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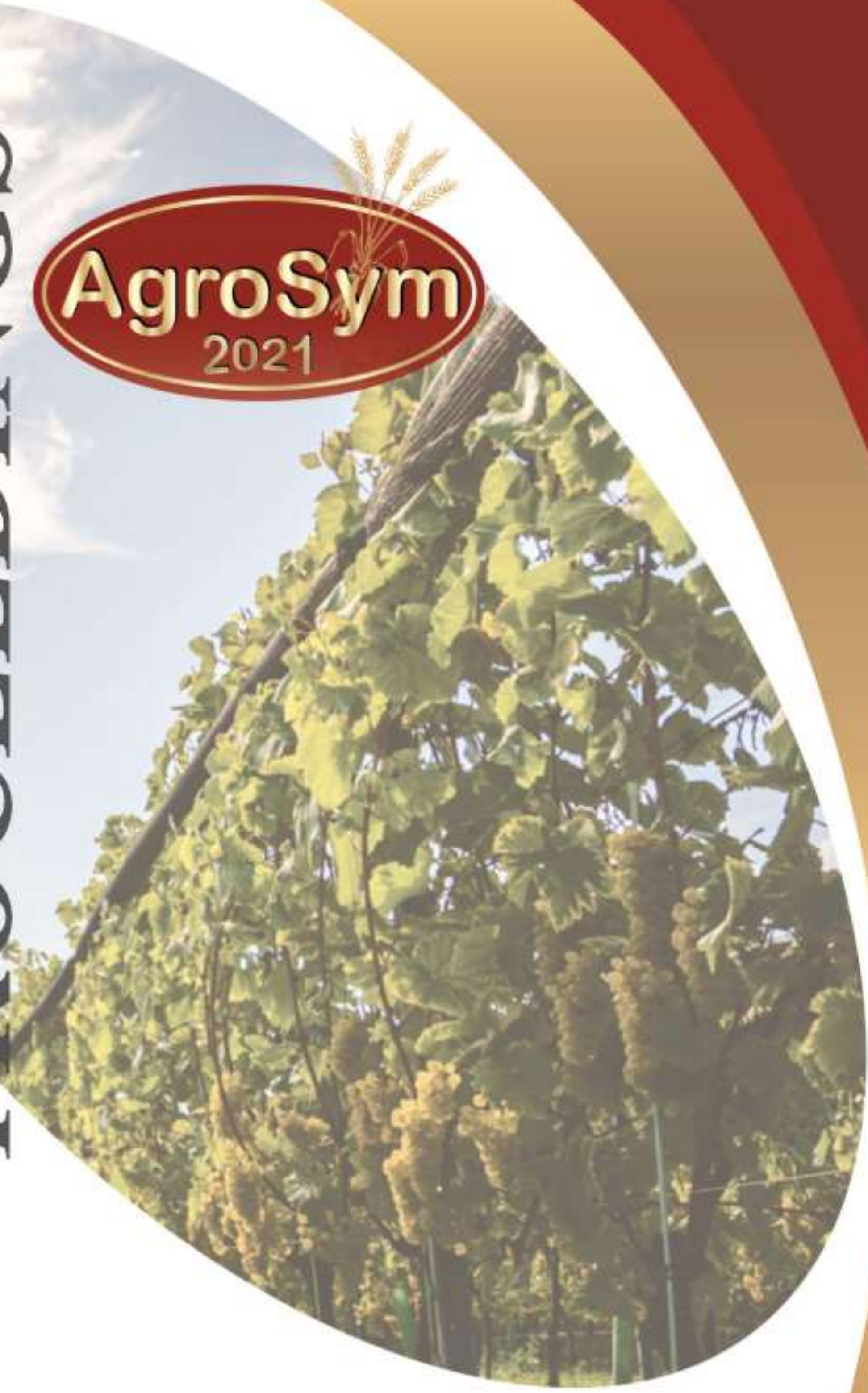

XII International Scientific Agriculture Symposium "AGROSYM 2021"

October 7-10, 2021

agrosym 2021

BOOK OF PROCEEDINGS

XII International Scientific Agriculture Symposium
"AGROSYM 2021"

Jahorina, October 07 - 10, 2021

Impressum

XII International Scientific Agriculture Symposium „AGROSYM 2021"

Book of Proceedings published by

University of East Sarajevo, Faculty of Agriculture, Republic of Srpska, Bosnia
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CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

631(082)(0.034.2)

INTERNATIONAL Scientific Agriculture Symposium "AGROSYM" (12 ; Jahorina ; 2021)
Book of Proceedings [Електронски извор] / XII International Scientific Agriculture Symposium "AGROSYM 2021", Jahorina, October 07 - 10, 2021 ; [editor in chief Dusan Kovacevic]. - Onlajn izd. - El. zbornik. - East Sarajevo : Faculty of Agriculture, 2021. - Ilustr.

