

Growing of green beans in open field by application of biofertilizers

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Abstract

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The aim of the study was to determine the influence of biofertilizers on the vegetative growth and productivity of green beans cultivated by the organic method in the region of Thracian Lowlands.

The field trials were conducted during the period from 2015 to 2017 in the experimental field of Vegetable Crops Research Institute “Maritsa” – Plovdiv, on highly leached meadow cinnamon soil after spinach (autumn sowing). Three Bulgarian varieties of green beans: Tangra, Pagane and Evros were tested with two biofertilizers: Emosan and Biosol, under the scheme of growing 80/30 cm.

The differences in the productivity of the tested green beans varieties produced by the organic method have been identified. With the largest vegetative mass are the plants of Evros variety, fertilized with Emosan (177.21 g), followed by the combined application of Biosol + Emosan (176.84 g), where the largest bean is mass and a number of beans per plant. The impact of fertilization with Biosol on vegetative manifestation is less pronounced for these indicators.

The highest yield was obtained from the Evros variety. Under the influence of bioproducts, yields range from 13550.4 kg/ha (fertilization with Biosol) to 14560.5 kg/ha (combined fertilization with Biosol and Emosan), the increase is 15.9% and 24.5%, respectively compared to the control. The average effect of the bioproducts, included in the survey for the Evros and Pagane varieties, is very close – 22.8%. No statistically significant differences were found between the two varieties relative to the total yield indicator. The impact of applied bioproducts is the least pronounced in the Tangra variety.

It was established that the variety has a greater impact on the level of yield compared to fertilization with bioproducts.

Evros and Pagane varieties are suitable for organic growing and they are recommended for use in organic farms.

Keywords: *Phaseolus vulgaris* L.; organic production; biofertilizer; weight of beans; number of beans; yield

Introduction

Organic farming is a production system that combines best environmental practices with the aim of producing safe food, preserving natural resources and obtaining stable yields (Boteva & Cholakov, 2010; Vlahova, 2012; Vlahova, 2013). Special attention and huge financial resources are paid for the organic agriculture throughout the world. In the leading countries of Europe, the USA, Canada and Australia legal, managerial and technological systems of farming and marketing of organic products are operating and constantly improving (Willer &

Lernoud, 2017; 2019). The use of biofertilizers as an alternative to chemical fertilizers increases vegetative growth, yield and fruit quality in vegetable crops (Poudel et al., 2002; Aly, 2002). The effect of organic and chemical fertilizers occurs significantly on the biochemical performance like chlorophyll content, protein and carbohydrate concentration of the crop plant and highlights the prospects and potential of using organic fertilizers (Sharma & Chetani, 2017). Depending on the types of organic fertilizers and biopreparations, the yield of cabbage increased by 15.2–47.2%, cucumber by 17.4–88.7% and tomato by 14.4–47.1% (Aitbayev et al., 2018).

Trade in organic products is topical and one of the most dynamically developing sectors in the EU economy (Yordanova, 2003). Breeding programs are directed to development of hybrid varieties that are more resistant and suitable for organic production (Antonova, 2012; Nacheva et al., 2013; Todorova, 2013).

With the development of organic production, the importance of bean crops is growing up. In Bulgaria, beans are a traditional food for the population and the conditions for growing are favourable in more part of the country. The short vegetation period and production of organic N from the bacteria found in plant roots, defines green beans as economically important vegetable crops used as cover crops and green fertilizers (Nakhone & Tabatabai, 2008). Bean a very good pre-culture in vegetable production (Panayotov, 2000), suitable for incorporation in a system of organic production which enriches the soil with nitrogen, releasing vegetative masses in quantities equal to fertilizing with 30 t/ha.

The yields in organic farming of green beans are lower but the quality of the output is higher (Abubaker et al., 2007). At the same time, green beans improve the nutritional status of the soil. Growing green beans by the organic method is promising. The information in our country on growing green beans by the organic method is not enough (Cholakov et al., 2015).

Material and Methods

The experiment was carried out during the period from 2015 to 2017 year in the field of the Maritsa Vegetable Crops Research Institute – Plovdiv, on a strongly leached cinnamon soil. Three Bulgarian green beans varieties (Evros, Pagan and Tangra) and two biofertilizers (Emosan and Biosol, alone or in combination) were tested. The sowing was made in the period from 4th to 6th of June after a predecessor crop spinach (autumn sowing). The spinach was grown in accordance with the principles of organic production.

