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EFFECT OF SOIL CONDITIONER ON YIELD AND QUALITY OF ORGANIC SOYBEAN

Vera POPOVIC[1*], Vladimir SIKORA[1], Đorđe GLAMOCLIJA[2], Janko CERVENSKI[1], Mirjana VASIC[1], Jelica GVOZDANOVIC VARGA[1], Livija MAKSIMOVIC[1]

[1]Institute of Field and Vegetable Crops, Novi Sad; Serbia
[2]University of Belgrade, Faculty of Agriculture, Zemun - Belgrade, Serbia
(Corresponding author: vera.popovic@ifvcns.ns.ac.rs)

Abstract

We studied the effect of a soil conditioner on the yield and quality components of organic soybean. The study object was the cultivar Galina, maturity group 0. Experiments in four replications were performed in a field of Institute of Field and Vegetable Crops in Backi Petrovac using organic farming methods. The experiments included two variants: an untreated variant (control) and a fertilized variant (applying Fertdolomit, a commercial soil conditioner).

The following soybean characteristics were analyzed: grain yield (kg/ha), protein and oil contents (%), yields of total proteins and oil (kg/ha), and their correlations. Extremely high yields of soybean were achieved. The average soybean yield was 5732 kg/ha. The yield in the treated variant was higher by 256 kg/ha or 4.57% than that in the control. The control and the treated variant showed no statistically significant differences in the protein and oil contents. The yields of protein and oil were higher in the treated variant than in the control by 4.67% and 5.85%, respectively.

The correlation analysis showed that the variables were mutually dependable. Highly significant positive correlations were found between grain yield and oil content, grain yield and protein yield and between grain yield and oil yield. Negative and nonsignificant correlations were found between grain yield and protein content and between oil content and protein content in soybean grains. Soil conditioning showed to be a feasible method of improving grain yield and protein and oil yields of organic soybean.

Key words: *Glycine max, organic farming, yield, content and yield of protein and oil, top dressing*

Introduction

Soybean (*Glycine max* (L.) Merrill) is the most important legume crop. Its importance is primarily due to the chemical composition of grain (Miladinovic et all. 2008, Popovic, 2010). It is a major source of vegetable proteins. Soybean grain contains about 40% of proteins which include all essential amino acids - lysine, tryptophan, methionine, etc. It also contains 20 - 25% of oil which has a favorable fatty acid composition and large amounts of minerals and vitamins A, B1, B2, C, D, E and K. Soybean is capable of fixing nitrogen, it fits well into crop rotations and it is a good preceding crop. Best proceeding crops for soybean are wheat, corn and sugar beet (Malesevic et all, 2008). Soy is suitable for growing in organic production.

Organic farming facilitates the conservation of soil and water, protection of plant, animal and human health, biodiversity and agrobiodiversity. The Regulations on the Methods of Organic Crop Production stipulate: "Fertilization in organic production is carried out in accordance with soil fertility status and type of organic production employed. Use of

fertilizers of organic origin and natural mineral fertilizers is allowed in organic production, in order to maintain and improve soil fertility"(Babovic et al., 2005). Popovic et al. (2012) reported that the application of top dressing brought significant yields of grain, and increased protein and oil contents in soybean grain.

Organic farming places emphasis on the control, quality and safety of the produce, along with the application of ecological principles. Control over the production of organic soybeans is required for customers to obtain high quality produce. High yields and grain quality (Popović et al., 2012) prove that soybeans can be successfully grown in organic production if proper zoning and proper production technology are applied. Organic farming maintains and improves soil fertility in the long run. Soil fertility is maintained by a production system - crop rotation harmonized with proper soil cultivation, fertilization based on soil fertility level (organic and other permitted fertilizers), and other cultural practices (Bavec F, M Bavec, 2006). To be successful, organic farming must be established on a soil well-provided with organic matter and possessing good structure and water-air properties. Soil tillage is a central point of organic production. Crop rotation and field rotation are important in the development of integrated systems. The following weed control measures are important in the production of organic soybean: proper treatment of crop residues and by-products of primary agricultural production, crop rotation, intercropping, companion cropping, exploitation of allelopathic relations, etc. Crops that contain natural chemical toxins or possess allelopathic properties should be used in the control of weeds, diseases and pests (Malesevic et al., 2008). An important mechanism of weed control in organic production is the competitiveness of organic varieties, i.e., their capacity to suppress weeds (Berenji and Sikora, 2009).

Soybean is sensitive to moisture shortage, especially in the stages of pod forming and grain filling. Irrigation improves growing conditions in dry periods, providing optimal conditions for the growth and development of soybean plants and resulting in high yields of quality grain (Bosnjak, 2008).

