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Effect of microbial fertilizer on soybean yield in organic and conventional production

[a]Gordana DOZET*, [a]Gorica CVIJANOVIC, [b]Vojin DJUKIC, [c]Drago CVIJANOVIC, [d]Ljiljan KOSTADINOVIC

[a]Megatrend University Belgrade, Faculty for biofarming, Backa Topola, Serbia
[b]Institute of Field and Vegetable Crops, Novi Sad, Serbia
[c]Institute of Agricultural Economics, Belgrade, Serbia
[d]Institute of Food Technology, Novi Sad, Serbia

*Corresponding author: gdozet@biofarming.edu.rs

Abstract

Two-year survey was conducted according to the principles of organic and conventional dryland cropping technologies. Experiment was placed in Backa Topola, on calcareous chernozem with wheat as preceding crop. In ecological production basic soil fertilization was performed with 15 $t \cdot ha^{-1}$ cowshed manure, and in conventional production as pre-sowing treatment was applied 100 kg $N \cdot ha^{-1}$. In both years were similar weather conditions. Examination factors were production ways and application of microbial fertilizer. Microbial fertilizer was in liquid state and it contained various types of microorganisms. Data were processed by two-factorial split-plot experiment variance analysis method, and differences between treatments were analyzed by LSD-test. Correlation analysis was conducted. The aim of this work was to determine yield of organic and conventional cropping technologies and correlational dependency between surveyed characteristics. The average yield was statistically very significantly higher ($p<0.01$), for 24.09% in conventional production compared to ecological production. However, in the world, the average price of organic soybean (Anonymus, 2014a), is higher in comparison with prices of soybean from conventional production (Anonymus, 2014b). The highest yield was reached in variations with microbial fertilizer soil treatment and in phenophases at the beginning and during the flowering. Number of pods was in a strong ($p<0.01$) positive correlation with number of grains, and grain weight per plant with yield. Strong negative correlation was faund between number of grains and 1000-kernel weight (-0.76). Ecological soybean production, as production system with respect of environmental principles and standards, as well as specific local agroecological conditions, has its priority

Keywords: price, conventional and organic production, microbial fertilizers, yield, soybean

Introduction

Numerous negative consequences for soil, water, air, biodiversity and human health imposed the need of important changes in agricultural production and development of ecological, sustainable systems which introduced production control, documentation and sertification system and therefore mean security to consumer. Agricultural production development occurs by different intensity and has geographical, socio-economic and ecological features. Global agricultural production includes traditional agriculture, conventional and sustainable agricultural systems, which are represented by good agricultural practice, integral and organic agriculture. Precise agricultural system includes modern technical-technological knowledge and can be applied in all kinds of agricultural production, but only where technical conditions and knowledge are present (Cvijanovic et al., 2013). Areas under soybean vary, partly because of yield, and partly because of economic conditions, but it became important factor of crop production (Dozet, 2009). Soybean grain is used as different productions for human nutrition, and therefore it is necessary that soybean production is conducted without application of mineral fertilizers and pesticides. Organic agriculture is system of ecological production management which promotes and improves biodiversity, matter circulation and biological soil activity (Kovacevic and Oljaca, 2005). In agricultural production, measure targets and guidelines are integral and organic agriculture, and that means finding alternative fertilization ways to avoid soil degradation consequences (Cvijanovic G. et al., 2010). Organic products trade has increased during the last three years from 25 to 40 billion dollars. Pices of organic products are still high, inspite increased sales and in average are higher for 15 to 30 % compared to conventional produstion products (Dozet et al., 2013b). It has been found that soil humus level and nitrogen content, microorganisms number and activity can be increased by growing soybean in clean intercropping (Cvijanovic and Dozet, 2012). In food market, both domestic and international there is great competition for high quality of certain source, or specific geographic origin, then are bigger chances for success and that is why marketing is important (Cvijanovic D., 2000, Dozet et al., 2011). Average price of soybean from organic production in past year (2013) was 28.23 \$/bushel (Anonymus, 2014a), while from conventional production it was 14.70 \$/bushel (Anonymus, 2014b).