Plant protection practices were taken for prevention or with curative intent, with bio insecticides and bio fungicides, certified for use in organic production. Mechanized and manual processes were applied against weeds. The harvests were carried out periodically in the technological maturity of beans.

Characteristic of bioproducts used in this experiment

Biosol (Sandoz GmbH) – A by-product of the production of penicillin, containing fumigant biomass (micelle). Contains: Dry matter – 95.60%; CaO -0.21%; Organic substance – 90.70%; MgO -0.05%; pH (CaCl₂) – 3.0; Cl – 0.04%; S – 1.80%; C: N = 5:1; B – 7.1 mg/kg; N (total) – 6-8%; Zn –

6.0 mg/kg; Phosphates (P₂O₅) – 0.5-1.5%; Fe – 10.1 mg/kg; Potassium (K₂O) – 0.5-1.5. Product is certified for organic production.

Emosan – HemoZymNK (Arkobaleno, Italy) – Organic nitrogen fertilizer with long lasting effects on soil and plants. Contains total nitrogen (N) – 5%; organic nitrogen (N) – 5%; organic carbon (C) – 14%; protein – 34 p/p; humidity – 65 p/p; K – 0.4 p/p; P – 0.06 p/p, etc.; pH -7.0 – 10.0. Product is certified for organic production.

In order to determine the effect of applied organic products on green beans yield formation, the following treatments were included in this study:

Variants

1. Control – no fertilization;
2. Fertilizing with Biosol -1000 kg/ha, applied once, in the time before sowing;
3. Fertilizing with Emosan – 200 L/ha, applied twice: in the time before sowing – 150 L/ha and in phase full blossoming of plants in dose 50 L/ha, by drip irrigation system;
4. Combined fertilization with Biosol – 800 kg/ha + Emosan – 100 L/ha.

The experiment was set by the method of the long parcels in 4 replicates, with a reporting area of 4 m² and a scheme of sowing 80/30 cm.

Highly leached cinnamon soil has a heavy mechanical composition with mineral nitrogen content (NH₄ – N + NO₃ – N) – 2.01 mg/100 g soil (determined by distillation); 18.2 mg P₂O₅ and 17.5 mg K₂O per 100 g soil (determined by Egner River); soil response pH 6.8 in water (potentiometrically defined) with a humus content of 2.2% (by Thurin) (Tomov et al., 1999).

Study Indicators:

1. Biometric Measurements: Five plants were analyzed by replicates:

- Vegetative mass (leaves + stems) per plant (g);
- Weight and number of beans per plant (g);
- Weight of a bean (g).
- Number of beans

2. Yield – Formed by standard beans of all harvests – kg/ha.

3. Statistical data processing – The treatment of the results obtained includes a Two-factor dispersion analysis and a Duncan's Multiple Range Test (Duncan, 1955; Lakin, 1990) comparative analysis performed with SPSS 12 for Windows.

Results and Discussion

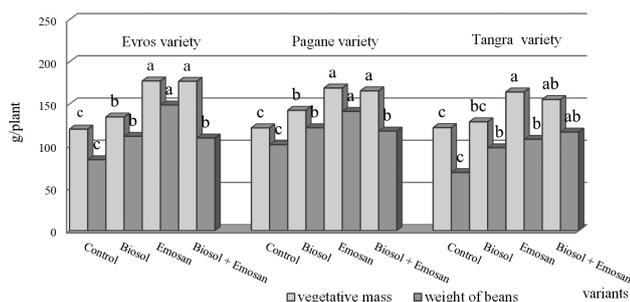
The soil from the experimental field is well stocked with absorbed phosphorus and potassium. In terms of nitrogen

Table 1. Agrochemical soil parameters average over the study period

Soil depth, cm	pH	K ₂ O, mg/ 100g	P ₂ O ₅ , mg/ 100g	NO ₃ -N, mg/kg	NH ₄ -N, mg/kg	Total N, mg/kg
0-20	6.88	27.86	39.30	10.63	9.58	20.21
20-40	7.10	20.72	28.62	20.95	3.16	24.11

content, it is poorly stored. The soil reaction is neutral to slightly alkaline, suitable for growing beans (Table 1).

