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John Naisbitt University, Belgrade
Faculty of Management Zajecar

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6. MEĐUNARODNI SIMPOZIJUM O UPRAVLJANJU PRIRODNIM RESURSIMA

6th INTERNATIONAL SYMPOSIUM ON NATURAL RESOURCES MANAGEMENT

Urednici/Editors
Dragan Mihajlović
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6. MEĐUNARODNI SIMPOZIJUM O UPRAVLJANJU PRIRODNIM RESURSIMA JE FINANSIJSKI PODRŽAN OD MINISTARSTVA PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA REPUBLIKE SRBIJE

6th INTERNATIONAL SYMPOSIUM ON NATURAL RESOURCE MANAGEMENT IS FINANCIALLY SUPPORTED BY THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGICAL DEVELOPMENT OF THE REPUBLIC OF SERBIA

MORPHOLOGICAL BEAN (*Phaseolus vulgaris* L.) CHARACTERISTICS IN ORGANIC BREEDING SYSTEM

MORFOLOŠKE OSOBINE PASULJA (*Phaseolus vulgaris* L.) U ORGANSKOM SISTEMU PROIZVODNJE

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ABSTRACT

The biennial field experiment with beans was set on Faculty of Biofarming in Backa Topola's experimental field on calcareous chernozem in an organic breeding system. Weather conditions in the years of analysis were very different. That has reflected even on the examined morphological characteristics and the bean yield. The statistical processing of data has been done by the split-plot method. The use of microbiological fertilizer and varieties had a significant influence on the examined characteristics, except on the number of lateral branches. A positive correlation between the yield and plant height, number of lateral branches, nodule mass (symbiotic bacteria on the bean's root), number of pods and grain mass has been determined.

KEYWORDS

bean, microbial fertilizer, morphological characteristics, organic production, variety

APSTRAKT

Dvogodišnji eksperiment sa uzgojem pasulja sproveden je na Fakultetu za biofarming na eksperimentalnom polju u Backoj Topoli u krečnoj crnici u okviru organskog sistema proizvodnje. Vremenske prilike u toku godina analize su bile promenljive. Ovo se odrazilo na proučavane morfološke osobine pasulja i njegovog prinosa. Split-plot metoda je koriščćena za statističku obradu podataka. Upotreba mikrobiološkog djubriva i različitih vrsta imali su snačajan uticaj na proučavane osobine izuzev na broj lateralnih grana. Utvrdjeno je postojanje pozitivne korelacije izmedju prinosa i visine biljke, broja lateralnih grana, kvržične mase (simbiozne bakterije na korenu pasulja), broja mahuna i zrna.

KLJUČNE REČI

pasulj, mikrobiološko djubrivo, morfološke osobine, organska proizvodnja, različite vrste

1. INTRODUCTION

Beside wheat, buckwheat, potatoes and cabbage, the most common aliment is bean. It is an annual plant from the pod family. Today, bean production in Serbia is characterised by significant surfaces with low and wavering average yields. Bean is a plant with a long breeding tradition. Once bred as a intercrop in corn production, now on smaller surfaces, in housegardens for personal use, also on bigger surfaces for industrial production, with irrigation and mechanised harvesting methods. It resembles a traditional meal in our country. Bean takes 4,3% of the entire vegetable consumption in Serbia. The global bean consumption is 2,4 kilograms. The consumption in Europe is modest and equivalent to 0,7 kilograms, which is 4,5 kilograms less than in Serbia. The bean consumption in Serbia is recording an increase (Vlahović et al., 2010). Organic agriculture is congruent with the overall concept of sustainable development, because it aspires to ecologically clean, profitable, ethically acceptable and socially righteous agricultural production. The agricultural modernisation led to the disruption of the bond between ecology and agricultural production, since the ecological principles are often ignored or omitted (Webster & Chang, 1997). One of the aspects of negative changes includes diseases of vegetable crops. They are one of the main yield quantity and quality decreasment causes, which expresses the importance of vegetable crop protection. In the battle with plant diseases, agrotechnical and chemical measures are applied. Although chemical measures are broadly applied because of high efficiency and speed of action, their application causes a series of baleful consequences such as environment polution, disruption of microbiological processes in the soil, appearence of baleful microorganisms' resistance to fungicides, and others (Joergensen et al., 2010). Organic agriculture is a sustainable, natural alternative to the intensification of production methods. It uses traditional processing, soil maintaining and pests control methods. Organic production is based on modern scientific comprehension of ecology and agriculture, and it entirely supports and follows technological develpment and mechanisation. Products obtained this way are of high quality, safe for human health, and the mere production contributes to the environment protection. The number of researches that are directed to the finding of an alternative measure use in plant production so that unwanted consequences could be avoided is ever greater. One of the measures is the use of microbiological fertilizers (Cvijanović et al., 2010**)**. Microorganisms that have a defensive and stimulative influence contribute to the intensification of the soil's biologocal activity, and by that to the yield and the morphological characteristics as well. Protection from the soil degradation in agricultural production is still one of the measures in the realm of goals and directives of integral and organic production.