Sistemski zahtjevi: Nisu navedeni. - Način pristupa (URL): http://agrosym.ues.rs.ba/article/showpdf/BOOK_OF_PROCEEDINGS_2021_FINAL.pdf. - El. publikacija u PDF formatu opsega 1465 str. - Nasl. sa naslovnog ekrana. - Opis izvora dana 15.11.2021. - Bibliografija uz svaki rad. - Registar.

ISBN 978-99976-787-9-9

COBISS.RS-ID 134751233

INTERACTION OF FERTILIZATION AND SOYBEAN GENOTYPE ON NUMBER OF PODS, WEIGHT OF 1000 GRAINS AND GRAIN YIELD

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Abstract

In the last few decades, new soybean varieties with different characteristics, grain quality and purpose have been created, contributing to its expansion and increase in the cultivation area. Thanks to good agronomic characteristics, soybean has found its place in sustainable production systems. In order to increase the yield and quality of grain in sustainable soybean growing systems, different foliar treatments with different active substances have been increasingly applied. The aim of the study was to determine the impact of the application of EM Aktiv with effective microorganisms on the number of pods per plant, weight of 1000 grains and grain yield of different soybean cultivars grown in an integrated cultivation system. The research was conducted in the period 2016-2019 in the experimental field of the Institute of Field and Vegetable Crops Novi Sad. Varieties from three maturing groups Galina (0 group), Sava (I group) and Rubin (II group) were grown. Variants of fertilization application were: T1 control, T2 EM Aktiv was applied to the soil before sowing 20 $l.ha^{-1}$, and later in vegetation 6 $l.ha^{-1}$ (the first foliar treatment in the phase of three to four trefoils and the second before flowering in the budding phase), T3 NPK 8:15:15 300 $kg.ha^{-1}$ in basic treatment and T4 combination of T2 and T3 treatments. On average for all three years of the study were found statistically significant differences between the variables in all properties. The highest values were determined when applying T4 treatment. The number of pods was 55.92, the weight of 1000 grains was 163.61 g and the yield was 4.240 $kg.ha^{-1}$. The cultivar Rubin (II maturing group) showed the highest values for all examined variables on average after all treatments.

Key words: *soybean, fertilization, effective microorganisms, yield.*

Introduction

Soybean (*Glycine max* (L.) Merr) is one of the most important crops for the diet of the population due to its multiple purposes. Today, a large number of scientific and technological knowledge is constantly confirming its value and increasing its constant use. In addition to protein (40%) and oil (20-25%), soy contains various plant specialized (secondary) metabolites, such as isoflavones and saponins (Ahmad et al., 2014; Singh et al., 2017). Soybeans have a special genetic predisposition for a symbiotic relationship with bacteria that fix atmospheric nitrogen and arbuscular mycorrhizal fungi, which gives it an advantage for growing in a sustainable production system. Due to all that, the areas under soybean increase, however with greater oscillations in yields. For stable production of soybeans, it is necessary to know well the needs of the plant for nutrients, agroecological conditions for its production, to apply adequate technology as well as the appropriate assortment. The problem of soybean fertilization has been studied, but, in addition, many issues of nutrition of this plant have not yet been clarified, so there is no increase in yield under the influence of fertilization as in other plants. Soybean responds well to supplemental feeding foliar treatment of a variety of nutrients. Silberbush (2002) states that foliar nutrition of soybeans is widely used to correct plant deficiencies caused by improper root supply. Camberato et al. (2010) reports that if symptoms of nutrient deficiency occur during the growth phase, the most effective method to overcome deficiencies is to use a foliar diet. Mallarino (2005) concluded that foliar nutrition of soybeans in the early stages of growth increases grain yield by 10-30%. Oko et al. (2003) state that foliar treatment of soy with urea in phases R2 and R3 increases the yield by 6-68% compared to the control, while Haq and Mallarino (2005) pointed out that foliar application achieves an increase in protein and oil yield. However, with the development of methods in sustainable production systems, there is an increasing number of research related to the application of biophysics methods and various biofertigators. By applying low frequency electromagnetic waves with organic fertilizers, soybean yield can be increased (Cvijanović 2018) as well as the protein content in the grain (Đukić et al. 2017).