The aim of this study was to determine the yield of organic and conventional cropping and the correlation between the studied traits. Also, it is established that the optimal use of biological fertilizers.

Materials and Methods

Examination of impact of soybean growing technology and microbial fertilizer application on yield and yield components was based on experiment conducted in Backa Topola, on calcareous chernozem with wheat as preceding crop during 2012 and 2013. The first examination factor in experiment was organic and conventional growing principle, and the second was application of microbial fertilizer. Size of experiment was 50 m x 25 m = 1250 m^2. Experiment was set in four repetitions with row length of 5 m. Each repetition was divided into 16 plots (8 plots for conventional and 8 for ecological production). Seed of soybean variety Galina was used for sowing, which is early-maturing variety, belongs to 0^{th} ripening group and it is created by Institute of Field and Vegetable Crops in Novi Sad. Seed from ecological seed production was used for ecological cropping, while for conventional cropping seed was from conventional seed production. Soybean preceding crops in previous three years were barley, corn and wheat. Preceding crops weren't fertilized by mineral fertilizers and chemical plant protetction wasn't used in previous three years. The area planned for ecological production was basically fertilized by cowshed manure of 15 $t.ha^{-1}$. And the planned for conventional production was fertilized by 100 kg $N.ha^{-1}$ before sowing. Besides cowshed manure and nitrogen, liquid microbial fertilizer was applied with mixture of different microorganisms (lactic acid bacteria, photosynthetic bacteria, yeast, actinomycetes, fungi). Sowing was conducted mechanically by six-row seeder with 4cm depth, row spacing of 50 cm, and space between plants in row was 4 cm. Size of basic plot was 15 m^2. Plant assembly was 500.000 plants per hectare. Crop protection from weeds was done by cultivating, manual hoeing and weed pulling. Cultivation and manual hoeing were conducted twice. Cultivation was performed by horse harness, to avoid the negative impact of tractor exaust gases in ecological growing. Microbial fertilizer was applied in both production ways and in all plots, in 8 variants: 1 – control (without microbial fertilizer), 2 – soil treatment seven days before sowing, 3 – in fenological phase from 1^{st} to 3^{rd} leaf, 4 – beginning of flowering, 5 – full bloom, 6 – soil treatment and beginning of flowering, 7 - soil treatment and full bloom, 8 – soil treatment, beginning of flowering and full bloom. Reproductive phases, beginning of flowering and full bloom were determined by definition og Fehr and Caviness (1977). Soil was treated by 30 $l.ha^{-1}$ of microbial fertilizer diluted in water amount of 500 $l.ha^{-1}$. And it was inoculated into soil by tractor tiller, depth of 10 cm. In variants with foliar application of preparation the amount was $l.ha^{-1}$ microbial fertilizer diluted in 400 l of water, which was applied by knapsack sprayer. Harvest was performed manually (plants were taken from two middle rows witout frontal plants and carefully tied in bundles) and treshing was performed by Winterstaigner harvesters for soybean experiments in Institute of Field and Vegetable Crops in Novi Sad. Treshed grain was measured, moisture was determined which was reduced to 13 % and based on that yield per area unit was calculated.

Data were processed by two-factorial split-plot experiment variance analysis method, and differences between treatments were analyzed by LSD-test. Correlation analysis of examined features was conducted, and correlation factors siginificance was determined by t-test (Hadzivukovic, 1991). Basic chemical soil analysis was performed in accredited laboratory of Agricultural Advisory and Professional Service in Backa Topola. Temperature and precipiptation data were obtained from valid weather station in Backa Topola.

Results and Discussion

Chemical properties of chernozem represent special value of this kind of soil (Tab. 1). $CaCO_3$ is present in this soil from its surface, but in AC and C horizon it is present in great amounts.

Because of that, in humus accumulative horizon chernozem has neutral, and at greater depth weak alkaline reaction.

