($p<0.05$). The treatments had a statistically highly significant influence, while the hybrids did not show a statistically significant influence on the grain yield. The highest yield was with fertilization with 120 kg ha^{-1} (3.77 t ha^{-1}), which was statistically significantly higher only in relation to fertilization with 160 kg ha^{-1}. The highest yield was in the treatment EM3 4.00 t ha^{-1}, which is statistically highly significant only in relation to the variant without treatment.

Table 2. The height of the yield of maize grains (t ha^{-1})

N kg ha^{-1} (A)	Genotypes (B)	Treatments (C)			x̄ AB	x̄ A
		EM1	EM2	EM3		
160	427	2.10	3.10	3.38	2.86	3.21
	548	3.41	3.65	3.63	3.56	
x̄ AC		2.75	3.38	3.51		
120	427	3.41	3.12	4.75	3.75	3.77
	548	2.99	3.73	4.27	3.66	
x̄ AC		3.20	3.43	4.49	3.71	

102	427	3.49	4.05	4.00	3.85	
	548	3.07	3.59	4.02	3.56	3.70
x̄AC		3.28	3.82	4.01		
x̄ BC	427	3.00	3.43	4.03	3.54	
	548	3.15	3.66	3.97	3.60	x̄ B
x̄ C		3.08	3.54	4.00		
Average					3.57	

	A*	B^{ns}	AB*	C**	AC*	BC*	ABC
F test	0.07	0.54	0.11	0.00	0.20	0.14	
LSD 0.01	0.54	0.41	0.52	0.34	0.60	0.66	
LSD 0.05	0.45	0.62	0.74	0.47	0.82	0.96	

Based on the obtained results, it can be said that by using EM Active as a biostimulator, stable yields can be achieved even with a reduced amount of mineral nitrogen. Also, the consequences caused by unfavorable abiotic influence can be mitigated. Taking into account the fact that maize is grown on the largest areas in the natural irrigation system, such research is certainly of great importance. Dry conditions in 2017 had a negative impact on the absorption of mineral substances from the soil, which was reflected in the grain yield. The protein content in maize kernels is on average 10-13% (Radosavljevic et al., 2020), while Ballesta and Lioveras (1996) determined that the nitrogen content in maize kernels ranges from 1.08% to 1.39%.

Nitrogen in the grain originates from nitrogen taken from the soil during grain filling and from nitrogen transported from the vegetative organs into the grain. The average nitrogen content was 1.40% (Table 3). All investigated factors and their interactions had a statistically significant effect on the nitrogen content. A statistically significant difference was found between the treatments, with the highest protein content found in the control variant.

Table 3. Nitrogen content in maize grain (%)

N kg ha-1 (A)	Genotypes (B)	Treatments (C) EM1	EM2	EM3	x̄ AB	x̄ A
160	427	1.34	1.28	1.29	1.30	
	548	1.46	1.41	1.35	1.41	1.35
x̄ AC		1.40	1.34	1.32		
120	427	1.39	1.45	1.25	1.36	
	548	1.46	1.48	1.46	1.47	1.41
x̄ AC		1.42	1.47	1.35		
102	427	1.85	1.38	1.28	1.50	
	548	1.30	1.35	1.45	1.37	1.44
x̄ AC		1.58	1.36	1.37		

$\bar{x}$ BC	427	1.52	1.37		1.27	1.39	$\bar{x}$ B
	548	1.41	1.41		1.42	1.41	
$\bar{x}$ C		1.47	1.39		1.35		
					Average	1.40	
	A**	B**n	AB**	C**	AC**	BC**	ABC**
F test	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LSD 0.01	0.02	0.01	0.02	0.03	0.06	0.05	0.08
LSD 0.05	0.02	0.02	0.03	0.04	0.08	0.06	0.11

Conclusion

Based on the obtained results, it can be concluded that both treatments with effective microorganisms would have a significant impact on the weight of 1000 grains and the yield. The greater effect of application is in variants with a smaller amount of mineral nitrogen. In general, it can be concluded that it is desirable to introduce the application of effective microorganisms as a supplementary measure.

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