The use of microbiological fertilizers represents the intake of living organisms into the soil with improvement and the supplying of plants with necessary nutrients as a goal. By this, the accessability of nitrogen, phosphorus, iron, sulphur and plant growth stimulators can be increased. The transformation of organic matter is accelerated. With these stimulants, fast and direct decay of plant residues, nitrogen fixation, decrease of carbon dioxide concentration in the soil, release of elements out of hardly accessable into easily accessable forms can be achieved.

Their intake is called biofertilization. They contain microbiologically active matter or preparations that have useful varieties of microorganisms. The active matter inside them is a living organism. Some varieties of microorganisms produce growth stimulators, antibiotics, and by that they stimulate plant growth and protect the plant from pathogens. By using them, neither soil nor atmosphere polution can appear. They are used individually, with mineral fertilizers and applied foliarly as a side dressing.

The goal of the research is to analyze the influence of the variety and microbiological fertilizer EM Aktiv on the morphological bean characteristics and bean yield, as well as the analyzed characteristics' interraction. Thereby conclusions, that can be used as a reccomendation to producers in a broad vegetable praxis, can be obtained, especially in an organic system of breeding.

2. MATERIAL AND METHODS

In the variety trial, two bean varieties received from The Institute of Field and Vegetable Crops Novi Sad were used. The variety Maksa, which has a white seed coat, and the variety Zlatko, which has a gold coloured seed coat. Both of them are of a short, limited growing and have a similar mass of 1000 seeds. Both of them are suitable for mechanised harvesting.

Microbiological fertilizer and effective microorganisms (EM Aktiv) were used. EM Aktiv is a liquid concentrate in which more than 80 varieties of main antibiotic microorganisms that can be found in nature in the soil were bred. The preparation does not contain genetically altered microorganisms, yet it contains a strong congregation of aerobic and anaerobic microorganisms. Both of them, regardless of the different life forms, live in an ambiance in a regime of active food resource exchange, where the products of one group’s metabolism represent the other group’s food, and by that an accumulation of positive characteristics of the united groups occurs.

The experimental field plot was set on the Faculty of Biofarming in Bačka Topola's experimental allotment. A soil analysis was done before sowing. A sampling of the soil was done from the arable layer's depth, 0-30 cm. The plot was set as a two factorial experimental field plot, in four repeatings. The data was statistically processed by the method of a two factorial split-plot experiment, where the big allotments were the varieties and the subplots were microbiological treatments. The central values were tested by LSD test. A correlation dependence between the more important examined characteristics was done. The statistic programmes GenStat (Trivial version) and Statistica 12.0 were used.

