YIELD RESPONSE OF BEAN TO DIFFERENT AGRICULTURAL PRACTICES AND MICROBIAL ACTIVITY IN ITS RHIZOSPHERE

Simonida ĐURIĆ[1], Dragana STAMENOV[1] , Timea HAJNAL-JAFARI[1], Bojana PETROVIĆ[2], Mirjana VASIĆ[3]

[1] University of Novi Sad, Faculty of Agriculture, Dositeja Obradovića Sq.8, Novi Sad, Serbia
[2] PhD student at Mendelova Univerzita v Brne, Czech Republic
[3] Institute of Field and Vegetable Crops, Novi Sad, Serbia
University of Novi Sad, Faculty of Agriculture,
Department of Field and Vegetable Crops, 21000 Novi Sad, Serbia
Corresponding author: Dragana STAMENOV, e-mail: *dragana.stamenov@polj.uns.ac.rs*

Abstract *. The aim of this study was to compare the effect of organic and conventional production on yield parameters of bean (Phaseolus vulgaris) as well as on the number of rhizospheric microorganisms. Studies were conducted at two sites on chernosem soil. Organic production was conducted on the field in the village Pivnice, while conventional production was conducted in the village Čurug, Serbia during 2014. Varieties of Balkan, Zlatko, Belko, Sremac, Slavonac, Maksa, and 20-tica were used. Before sowing, the bean seeds were inoculated by biofertilizers NS-Nitragin for beans and faba beans. NS- Nitragin contains a mixture of selected strains of symbiotic bacteria Rhizobium leguminosarum bv. phaseoli. Laboratory measurements were performed in microbiological laboratories of Faculty of Agriculture, Novi Sad and in the Institute of Field and Vegetable Crops, Novi Sad. The height and mass of the plant, the number and weight of the bean seeds per plant as well as the number of microorganisms in its rhizosphere (the total number, number of azotobacter, actinomycetes and fungi) were determined. In this research, the average values of all examined parameters of plant yields were lower in the organic production compared to conventional, except for variety Slavonac. In this case it was obtained a statistically significant increas of plant mass, number and weight of seeds per plant in organic production compared to conventional. Those results indicate that the variety Slavonac should be grown in organic production. The results showed that inoculation can have a positive effect on the number of microorganisms in the rhizosphere of the bean. The number of the investigated groups of microorganisms, apart from actinomycetes, increased in the organic production, where microbiological fertilizers were applied. In average, statistical analises showed that inoculation did not have a statistically significant impact on the number of the investigated groups of microorganisms.*

Key words*: bean, yield, microbial activity, organic, conventional production*

INTRODUCTION

Management practices used in agriculture influence soil properties, nutrient use efficiency and crop production. Conventional crop management systems that rely on inorganic fertilizers and agrochemicals have, in recent years, increased agricultural productivity though at high environmental cost (PIMENTEL, 2005). In addition to significant energy consumption during production and processing many negative consequences for the environment are also documented (LAZIĆ i sar. 2012, PUCAREVIĆ et al. 2013). Final products of conventional farming, very often contain illegal or even harmful quantities of 220 agrochemicals residues, usually persistent pesticides and nitrates (COCKBURN et al . 2014 NOUGADERE et al. 2011). Moreover, reduced content of nutritive and aromatic substances are also measured (LARION,

2009). On the other hand, organic farming systems which depend on organic sources of nutrients (i.e., animal manure, crop residues, green manure crops and catch crops) may sustain productivity at reduced environmental cost by enhancing microbial nutrient turnover (WATSON et al., 2002). Organic agricultural production has all necessary conditions for the production of high quality food (BOURN and PRESCOTT , 2002). So today, organic agriculture has become an important alternative to intensive, conventional farming.