The aim of this study was to determine the impact of top dressing on the yields of grain, contents and quality of protein and oil in organic soybean.

Material and Method

The experiment was carried out in the plot Veliki Bodonj, of Institute of Field and Vegetable Crops in Backi Petrovac, in 2011. The experiment with an NS soybean cultivar, maturity group 0, was in the third year of conversion, using organic farming methods, and it was established according to the split plot method with four replications. The experimental unit size was 10 m^2, with the row spacing of 50 cm. The preceding crop was corn. The soybean cultivar Galina was grown in the stand of 500,000 plants/ha. The soil type in the experimental plot was chernozem.

Table 1. Chemical soil properties, Backi Petrovac, 2011.

Depth	Humus %	pH in KCl	pH in H_2O	$CaCO_3$ %	Total N	P_2O_5 mg/100g	K_2O mg/100 g
0-30	2.65	6.85	7.48	3.26	0.204	15.40	21.40
30-60	2.10	7.28	8.41	12.62	0.163	6.70	13.60

Ther chemical analysis of the soil showed that the soil layer of 0-30 cm was slightly alkaline, poorly supplied with humus, medium calcareous, and well supplied with nitrogen, available phosphorus and available potassium. The soil layer of 30-60 cm was moderately alkaline, poorly supplied with humus, very calcareous, medium provided with N and K_2O and low in P_2O_5 (Table 1). Soybean sowing was performed on April 30. Seed inoculation with

Nitragin, a microbiological preparation, was done immediately before sowing. The experiment included two variants:

1 Control variant, without soil conditioner + Nitragin
2 Fertilization variant, with soil conditioner + Nitragin

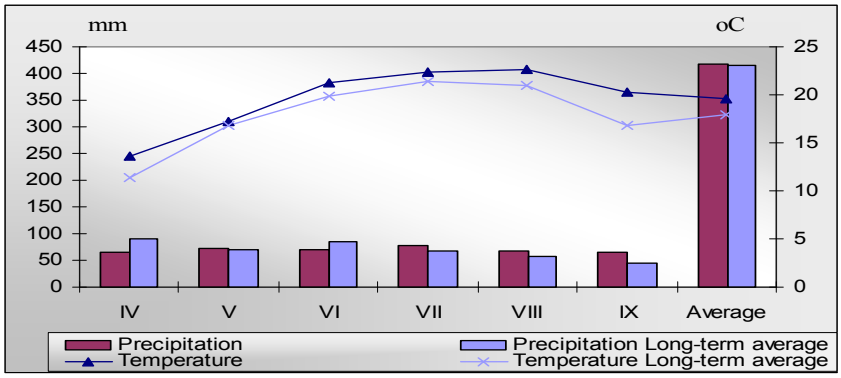
In this study we compared the impact of top dressing on soybean traits in the treated variant against the untreated control. We examined Fertdolomit, a soil conditioner, which was applied in the concentration of 40 kg/ha at the vegetative stage (V1). season Conventional cultural practices for soybean were applied during the growing. Irrigation was applied three times during the growing season (June 4, June 21 and September 16) with 30 liters of water per m^2. Harvest was done by hand. After harvest, samples were measured for moisture content. The yield was calculated per unit area, on 14% moisture basis. Protein and oil contents were determined with Perten DA 7000 spectrophotometer using a non-destructive method.

The analysis of the experimental data was performed by descriptive and analytical statistics using the statistical package STATISTICA 10for Windows. The analysis of variance with one variability factor (top dressing) was presented as the linear model (Maletic, 2005):

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}, \qquad i=1,2,...,k; \quad j=1,2,...,n.$$

Significance of results was estimated by the LSD test for significance levels of 5% and 1%. Relative dependence was determined by the correlation analysis and the obtained coefficients were tested by the t-test for significance levels of 5% and 1%. The results were presented in tables and graphic forms.

Meteorological conditions: During the 2011 growing season, the mean monthly temperature was 19.53°C, 1.65°C higher than long-term average for Backi Petrovac. The rainfall (417.5 mm) was at the level of the long-term average (Graph 1).



Graph 1. Average temperature (°C) and precipitation sum (mm), Backi Petrovac, 2011

Since we cannot predict the environmental conditions suitable for seed production in a region, it is important to monitor the variation of environmental factors and their effects on physiological processes that determine seed quality (Malesevic et al 2010, Popovic, 2010, 2012).

Results and discussion

The main objectives of soybean production are to achieve high and stable yields, through maximum utilization of the genetic yield potentials, and a high quality of grain.