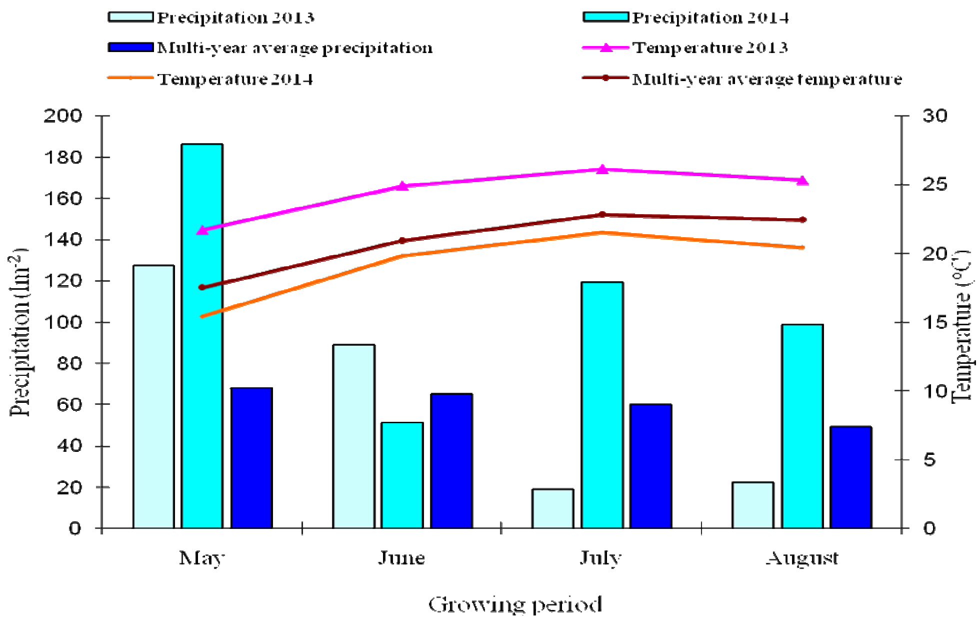
In the experimental plot, before the harvest, allotments were treated in a variant where the soil was treated with mocrobiological fertilizer. The soil was treated with a solution by a dorsal sprayer (340 ml per elementary allotment of 10m², that is 30 lha^{-1} of soulution diluted with water in a mixing ratio of 1:10.), seven days before sowing (a specific elementary plot) and mixed with the microbiological fertilizer by raking. The second treatment represented the use of microbiological fertilizer, that is the use of effective microorganisms (EM Aktiv) by spraying the plants in a phenological phase of 3-4 leaves on the flowering's beginning as well (an amount of 6 lha^{-1} is deluted with water in a mixing ratio of 1:100). That was done with a dorsal sprayer. During the vegetation, standard agronomic practice was applied by the principles of organic production.The sowing of the variety trial was done on 8th May 2013 and on 12th May 2014. Bean was sowed in rows with a inter-row distance of 50 cm, the distance between plants in a row was 4 cm, 4 rows were sowed in every elementary allotmen with a length of 5 m, so that the size of every elementary allotment is equivalent to 10 m^2.

During physiological maturity, 10 plants were taken from every variant for morphological analasys. The plants were taken from the middle rows, omitting the frontal plants. The yield by hectare was calculated on the basis of the elementary alotment yield.

3. RESULTS AND DISCUSSION

3.1. Weather conditions

In 2013 the average monthly air temperatures have significantly deviated from the long-term average. The month Juli (26,1°C) was outstandingly warm. In that period on the area of our plot a tropical climate has appeared (by the end of Juli), which adversely affected the bean (Graph. 1).



Graph 1. Weather Conditions

The sum of precipitation for the vegetation period of May-August 2013 amounted to 257.9 $lm^{-2.}$ In comparison with the long-term precipitation average of 242.8 lm^{-2}, it can be considered arid. The amounts and the distribution of precipitation were not satisfying in Juli and August when bean pods were forming and when the grains were being filled in the bean pods. By the temperature height and drought intensity during the vegetation period, May-August 2013, it can be concluded that this was one of the outstandingly warm and arid years in the last few decades.

The optimum soil temperature for cropping up is 10 - 12°C (Gvozdenović et al., 2007). Considering the values of the 2014 graph, it can be cocluded that the soil temperature during sowing was a few degrees higher (16°C) than optimum. The reason for this is that the sowing was somewhat later than recommended for our agroecologic area. The average temperatures for the vegetation period of May-September were optimum for growth and development. The temperature values in the faze of flowering and fertilization were also optimum.

Although it originates from humid and moderately warm regions, it has huge demands for soil moisture, as well as those for atmosphere humidity (Gvozdenović i sar., 2007; Todorović et al., 2008). In Graph 1 the sum of precipitations for the vegetation period of May-September 2014 is shown and it can be concluded that it is quite bigger than the long-term average (for Bačka it amounts to 325 lm^{-2}). However, for good growth, development and a stisfying yield, 250 – 400 lm^{-2} of precipitations per hectare is needed (Todorović et al., 2008), therefore the amount of precipitations was totally satisfying. The thing that is commonly omitted, yet very important, is the distribution of precipitation. In the first vegetation period, the bean had a substantial amount of moisture, which served the growth and development well. However, common and abundant precipitations in the second and third decade of May led to crust forming (before sowing as well as after cropping up). That affected the forming of a bad canopy, so the number of plants by area unit was smaller than expected. In the faze of flowering and grain filling, the amount of precipitations was also satisfying. For normal maturation and vegetation ending, dry weather is needed (Todorović et al., 2008), which was not the case in 2014. In this period, precipitations were common and abundant. That has negatively affected the bean crop, because a retrovegetation occurrence and an occurrence of bean swelling and germination in the legume have appeared.