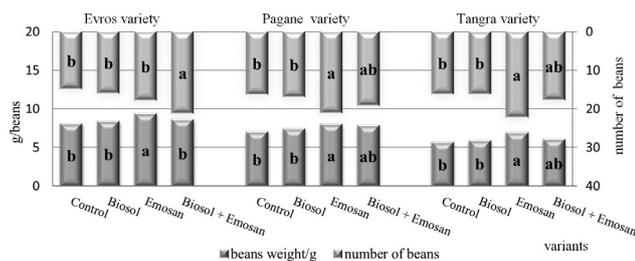
The influence of the used two biofertilizers on the vegetative mass of the plants is more pronounced in fertilizing with Emosan, followed by the combined application of Biosol and Emosan, the differences are small and statistically unproven (Figure 1). The results are one-way for all three varieties. With the largest vegetative mass are the plants of Evros variety, fertilized with Emosan (177.21 g), followed by the combined application of Biosol + Emosan (176.84 g), where the largest bean mass (148.74 g and 109.72 g) and a number of beans per plant (35.75 and 26.92) (Figure 2). The impact of fertilization with Biosol on vegetative manifestations is less pronounced for these indicators.



a, b, c – Duncan’s multiple range test (p < 0.05)

Fig. 1. Effect of organic products on the vegetative mass

The results for the influence of the bioproducts on the vegetative mass (leaves + stems) are similar for the Pagane variety. With regard to the mass of the beans formed on a plant, fertilizing with Emosan significantly exceeds the other variants (Figure 1). The number of the beans in the Pagane variety



a, b – Duncan’s multiple range test (p < 0.05)

Fig. 2. Effects of bioproducts on productivity of plants

ranges from 17.75 to 25.83. The largest number was obtained with fertilizer with the Emosan (25.83 pieces). The lowest results were obtained from the control plants (Figure 2).

The general tendency is also preserved in the Tangra variety, but the influence of the bioproducts is less pronounced. Of biometric measurements it can be seen that the differences between the variants fertilized with Emosan and combined administration of Emosan and Biosol are not great, as more significant are among the varieties.

The regressions show high coefficients of determination, which allows to predict the productivity of green beans under the influence of imported bio fertilizers depending on the vegetative mass formed (in 0.64 – 0.70% of cases) (Figure 3).

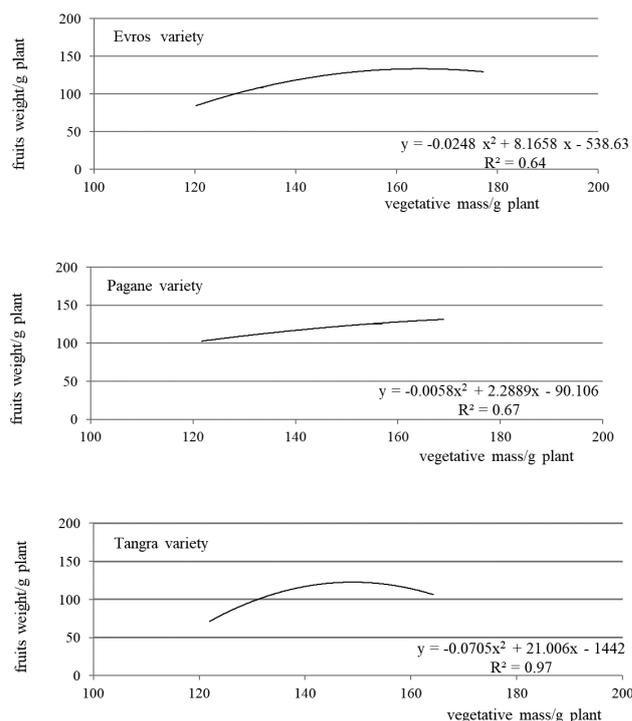


Fig. 3. Dependence between the mass of vegetation and the mass of the beans

The green bean yields of the tested varieties are highest for the Evros variety. Under the influence of bioproducts they range from 13550.4 to 14560.5 kg/ha, with an increase of 22.2% on average compared to the control. The yields obtained were the highest values for fertilizing with Emosan,

followed by the combination of Biosol + Emosan, they increase by 24.5% and 20.3% respectively. The differences between the two variants are statistically unproven (Figure 4).