Humus content in A horizon is intermediate, and it declines by depth. Total nitrogen content in soil follows the same trend, with good coverage in active part of profile. Natural stocks of readily available phosphorus are low, and that is why the soil in A arable horizon has intermediate content of readily available phosphorus, while subarable A horizon has low content of this element and in greater depth it is present only in traces. Potassium content is good, but its content also declines by depth. Based on these data it can be concluded that the soil where experiment was conducted has favorable physical and chemical properties. The most important agronomic properties of soybean are and components of yield.. These characteristics change by the impact of ecological factors, which vary during the grow phase according to site and year. Great variation in external factors may cause plant stress, such as extremely high temperatures, lack of water, inadequate mineral nutrition, strong wind and low relative humidity (Dozet, 2009, Djukic, 2009). Impact of external factors, especially climate, on yield of all crop cultures is well known. Soybean has its specificities because of greater dependance on external factors compared to other crops.

According to its requirements, soybean can be classified in plants which require higher temperatures and at high temperatures are well-developed, but also, soybean is resistant to short periods of low temperatures and frost. In flovering phase soybean is sensitive to low soil moisture, and o low relative humidity, especially if drought occurs at the same time with high temperatures (Sekulic and Kurjacki, 2008).

Table 1. Chemical compositions of silages from different triticale genotypes

Horizons	Depth	pH		$CaCO_3$	Humus	N	mg/100g soil	
	(cm)	KCl	H_2O	(%)	(%)	(%)	P_2O_5	K_2O
A arable	0-35	7.01	8.05	1.95	2.63	0.173	11.2	20.5
A subarable	35-55	7.20	8.25	3.79	2.03	0.134	7.9	17.2
AC	55-95	7.79	8.63	19.19	1.60	0.105	2.9	10.5
C	95-200	8.05	8.75	32.12	0.36	0.024	2.4	6.6

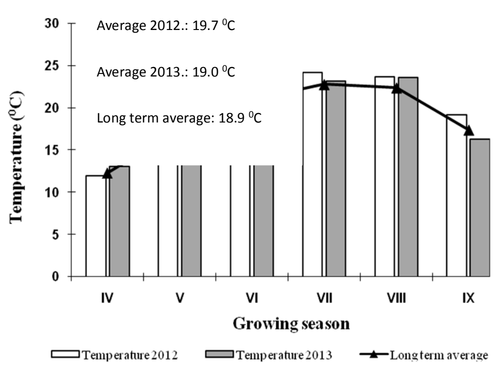

Figure 1. Average temperatures during soybean vegetation in 2012 and 2013 (°C)

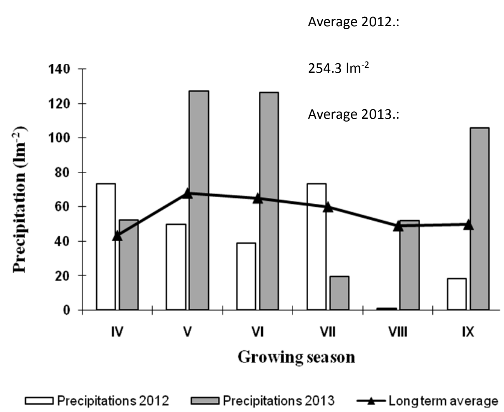

Figure 2. Precipitation sum by months during soybean vegetation in 2012 and 2013 (lm^{-2})

In both year average month temperatures during vegetation were at the multy-year average (Figure 1) and they were appropriate to soybean requirements during the grow and development phases.

Precipitation significantly deviated from multy-year average for vegetation period from April to September (Figure 2.). In 2012 precipitation sum was lower for 24.4 % (82.1 $l.m^{-2}$), and in 2013 it was higher for 43.5 % (146.4 $l.m^{-2}$)compared to multy-year average

However, precipitation distribution was better in 2012 because there were more precipitation in July compared to 2013 and multy-year average. Then soybean was in flowering phase and pod formation, when soybean needs the most the soil moisture. Too much water in stages from germination to flowering, as it was the case in 2013, plants form big aboveground mass and relatively shallow root system, which reduced plant's resistence to drought.