Soil microorganisms constitute an active component of the soil organic pool, controlling the breakdown of organic matter and, hence, the release of nutrients and their availability for other organisms. The microbial biomass also acts as a small but labile reservoir of nutrients that contributes to maintaining long-term agricultural sustainability (BERGSTROM et al., 1998). An understanding of microbial processes is important for the management of farming systems, particularly those that rely on organic inputs of nutrients. In organic agriculture, biofertilizers that are used usually contain one or more strains of microorganisms. Different bacteria that have been reported as a component of microbiological fertilizers belong to the following genera: *Bradyrhizobium, Azotobacter, Azospirillum, Bacillus, Pseudomonas, Rhizobium* and others (LUCY et al. 2004; BERG, 2009). These bacteria are involved in nitrogen fixation, some of them can penetrate into the root of the plants, forming nodules or lumps (WANG et al., 2000, GARCIA et al., 2004).

Beans (*Phaseolus vulgaris* L.) is one of the most important legumes in the human diet in the world. In Serbia it is grown on over 20, 000 hectares with an average yield of around 1.3 t / ha. Beans are grown mostly because of seeds, which is rich in proteins, mainly used for human consumption. In addition to protein, it contains a large number of amino acids necessary for human consumption, such as: tyrosine (0.5%), tryptophan (0.17 to 0.70%), lysine (0.68 to 2.18%) arginine (1.47 to 2.66%), cystine and histidine methionine (GOVEDARICA and JARAK, 1995).

The objective of this work was therefore to compare the effects of organic and conventional production of bean (*Phaseolus vulgaris*) measuring plant yield parameters and to monitor the number of rhizospheric microorganisms.

MATERIAL AND METHODS

Studies were conducted at two sites in chernosem soil. Organic production was conducted on the field in the village Pivnice, while conventional production was conducted in the village Čurug, Serbia. The experiment was conducted in soil having the following characteristics:

Table 1.

Agrochemical characteristics of soils at the sites Čurug and Restaurants

lokalities	pH		$CaCO_3$ %	Humus %	Total N %	AL-P_2O_5 mg/100g	AL-K_2O mg/100g
	in KCl	in H_2O					
Čurug	7,31	7,69	4,22	1,50	0,07	47,85	22,38
Pivnice	7,20	7,76	4,78	3,02	0,15	4,47	16,07

The experiment was set up in 2014 following the system of the separate plots.

Seven bean varieties were used: Balkan, Zlatko, Belko, Sremac, Slavonac, Maksa, and 20-tica (Institute of Field and Vegetable Crops, Novi Sad, Serbia).

Before sowing, the seed of beans were inoculated by biofertilizer NS-Nitragin (Institute of Field and Vegetable Crops, Novi Sad) for beans and faba beans. NS- Nitragin contains a mixture of selected strains of symbiotic bacteria *Rhizobium leguminosarum* bv. *phaseoli*. Sowing was carried out at the optimum time and all necessary agro-technical measures, according to production type, were applied.

Laboratory measurements were performed in microbiological laboratories of Faculty of Agriculture, Novi Sad and in the Institute of Field and Vegetable Crops, Novi Sad. Plant samples and soil samples for microbial analisys were taken at the end of vegetation season.

The following parameters of plant yield were measured: the height and mass of the plant, the number and weight of bean seeds per plant.

The number of microorganisms was determined using the dillution method (TROLLDENIER, 1996). Appropriate nutrient media were used (Hi Media Laboratories Pvt. Limited, Mumbai, India): nutrient agar for the total number of bacteria, synthetic agar for the number of actinomycetes, potato dextrose agar for the number of fungi and N-free medium with manitol for the number of azotobacter.

The data were statistically processed by means of Statistics 10 softwere. The significance of the difference between the applied treatments was determined using Fisher's LSD test.

RESULTS AND DISCUSSION

Yields in organic agriculture are generally lower than in conventional. According to the DE PONTI et al. (2012), SEUFERT et al. (2012), differences between crop yield in organic and conventional production system ranges from 5 to 34%. Different strains of rhizospheric microorganisms, that are applied as biofertilizers in organic production have a stimulatory effect on the growth and development of plants (VESSEY et al., 2003). To what extent this effect influences plant yield depends on the type of soil, effectiveness of indigenous and applied strains of microorganisms, plant species, plant variety or hybrid (WALKER et al., 2003).