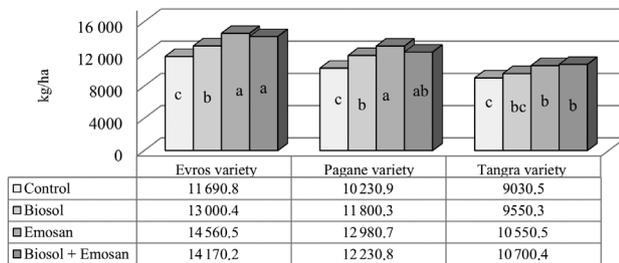


Fig. 4. Effect of bioproducts on the yield

The same trend of results was observed for Pagane variety. Under the influence of bio-products, yields range from 11803 kg/ha (fertilized with Biosol) to 12987 kg/ha (fertilized with Emosan), an increase of 11.6% and 22.9%, respectively in comparison with the control.

The influence of imported bioproducts is the least pronounced in the Tangra variety, where the lowest yields were reported, with an average effect of 13.7% respectively from the control.

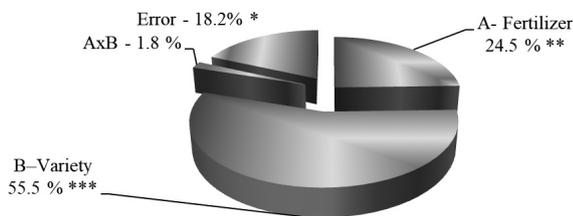


Fig. 5. Degree of influence of fertilization and variety on the yield

The average effect of the bioproducts for the Evros and Pagane varieties, included in the survey is very close – 22.8%. The influence of imported bioproducts is the least pronounced in the Tangra variety, where the lowest yields were reported.

The results of the study show that the variety has a greater impact on the level of yield compared to fertilizing bioproducts (Figure 5).

The comparative analysis found no statistically significant differences between Evros and Pagane variety, relative to the total yield indicator. Values ranged from 9.2% for Biosol variants to 13.6% for plants treated with Biosol and Emosan (Table 2).

Comparing the yields, it was found that Evros variety was with higher productivity to Tangra variety by 22.8% in terms of total yield (Table 3). It was observed increase of yield from Evros variety in comparison with Tangra variety from 24.5% (Biosol + Emosan) to 27.5% (Emosan). The differences found are statistically substantiated, with the strongest evidence of Emosan treated variants (<0.001).

The results of the study show that the Evros and the Pagane varieties are suitable for organic farming and are recommended for growing in organic farms.

Conclusions

The differences in the productivity of the tested green beans varieties produced by the organic method have been identified.

The results are one-way for all three varieties. With the largest vegetative mass are the plants of Evros variety, fertilized with Emosan (177.21 g), followed by the combined application of Biosol + Emosan (176.84 g), where the largest bean mass (148.74 g and 109.72 g) and a number of beans per plant (35.75 and 26.92). The impact of fertilization with Biosol on vegetative manifestation is less pronounced for these indicators.

Table 2. Effect of bioproducts on the yield of Evros and Pagane depending on the variety, kg/ha

Variants	Evros variety	Pagane variety	Difference	Std. Deviation	Std. Error Mean	%	Sig.
Control	11698	10239	1459	125.9	72.7	12.5	n.s.
Biosol	13004	11803	1201	140.1	80.9	9.2	n.s.
Emosan	14565	12987	1578	157.8	91.1	10.8	n.s.
Biosol + Emosan	14172	12238	1934	193.4	11.7	13.6	n.s.

Table 3. Effect of bioproducts on the yield of Evros and Tangra depending on the variety, kg/ha

Variants	Evros variety	Tangra variety	Difference	Std. Deviation	Std. Error Mean	%	Sig.
Control	11698	9035	2663	96.3	55.6	22.8	+
Biosol	13004	9553	3451	85.1	49.1	26.5	+
Emosan	14565	10555	4010	11.0	6.4	27.5	+++
Biosol + Emosan	14172	10704	3468	99.8	57.6	24.5	+

The highest yield was obtained from the Evros variety, when fertilized with Emosan and combined fertilization with Emosan and Biosol. The average effect of the bioproducts for the Evros and Pagane varieties, included in the survey is very close – 22.8%, no statistically significant differences were found between the two varieties relative to the total yield indicator. The influence of imported bioproducts is the least pronounced in the Tangra variety, where the lowest yields were reported.

It was established that the variety has a greater impact on the level of yield compared to fertilization with bioproducts.

It has been found that suitable for organic farming is Evros variety, followed by Pagane variety that are generated in high yields from 17053 to 20574 kg/ha.

The Evros and the Pagane varieties are suitable for organic farming and are recommended for growing in organic farms.

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