3.2. Number of lateral branches

The number of lateral branches is an important morphological characteristic because, if the bean is arborescent with fertile flowers, that is legumes, being produced on lateral branches, it indirectly influences the yield increment. Also, the mentioned characteristic is important for the compensation of a bad canopy that could have happened because of a lot of reasons Depending on the bean variety, the number of lateral branches varies. Beside that, the plant spacing and weather conditions can also influece the number of lateral branches.

Table 1. The number of lateral branches depending on the variety and the use of microbiological fertilizer.

Year	Microbial fertilizer (B)	Variety A		$\bar{x}$ B	Factor	LSD	
		Zlatko	Maksa			1%	5%
2013	Control	5.4	4.1	4.8	A	1.56	0.85
	Treatment soil	4.7	6.0	5.4	B	1.43	1.06
	Treatment in vegetation	4.8	6.0	5.4	AxB	2.02	1.49
	$\bar{x}$ A	5.0	5.4	5.2	BxA	1.94	1.48
2014	Control	6.8	6.7	6.7	A	1.95	1.06
	Treatment soil	4.7	4.3	4.5	B	1.51	1.12
	Treatment in vegetation	6.9	4.5	5.7	AxB	2.14	1.58
	$\bar{x}$ A	6.1	5.2	5.6	BxA	2.12	1.57
Average 2013-2014				5.4			

The average number of lateral branches per plant in this research amounted to 5.4 (Tab. 1.).The variety Maksa had the smallest number of lateral branches recorded in 2013 (4.1) and the variety Zlatko had the biggest (in a control variant).

Differences between the varieties were not on a level of statistical significance. Observing factor B (use of microbiological fertilizer) in 2013 there were no significant differences, but in 2014, during the control (6.7), a significantly higher number of lateral branches compared to the microbiological fertilizer soil treatment variant was computed (4.5).

The AxB interaction is significant in both examined years, except for the variety Zlatko in 2013. The BxA interaction was significant only for the treatment in vegetation, where the Variety Zlatko (6.9) in 2014 produced a significantly larger number of lateral branches compared to the variety Maksa (4.5). For specific plant species, such as soybean, it was established by Dozet (2006), Dozet and Crnobarac (2007) that, because of the row spacing change, the number of lateral branches was being increased. The use of microbiological fertilizer has an affect on the increase of plant density, and by that on the increase of lateral branches as well, which reflects positively on the yield.

3.3. Plant height

One of the basic bean characteristics is it's height. By height, bean varieties can be: low (dwarf bean), medium high and heigh varieties. The plant height often varies and depends on climate conditions and mostly represents a varietal bean characteristic (Todorović et al., 2008). Also, for many varieties it depends on the fertilizationand of the vegetational space's shape as well (Dozet et al., 2007; Dozet, 2009).

The average plant height in both years amounted to 49.7 cm, concidering that in 2013 it amounted to 53.9 cm, and in 2015 it amounted to 45.4 cm (Tab. 2). Observing the variety's influence on the plant height, no regularity was assessed. In 2013 a significantly bigger ($p<0.05$) height of variety Zlatko (55.8 cm) was measured in comparison with the variety Maksa (52.0 cm). In 2014 the variety Maksa (47.7 cm) had a significantly ($p<0.01$) bigger plant height in comparison with the variety Zlatko. That implicates that specific weather conditions in the production year have a huge influence on the examined characteristic, as well as the interaction of the genotypes with weather conditions. A significant difference in plant height between the varieties in an organic breeding system was assessed by Petrović (2015).

Table 2. Plant hught depending on the sort and the use of microbiological fertilizer (cm).

Year	Microbial fertilizer (B)	Variety A		$\bar{x}$ B	Factor	LSD	
		Zlatko	Maksa			1%	5%
2013	Control	54.7	46.5	50.6	A	4.71	2.56
	Treatment soil	55.4	53.4	54.4	B	2.89	2.13
	Treatment in vegetation	57.4	56.0	56.7	AxB	4.09	3.02
	$\bar{x}$ A	55.8	52.0	53.9	BxA	4.35	3.19
2014	Control	42.0	47.6	44.8	A	4.09	2.23
	Treatment soil	42.1	47.8	44.9	B	5.76	4.25
	Treatment in vegetation	45.2	47.7	46.4	AxB	8.15	6.01
	$\bar{x}$ A	43.1	47.7	45.4	BxA	7.48	5.54
Average 2013-2014				49.7			

The biggest plant height, in both years of research, was achieved in the microbiological fertilizer treatment during vegetation (56.7 cm and 46.4 cm), concidering that in 2013 it was on the level of high statistical significance in comparison with the control variant (50.6 cm), which was 12.6% more. Similar results of a positive influence of applied microbiological fertilizer on the plant height in a research with bean, corn and soybean are presented by Milić et al. (2003).