In this study, the average values of all examined yield parameters were lower in plants that were grown under the conditions of organic production in comparation with conventional, except for variety Slavonac (Table 2).

The use of organic way of production had a better effect on the height and mass of plant, number and mass of seeds per plant of variety Slavonac, than conventional farming system. In comparison with the conventional farming, a statistically significant increase in the mass of plant, number and mass of seeds per plant were recorded for variety Slavonac in organic production. The height of the plants in organic farming was by 7% higher than in the conventional, whereas the mass of plant was by 60% higher. The number of seeds per plant was by 70.5% higher in organic production than in the conventional whereas the mass of seeds per plant was by 81.2% higher.

It was recorded a statistically significant increase in the height of plant for varieties Belko, Maksa and Zlatko, mass of plant for varieties Belko and Maksa, and number of seeds per plant for variety Maksa in conventional production in comparation with organic. For variety Sremac all measured yield parameters were statistically higher in conventional farming.

Table 2.

The parameters of bean yield in conventional and organic farming

	Varieties	Height of plant (cm)	Mass of plant (g)	No. of seeds / plant	Mass of seeds / plant
Conventional	Belko	54.40 a*	34.39 b	71.96 c	18.07 c b
	Maksa	43.90 b	34.64 b	50.16 b a	20.83 c
	Zlatko	43.86 b	28.11 cb	36.13 d	15.04 d c
	20-tica	37.53 d	23.08 d c	34.40 d	13.53 d c
	Slavonac	36.30 d	30.10 c b	40.36 d b	15.06 d c
	Sremac	38.33 d	44.20 a	61.26 c a	21.87 b
	$\overline{X}$	42,38	34,42	49.05	17.4
organic	Belko	45.20 b	25.25 d c	66.76 c	14.63 d c
	Maksa	32.67 c	23.71 d c	37.26 d b	15.15 d c
	Zlatko	30.23 c	22.82 d c	26.76 d	11.58 d
	20-tica	37.20 d	18.35 d	28.03 d	12.21 d
	Slavonac	39,00 d	48.20 a	68.83 c	27.29 a
	Sremac	31.30 c	17.01 d	28.13 d	10.35 d
	$\overline{X}$	35,93	25.89	37.81	15.2

** The different letter above the number indicates significant difference at P<0.05 according to Fisher`s test.*

The use of biofertilizers in plant production increases the number and enzymatic activity of microorganisms which enhances the productive capability of soil (NANNIPIERI et al. 2003). These microorganisms reproduce in soil and with their enzymatic activity raise and maintain the appropriate level of organic matter in soil (HAJNAL et al., 2005; JARAK et al., 2009, STAMENOV et al., 2012). The effect of biofertilizers on the change of microbiological activity in soil depends on soil conditions, plant species, adaptability of introduced microorganisms etc. (VAN OVERBEEK et al., 1997; DOBBELAERE et al., 2003; EGAMBERDIYEVA, 2007).

This research showed that in average, the number of the investigated groups of microorganisms, apart from the number of actinomycetes, increased in soil samples of organic production in comparison with the conventional (Table 3). The use of microbiological biofertilizers had a better effect on the increase in the number of Azotobacter (14.36%) than on the total number of bacteria and fungi (8.5% and 2.8% respectively).

Table 3.