Table 2. Yield of organic soybean (kg/ha), 2011

Variety	Variant	Yield (kg/ha)	Average yield (kg/ha)
Galina	Control	5.604	5.732
	Fertdolomit	5.860	

Indicator	LSD test	Variant
Yield	0.05%	365.956
	0.01%	554.392

The results showed that the top dressed variant had a higher grain yield than the control (5860 kg/ha and 5604 kg/ha, respectively), however, the difference was not statistically significant ($p > 0.05$). The average yields in the top dressed variant were higher by 256 kg/ha or 4.57% compared with the control (Table 2). Top dressing proved to be a feasible method for increasing the grain yield of soybean.

Our results were in agreement with those of Senevirante et al. (2000) who reported that seed inoculation and fertilizer application increased grain yield of soybean.

Soybean grain quality is considerably reduced if there occurs a water deficit during pod formation. Yield reduction is caused by the abortiveness of young pods. If plants are grown in the presence of excess water, the yield is reduced too. In such conditions, the percentage of seed oil increases and the protein content decreases (Norman, 1978).

The obtained results indicated that top dressing did not affect the average protein content in soybean grain. The percentages of proteins were the same in the two variants, while the yield of proteins was higher in the top dressed variant by 99 kg/ha or 4.67% as compared with the control (Table 3).

Table 3. Protein content and protein yield in soybean grain, 2011

Variety	Variant	Protein content (%)	Protein yield (kg/ha)
Galina	Control	37.88	2.122
	Fertdolomit	37.89	2.221

Indikator	LSD test	Variant
Protein content	0.05 %	0.8959
	0.01 %	1.3573
Protein yield	0.05 %	138.926
	0.01 %	210.461

The average oil content was higher in the variants with top dressing by 1%, while the yield of oil was higher by 71 kg/ha or 5.85% compared with the control (Table 4).

Table 4. Oil content and oil yield in soybean grain, 2011

Variety	Variant	Oil content (%)	Oil yield (kg/ha)
Galina	Control	21.74	1215
	Fertdolomit	21.95	1286

Indicator	LSD test	Variant
Oil content	0.05 %	0.6610
	0.01 %	1.0014
Oil yield	0.05 %	114.1992
	0.01 %	173.0021

Studies have shown that the application of fertilizers in an early growth stage (V1) has positive effects on soybean growth and development. Soybean plants need a certain amount of nitrogen during the early stages of growth and establishment of vegetative organs, up to the formation of nodules and the establishment of symbiotic association (Senevirante et al, 2000).

Mutual relationships among the traits

Correlations are important indicators in soybean breeding programs. As soybean is primarily grown for protein and oil contents, the chemical composition in grain is important in breeding programs.

The correlation analysis showed that the variables mutually affected each other. Some effects were statistically significant. There were highly significant positive correlations between grain yield and oil content (r = 0.92 **) and grain yield on one side and protein and oil yields on the other (r = 0.95 **, r = 0.99 **, respectively). Highly significant positive correlations were found between oil content on one side and protein and oil yields on the other (r = 0.87**, r = 0.96**, respectively) and between protein yield and oil yield (r = 0.95**). Negative nonsignificant correlations were found between grain yield and protein content (r = -0.17) and protein content on one side and oil content and yield on the other (r = -0.16) (Table 5).

Table 5. Coefficients of correlation (r) between the tested traits

Trait	Yield	Protein content	Oil content	Protein yield	Oil yield
Yield	-	-0.17^{ns}	0.92**	0.95**	0.99**
Protein content	-	-	-0.16^{ns}	0.14^{ns}	-0.16^{ns}
Oil content	-	-	-	0.87**	0,96**
Protein yield	-	-	-	-	0.95**

^{ns} - nonsignificant; ** - significant at 0.01 level

Highly significant positive correlations between grain yield and oil content and negative correlations between protein and oil contents were reported by Chung et al. (2003) and Popovic et al. (2012b).

Conclusion

Preliminary results showed that the top dressing of organic soybean had positive effects on the studied parameters, the yields of grain, protein and oil. Top dressing proved to be a feasible method for improving the yield and chemical composition of grain of organic soybean. Organic farming integrates different approaches and methods which contribute to healthy living, working and preserving the natural environment, biodiversity and the ability to sell in the market of organic food.

Highly significant positive correlations were found between grain yield on one side and oil content, protein yield and oil yield on the other (r = 0.92**, r = 0.95**, r = 0.99**, respectively), between oil content on one side and protein yield and oil yield on the other (r = 0.87** and r = 0.96**, respectively), and between protein yield and oil yield (r = 0.95**). Nonsignificant negative correlations were found between protein yield and protein content (r = -0.17), and between oil content and protein content (r = -0.16) in soybean grain.

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