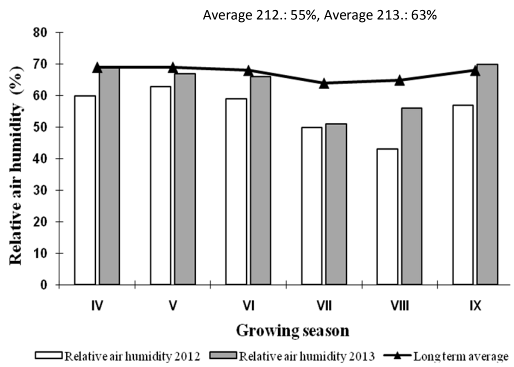

Figure 3 Relative humidity during soybean vegetation in 2012 and 2013 (%)

Average relative humidity significantly deviated from multy-year average and in 2012 it was just 55 %, while in 2013 it was 63 % (Figure 3). Relative humidity wasn't favorable for soybean in its reproductive phases.

Weather conditions, therefore growing and development conditions differ from year to year, because of what recomended production technology is based on long-term average values for certain production region (Dozet et al., 2013a).

Average soybean yield was 4005 kg.ha^{-1}, in 2012 it was 4032 kg.ha^{-1} and in 2013 it was 3977 kg.ha^{-1} (Tab. 2). Differences in yield between examinated years recorded Dozet (2006), Dozet (2009), Djukic (2009)

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Table 2. Soybean yield depending on growing technology and microbial fertilizer application (kg.ha^{-1})

Year		Variants	Method of production (A) Conventional	Organic	Average (B)
2012	Microbial fertilizer (B)	1	4375	3563	3969
		2	4175	3563	3869
		3	4550	3638	4094
		4	4563	3613	4088
		5	4388	3575	3981
		6	4675	3550	4113
		7	4413	3563	3988
		8	4675	3638	4156
		Average (A)	4477	3588	4032
2013	Microbial fertilizer (B)	1	4050	3650	3850
		2	4150	3500	3825
		3	4500	3550	4025
		4	4650	3555	4103
		5	4500	3510	4005
		6	4450	3560	4005
		7	4250	3570	3910
		8	4600	3590	4095
		Average (A)	4394	3561	3977
Average 2012-2013			4435	3574	4005

		Factors			
		A	B	AxB	BxA
2012.	$LSD_{0.01}$	175	182	253	250
	$LSD_{0.05}$	102	142	195	193
2013.	$LSD_{0.01}$	164	175	248	243
	$LSD_{0.05}$	90	131	185	182

The average yield was statistically very significantly higher ($p<0.01$), for 24.09% in conventional production compared to ecological production. Higher yield in conventional production ways was determined in previous research, too (Dozet et al., 2010, Strunjas et al, 2009, Strunjas et al, 2010, Dozet et al., 2013b). However, the average price of organic soybean (Anonymus, 2014a) is for 92.04% higher in comparision with price of soybean from conventional production (Anonymus, 2014b).

In both production ways, the highest yield was reached in variations with microbial fertilizer soil treatment and in phenophases at the beginning and during the flowering (Fehr and Caviness, 1977). The lowest yield had control and variant where microbial fertilizer was applied in pre-sowing soil treatment. Use of microbial fertilizer has complex and beneficial impact to numerous soil properties, and as the most important, it increases soil fertility (Cvijanovic et al, 2009, Cvijanovic et al, 2010a, Cvijanovic et al, 2010b, Cvijanovic et al, 2010c, Cvijanovic et al, 2011, Cvijanovic et al, 2012).