The number of microorganisms in the rhizosphere of beans (log number)

	Total number		fungi		actinomicetes		azotobacter	
Varieties	Convent.	Organic	Convent.	Organic	Convent.	Organic	Convent.	Organic
Belko	8.01 b,a	8.43 b,a	4.61 c,b,a	4.96 b,a	5.13 b,a	4.78 b,a	4,04 a	4,17 a
Sremac	8.30 b,a	8.47 b,a	4.61 c,b,a	4.26 c,b,a	5.72 b,a	4.91 b,a	2,92 b	4,48 a
Balkan	8.30 b,a	9.00 b,a	4.61 c,b,a	3.87 c	5.47 b,a	4.97 b,a	3,75 b,a	4,19a
Zlatko	8.18 b,a	8.97 b,a	4.37 c,b,a	5.14 a	5.41 b,a	5.49 b,a	3,96 b,a	4,03 a
Slavonac	8.04 b,a	8.67 b,a	4.67 c,b,a	4.90 c,b,a	5.53 b,a	5.54 b,a	3,97 b,a	4,24 a
20-tica	7.21 b	9.08 a	4.87 c,b,a	4.75 c,b,a	5.83 a	5.23 b,a	3,50 b,a	3,93 b,a
Maksa	8.69 b,a	8.97 b,a	4.03 c,b	4.75 c,b,a	4.49 b	4.71 b,a	3,70 b,a	4,47 a

$\bar{x}$	8.11	8.8	4.54	4.67	5.37	5.09	3,69	4,22

Convent.- Conventional production;

** The different letter above the number indicates significant difference at P<0.05 according to Fisher`s test.*

Comparing the two ways of plant production, organic and conventional farming, it was noticed that the total number of bacteria and number of *Azotobacter* were statistically higher in organic agriculture, for varieties 20-tica and Sremac (respectively), whereas for the other varieties, those differences were not statistically significant. The number of actinomycetes in conventional production was larger than in organic agriculture, but this difference was not statistically significant.

CONCLUSION

In this research, the average values of all examined parameters of plant yields were lower in the organic production compared to conventional, except for variety Slavonac.

Results indicate that the variety Slavonac should be grown in organic production.

The results of this study showed that inoculation can have a positive effect on the number of microorganisms in the rhizosphere of the bean. The number of the investigated groups of microorganisms, apart from actinomycetes, increased in the organic production.

In average, statistical analises showed that inoculation did not have a significant impact on the number of the investigated groups of microorganisms.

BIBLIOGRAPHY

1.BERG G. 2009, Plant-microbe interactions promoting plant growth and health: perspectives for controlled use of microorganisms in agriculture. Appl Microbiol Biotechn, 84, 11-48.

2.BERGSTROM D.W., MONREAL C.M., KING D.J. 1998, Sensitivity of soil enzyme activities to conservation practices Soil Sci. Soc. Am. J., 62, 1286–1295.

3.BOURN D., PRESCOTT J. 2002, A Comparison of the Nutritional Value,Sensory Qualities,and Food Safety of Organically and Conventionally Produced Foods, Critical Reviews in Food Science & Nutrition. Jan2002, 42(1), 1-34.

4.COCKBURN A, HEPPNER CW, DORNE JLCM 2014, Environmental Contaminants: Nitrate and Nitrite, Encyclopedia of Food Safety, 2, 332-336.

5.DE PONTI, T., RIJK, B., VAN ITTERSUM, M.K. 2012, The crop yield gap between organic and conventional agriculture. Agric. Syst. 108, 1-9.

6.DOBBELAERE S., VANDERLEYDEN J., OKON Y. 2003, Plant growth-promoting effects of diazotrophs in the rhizosphere. Crit. Rev. Plant Sci. 22, 107-149.

7.EGAMBERDIYEVA D. 2007, The effect of plant growth promoting bacteria on growth and nutrient uptake of maize in two different soils. App. Soil. Ecology 36, 184-189.

8.GARCIA J.A.L., PROBANZA A., RAMOS B, PALOMINO M.R 2004, Efect of inoculation of Bacillus licheniformis on feald. Agronomie for Sustainable Development, 24 (Suppl 4), 169-176.

9.GOVEDARICA M., JARAK M. 1995, Mikrobiologija, Univerzitet Novi Sad.