The use of microbiological multiple inocula with effective microorganisms (EM) is increasingly used in plant production. Different types of microorganisms and a large number of highly effective strains affect the stimulation of plant growth, protection against disease, increase resistance to abiotic stresses, improve the chemical properties of fruits (Filipović et al., 2020; Cvijanović et al., 2019) and increase yield. The use of effective microorganisms in plant production can increase the nutritional properties of fruits, according to the results of studies by Daiss et al., (2008), which found an increased content of phosphorus and magnesium in chard leaves. Yue et al., (2002) found that the application of EM can increase the intensity of photosynthesis in functional leaves during mid-vegetation. Using EM, the same authors found that there was a decrease in stomata openness, the activity of the enzyme nitrate reductase increased in the grain, while increasing the yield and quality of the grain (% protein and fat). The aim of the research was to determine the influence of EM Aktiv preparation with effective microorganisms on the number of pods per plant, weight of 1000 grains and grain yield of different soybean cultivars grown in an integrated cultivation system.

Materials and methods

The research was conducted in the period 2016-2019 in the experimental field of the Institute of Field and Vegetable Crops Roman trenches in Novi Sad. The land is of the chernozem type. The experimental field experiment in dry farming was set up according to the design of a split-plot experiment on an area of 2475 m^2. The experiment was set up in four replications, and the size of the basic plot was 15 m^2. Sowing was performed in the optimal agrotechnical period with three soybean genotypes of different FAO maturation groups: Galina (group 0), Sava (group I) and Rubin (group II). The fertilization was based on the principles of integrated production, where NPK fertilizer 8:15:15 was used for basic fertilization, the amount of 300 kg ha^{-1} during autumn tillage and the application of effective microorganisms in the preparation EM Aktiv (trade name) in the following variants:

T1-Control without fertilization; T2-Variant with the use of effective microorganisms in the preparation EM Aktiv (application initially on the ground before sowing in the amount of 20 liters per hectare and secondly foliar treatments in the development phase of plants from three to four trefoils and budding phase, ie buds on the soybean tree in the amount of 5 liters per hectare); T3-Variant with application of NPK fertilizer during basic tillage in autumn, fertilizer formulation 8:15:15, amount 300 kg ha^{-1}; T4-Variant where T2 + T3 treatments are combined.
In the phase of technological maturity of soybeans, 10 plants were taken from each basic plot for analysis. In this paper, the number of pods per plant, weight of 1000 grains and soybean grain yield were analyzed.

Results and discussion

The number of pods per plant represents the total number of pods from one soybean plant, from the main tree and branches. The average number of pods for the entire research period was 53.47. Observing the average values for the number of pods by individual varieties, it can be noticed that the highest value was recorded in the cultivar Rubin (59.91), which was statistically significantly higher than in the cultivar Galina (49.77). No statistically significant difference was found in relation to the Sava variety (55.06). According to the variants of fertilization, the number of pods was the highest when applying T4 treatment (55.92), which is statistically significantly ($p < 0.05$) higher number of pods compared to T3 treatment (52.60) and in relation to control (50.87) the significance was at the level of $p<0.01$. The number of pods in the variant with the preparation of EM Aktiv T2 (54.49) was statistically very significantly higher in relation to the control variant, while in relation to the T4 treatment no statistically significant difference in the number of pods per plant was found. The largest number of pods was found in the treatment of T4 with variety Rubin (62.94). According to Wiebold et al. (1981) by increasing the number of pods, soybean grain yield can be increased, which is one of the priority tasks in soybean cultivation and selection research. The obtained results can significantly improve soybean production.
The weight of 1000 grains is an important component of yield and an indicator of seed size. Grain mass can be affected by genotype, nitrogen diet, supplementation by various means. The average weight of 1000 grains for all three years of research was 162.28 g. Observing the average values for the weight of 1000 grains by individual varieties, it is noticed that the varieties Rubin (167.82 g) and Sava (162.94 g) had a statistically significant difference in the weight of 1000 grains in relation to the variety Galina (156.10 g). The difference in the mass of 1000 grains between the cultivar Rubin and Sava was not at the level of statistical significance. Observing the values for the weight of 1000 grains by fertilization variants, it is noticed that the highest value was recorded on the variant with application of T4 (163.61 g), and the lowest value on the control variant of the experiment (160.19 g), however these differences were not statistically significant. In the interaction of cultivars and treatments, the Rubin cultivar had the highest weight of 1000 grains at T4 treatment (169.73 g). According to the obtained results, it was determined that this trait is conditioned by a genetic factor, the amount of nitrogen (Haq and Mallarino, 2000), as well as foliar treatments. That soybean responds differently to foliar treatments has been shown by Dozet et al. (2016) in studies of foliar application with cobalt and molybdenum where there was a decrease in 1000 grain weight and yield height by 0.56%. Accordingly, the results of the application of a combined diet with mineral nitrogen and effective microorganisms are of great importance in the cultivation of soybeans of different genotypes.