Table 3. Correlative interdependence of some studied properties of soybean

Observed traits	LB	PH	PH1P	PN	GN	PW	GW	W1000	Y
LB		0.10	0.58*	0.06	-0.23	0.48*	-0.11	0.22	-0.11
PH	0.10		-0.02	0.54*	0.53*	0.13	0.52*	-0.20	0.52*
PH1P	0.58*	-0.02		-0.17	-0.40	0.34	-0.04	0.39	-0.04
PN	0.06	0.54*	-0.17		0.87**	0.02	0.40	-0.56	0.40
GN	-0.23	0.53*	-0.40	0.87**		-0.29	0.40	-0.76**	0.40
PW	0.48*	0.13	0.34	0.02	-0.29		-0.04	0.35	-0.04
GW	-0.11	0.52*	-0.04	0.40	0.40	-0.04		0.24	0.97**
W1000	0.22	-0.20	0.39	-0.56*	-0.76**	0.35	0.24		0.24
Y	-0.11	0.52*	-0.04	0.40	0.40	-0.04	0.97**	0.24	

$p<0.05^*$ $p<0.01^{**}$

Correlative interdependence was studied between following properties: number of lateral branches (LB), plant height (PH), plant height to first pod (PH1P), pod number (PN), grain number (GN), plant weight (PW), grain weight (GW), 1000-kernel weight (W1000), yield (Y).

Conclusion

Ecological soybean production, as plant production with respect of environmental principles and standards, as well as specific local agroecological conditionc, has its priority.

Application of modified and new technologies in crop production tends to the production of safe food, which would affect the human health in a positive way.

Ecological way of soybean production has impact on the environment.

Yield in organic production is lower compared to conventional production, but looking at the unite price, ecological soybean production is economically justified.

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References

Anonymus,2014a.www.ams.usda.gov/mnreports/lsbnof.pdf. Acceed: 29.04.2014.

Anonymus, 2014b. www.quotesoybeans.com. Acceed: 29.04.2014.

Cvijanovic, D., 2000. The marketing orientation as a function of the development of modern agro-industrial enterprises. *Agricultural Economics*, 29, 151-161.

Cvijanovic, G., Dozet, G., 2012, Conditions and possibilities recultivation of degraded soil in the area mining basin Kolubara. International Scientific Meeting Sustainable Agriculture and rural development interms of the Republic of Serbia strategic goals realization within the Danube regiom – preservation of rural values, Thematic proceedings, December, 6-8th 2012. Tara, Serbia, 293-310.

Cvijanovic, G., Dozet, G., Cvijanovic, D., 2013. Management in organic crop production, Monograph, Institute of Agricultural Economics, Belgrade, Serbia, 1-366.

Cvijanovic, G., Dozet, G., Cvijanovic, D., Puzic, G., 2011. Importance of application of nitrogen-fixing from the ecological and economic aspects in a system of sustainable agriculture and rural development. 9th International Scientific Conference, Serbia The challenges of globalization and sustainable development, Proceedings, November 25th, Belgrade, Serbia, 317-321.

Cvijanovic, G., Milosevic, N., Dozet, G., 2009. Application of biofertilizers in soybean production. Agriculture and countryside in our changing world" VIII. oszkár wellman international scientific conference 23rd April, 2009 Hódmezővásárhely. *Review on Agriculture and Rural Development*. Scientific Jouranl of Szeged, Faculty of agriculture, Vol. 4(1), 1-6.

Cvijanovic, G., Dozet, G., Micanovic, D., 2010a. Biofertilizers in the function of sustainable development, International scientific meeting: Multifunctional Agriculture and Rural Development (V) - regional specificities- Economics of Agriculture, I Book; Banja Vruica, 02-03.2010, Vol. LVII, 48-57.

Cvijanovic, G., Dozet, G., Milosević, N., Lalevic, B., 2010b. The importance of micro-organisms in organic production, International Tourism Fair, Mediterranean days, Thematic Proceedings from International Conference "Healthy life", 1-8, Trebinje, Bosnia and Herzegovina, 08.04-10.04. 2010., 86-93.

Cvijanovic, G., Milosevic, N., Dozet, G., Djukic, V., Jelocnik, M., 2010c. Producers education about microbiological inoculates application in function of soil fertility. „Agriculture and Countryside in the Squeeze of Climate Change and Recession " IX. Oszkár Wellmann International Scientific Conference Hódmezővásárhely, 22nd April 2010. *Review on Agriculture and Rural Development*. Scientific Journal of University of Szeged, Faculty of Agriculture. Vol. 5(1), 572-577.