10.HAJNAL T., JARAK M., MILOŠEVIĆ N., JELIČIĆ Z. 2005, Influence of bacterization on the number of microorganisms in the rhizospheric soil and the lengh of the above ground parts of maize plant. Savremena poljoprivreda, No1-2, 77-84.

11.JARAK M., ĐURIĆ S., SAVIN L., ČOLO J. 2009, Uticaj primene biofertilizatora na prinos ječma i mikrobiološku aktivnost u zemljištu. Traktori i pogonske mašine, Vol.14, No 4, 77-81.

12.LARION D. 2009, Nutritional quality and safety of organic food. A review. Agron. Sustain. Dev. 209(30), 33-41.
13.LAZIĆ S., ŠUNJKA D, PUCAREVIĆ M, GRAHOVAC N, VUKOVIĆ S, INĆIĆ D V, JAKŠIĆ S 2012, Monitoring of atrazine and its metabolites in groundwaters of the Republic of Serbia, Hemijska industrija , OnLine-First (00), 94-94.
14.LUCY M., REED E., GLICK B.R. 2004, Application of free living plant growth-promoting rhizobacteria. *Antonie van Leeuwenhoek*, 86, 1-25.
15.NANNIPIERI P., ASCHER J., CECCHERINI M.T., LANDI L., PIETRAMELLARA G., RENELLA G. 2003, Microbial diversity and soil functions, Eur.J.Soil Sci. 54, 665-670.
16.NOUGADÈRE A., RENINGER J.C., VOLATIER J.L., LEBLANC J.C. 2011, Chronic dietary risk characterization for pesticide residues: A ranking and scoring method integrating agricultural uses and food contamination data, Food and Chemical Toxicology, 49(7), 1484-1510.
17.PIMENTEL D. 2005, Environmental and economic costs of the application of pesticides primarily in the United States Environ. Develop. Sustain., 7, 229–252.
18.PUCAREVIĆ M., BURSIĆ V., PANKOVIĆ D., RALEVIĆ N.M., CARA M., KECOJEVIĆ I. 2013, Supercritical fluid extraction of tebupirimphos residues in sugar beet. Journal of Animal and Plant Sciences, 23(1).
19.SEUFERT V., RAMANKUTTY N., FOELY J.A. 2012, Comparing the yields of organic and conventional agriculture. Nature 485, 229-232.
20.STAMENOV D., JARAK M., ĐURIĆ S., MILOŠEV D., HAJNAL JAFARI T. 2012, The use of plant growth promoting Rhizobacteria in the production of English Ryegrass, Plant, Soil and Environment,58 (10), 477-480.
21.TROLLDENIER G. 1996, Plate Count Technique. In Methods in Soil Biology. Ed.Franz Schinner, Ellen Kandeler, Richard Ohlinger, Rosa Margesin. Springer-Verlag Berlin Heildeberg., 20-26.
22.VAN OVERBEEK L.S., VAN VEE J.A., VAN ELSAS J.D. 1997, Induced reporter gene activity, enhanced stress resistance, and competitive ability of a genetically modified Pseudomonas fluorescens strain released intoa field plot planted with wheat, App.environ.Microbiol., 63,1965-1973.
23.VESSEY J.K. 2003, Plant growth promoting rhizobacteria as biofertilizer, Plant Soil 255, 571-586.
24.WALKER H., GROTEWOLD E., VIVANCO J.M. 2003, Root exudation and rhizosphere biology. Plant Physiology, 132, 44-51.
25.WANG R., GUEGLER K., LA BRIE S.T., CRAWFORD N.M 2000, Genomic analysis of nutrient response in Arabidopsis reveals expression patterns and novel metabolic and potential regulatory genes that are induced by nitrate. Plant Cell, 12, 1491-1510.
26.WATSON C.A., ATKINSON D., GOSLING P., JACKSON L.R., RAYNS F.W. 2002, Managing soil fertility in organic farming systems Soil Use Manage., 18, 239–247.