Grain yield, as the ultimate goal of production, averaged 4034.81 kg ha^{-1}. The highest grain yield was in the variety Rubin 4240.22 kg ha^{-1}. In relation to the Sava variety, the increase was 300.06 kg ha^{-1} and in relation to Galina 494.10 kg ha^{-1}, which was a statistically significant increase in grain ($p < 0.01$). Regarding the treatment, the highest values were determined in the treatment T4 4240.22 kg ha^{-1}. The determined yield was higher by 583.17 kg ha^{-1} compared to the control (3657.05 kg ha^{-1}) ($p<0.01$). The other two treatments had statistically significant ($p<0.01$) differences (T2 for 486.16 kg ha^{-1} and T3 for 441.71 kg ha^{-1}) compared to the control. Between treatments T2 (4143.21 kg ha^{-1}) and T3 (4098.79 kg ha^{-1}) the difference of 44.42 kg ha^{-1} was not statistically significant.

Table 1. Influence of examined variables on number of pods, weight of 1000 grains and grain yield of soybean genotypes

Genotype (A)	Treatments (B)				x̄ (A)
	1 control	2 EM Aktiv	3 NPK	4 NPK+EM Aktiv	
			Number of pods per plant		
Galina	45.13	49.02	47.73	49.77	47.91
Sava	54.48	52.79	51.04	55.05	52.59
Rubin	56.02	61.67	59.03	62.94	59.91
x̄ AB	50.87	54.49	52.60	55.92	
Average 2016-2019					**53.47**
LSD		A**		B**	AB**
0.01		12.03		3.42	5.83
0.05		8.88		2.30	4.30
			Weight of 1000 grains (g)		
Galina	153.50	155.59	157.18	158.14	156.14
Sava	160.69	163.05	165.05	162.96	162.94
Rubin	166.37	168.18	167.08	163.73	167.82
x̄ AB	160.19	162.27	163.08	163.61	
Average 2016-2019					162.28
LSD		A**		B**	AB**
0.01		11.31		5.05	4.14
0.05		8.32		3.74	2.74
			Grain yield kg ha^{-1}		
Galina	3432.40	3853.07	3801.80	3909.21	3749.12
Sava	3622.23	3978.49	4011.19	4141.73	3940.16
Rubin	3909.40	4598.13	4483.37	4670.02	4415.23
x̄ AB	3657.05	4143.21	4098.79	4240.22	
Average 2016-2019					**4034.81**
LSD		A**		B**	AB**
0.01		166.12		153.81	151.07
0.05		123,02		110.30	107.25

The obtained results are compatible with the results of Xiaohou et al. (2001) who state that spraying with effective microorganisms can increase the yield and grain quality of different crops. The same authors state that by adding photosynthetic bacteria to the soil, the amount of nitrogen compounds that are the secretions of photosynthetic bacteria increases, which affects the increase of mycorrhizal fungi. These fungi can coexist with nitrogen-fixing bacteria, increasing nitrogen-fixing ability and grain yield. According to Javid (2006) foliar application of EM with the use of NPK fertilizers in the production of peas (*Pisum sativum* L.) increases grain yield by 126%. The same author found that applying EM in wheat production can increase grain yield by 27% compared to production where only chemical fertilizers were applied. By applying effective microorganisms, the yield of soybeans in two-year studies increased by an average of 10.84%, and by 6.86% and 14.81% per year (Dozet et al., 2014). Differences in yield were also conditioned by different agroecological factors.

Conclusion

The use of NPK fertilizers is justified in the production of soybeans, and the use of preparations with effective microorganisms has a positive effect on the tested properties. The application of effective microorganisms had better results compared to NPK treatment. The best results were obtained by applying a combination of NPK and effective microorganisms in all soybean genotypes. The Rubin variety, which belongs to 000 matures, had the best results.

Acknowledgement

The paper is part of the research of project no. 451-03-9/2021-14/200378, and 451-03-9/2021-14/200032, and TR 31092 funded by the Ministry of Science and Environmental Protection of the Republic of Serbia.

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