Cvijanovic, G., Dozet, G., Djukic, V., Djordjevic, S., Puzic, G., 2012. Microbial activity of soil during the inoculation of soya bean with symbiotic and free-living nitrogen'fixing bacteria. *African Journal of Biotechnology*, Vol. 11(3), 590-597.

Dozet, G., 2006. Influence of row spacing on soybean yield and quality of irrigated. MSc thesis, University of Novi Sad, Faculty of Agriculture, Novi Sad, Serbia.

Dozet, G., 2009. Effects of fertilization with nitrogen and application of Co and Mo on the yield and properties of soybean. Doctoral dissertation, Megatrend University in Belgrade, Faculty of biofarming Backa Topola, Serbia.

Dozet, G., Cvijanovic, G., Cvijanovic, D., Boskovic, J., Popovic, V., 2013b. Yield and oil content of soybean in organic and conventional cropping. *Agroznanje*, Vol. 14(1), 69-76.

Dozet, G., Cvijanovic, G., Balesevic T.S., Djordjevic V., Djukic, V., Popovic, V., 2010. Soybean grain protein content depending on density and variety in ecological production. „Agriculture and Countryside in the Squeeze of Climate Change and Recession " IX. Oszkár Wellmann International Scientific Conference Hódmezővásárhely, 22nd April 2010. *Review on Agriculture and Rural Development*. Scientific Journal of University of Szeged, Faculty of Agriculture. Vol. 5(1) supplement, 185-189.

Dozet, G., Cvijanovic, G., Djukic, V., 2013a. Changes in the technology of soybean production. Chapter 1 from the book - *Sustainable Technologies, Policies and Constraints in the Green Economy*, Advances in in Environmental Engineering and Green Technologies (AEEGT) Book Series, IGI GLOBAL BOOK USA, 1-22.

Dozet, G., Cvijanovic, G., Puzic, G., 2011. Analysis of the situation and prospects of agriculture in the municipality of Backa Topola. *Agricultural Economics*, Institute of Agricultural Economics Belgrade, Special Issue 1, I Book Year/Vol. LVIII, 88-95.

Djukic, V., 2009. Morphological and productive traits of soybean examined in rotation with wheat and corn. Doctoral dissertation, University of Belgrade, Faculty of Agriculture, Zemun, Serbia.

Fehr, W.R., Cavinnes, C. E., 1977. Stages of soybean development. Special report 80, Iowa State University, Iowa.

Hadzivuković, S., 1991. Statistical method from the application of agricultural and biological research: Faculty of Agriculture, Novi Sad, Serbia

Kovacevic, D., Oljaca, S., 2005. Organic farming of organic farming, University of Belgrade, Faculty of Agriculture, Zemun, 39.

Popovic, V., Glamoclija, Dj., Sikora, V., Djekic, V., Cervenski, J., Simic D., Ilin, S., 2013. Genotypic specificity of soybean [*Glycine max.* (L) Merr.] under conditions of foliar fertilization. *Romanian Agricultural Research*, No. 30, 259-270.

Sekulic, P., Kurjacki, I., 2008. The ratio of soybeans to the elements of the outside environment. Soybeans, Institute of Field and Vegetable Crops, Novi Sad; Soyaprotein, Becej, Serbia, 219-242.

Strunjas, V., Dozet, G., 2009. Density effect on soybean yield and quality in organic and conventional production. *Review of scientific papers agricultural students*. Proceedings, Vol. 6(6), University of Kragujevac, Faculty of Agronomy in Cacak, Cacak, Serbia, 27-29. August, 2009., 113-119.

Strunjas ,V., Dozet, G., Zecevic, V., 2010. Influence of Sowing Density on Yield and Quality of Soybean under Ecological and Conventional Production Systems. *Acta Agriculture Serbica*, Vol. XV(30), 125-131.