The AxB interaction in 2013 at variety Zlatko was not significant, while at variety Maksa it was of high significance with applied treatments (53.4 and 56.0 cm), compared to the control (46.5 cmThe BxA interaction was also selectively significant.

3.4. Plant height to the first pod

The plant height to first pod is more significant from the aspect of intensive bean breeding on large surfaces, where mechanised harvesting is done. Beside the height, it is important that the pod does not burst and perform grain abscission while harvesting.. On the other side, when bean is bred on smaller surfaces, it is better that it forms pods on a smaller height, because it is supposed by that that there will be more pods, and by that a bigger yield.

The average plant height until the first fertile pod amounted to 16.7 cm. In 2013 it amounted to 18.0 cm, and in 2014 to 15.4 cm (Tab.3). In both of the examined years, the variety Zlatko had the first fertile pod set higher in comparison with the variety Maksa. However, only in 2013 it was highly significantly higher ($p<0.01$). That is not congruent with researches Petrović (2015).

Tabele 3. The plant's height until the first pod depending on the variety and the use of microbiological fertilizer (cm).

Year	Microbial fertilizer (B)	Variety A		x̄ B	Factor	LSD	
		Zlatko	Maksa			1%	5%
2013	Control	18.1	14.8	16.5	A	2.69	1.47
	Treatment soil	21.6	14.4	18.0	B	3.02	2.23
	Treatment in vegetation	23.8	15.5	19.7	AxB	4.27	3.15
	x̄ A	21.2	14.9	18.0	BxA	3.99	2.96
2014	Control	14.7	13.9	14.3	A	3.29	1.79
	Treatment soil	16.5	16.2	16.4	B	2.68	1.98
	Treatment in vegetation	16.5	14.8	15.6	AxB	3.79	2.80
	x̄ A	15.9	15.0	15.4	BxA	3.72	2.75
Average 2013-2014				16.7			

In both of the examined years, the smallest plant height until the first fertile pod was measured in control (16.5 and 14.3 cm). The measured difference was not enough for it to be statistically significant as well.

The AxB interaction was not significant, except in 2013 at variety Zlatko, where a statistically and significantly smaller plant height until the first fertile pod in control (18.1 cm) was measured in comparison with the applied treatments of microbiological fertilizer (21.6 23.8 cm). The BxA interaction was significant in the first year of examination. Dozet (2006, 2009) in her soybean researches cites that weather conditions in the years of examination had the greatest influence on the examined characteristic. By author Kelli et al (1998), the height on which the first pod is formed is not supposed to be lower than 15 cm, it also should not burst and perform grain abscission while harvesting.

3.5. Yield

In every agricultural production, achieving a high and stable yield of satisfying quality is a priority. That is why the most important characteristic of every variety is it's production potential, that is the grain yield by area unit.

The average yield is 3335 $kgha^{-1}$, concerning that in 2013 it was 6647, and in 2014 it was 2223 $kgha^{-1}$ (Tab. 4).

Table 4. The yield depending on the variety and the use of microbiological fertilizer (kg/ha)

Year	Microbial fertilizer (B)	Variety A		x̄ B	Factor	LSD	
		Zlatko	Maksa			1%	5%
2013	Control	4050	5967	5009	A	151	82
	Treatment soil	3917	9000	6459	B	151	112
	Treatment in vegetation	4250	11500	7875	AxB	214	158
	x̄ A	4072	8822	6447	BxA	203	150
2014	Control	2014	2730	2372	A	784	427
	Treatment soil	2024	2330	2177	B	594	439
	Treatment in vegetation	1725	2514	2119	AxB	841	620
	x̄ A	1921	2525	2223	BxA	838	619
Average 2013-2014				3335			

In both of the examined years the variety Maksa achieved a higher yield in comparison with the variety Zlatko. In 2013 that was statistically highly significant, and in 2014 it was only significant. The average bean yield on our agroecological area is low and varies between 1000 and kgha^{-1}. In our field plot research, the average yield amounted to 3335 kgha^{-1}, which is conciderably higher, compared to the average bean yields in the Republic of Serbia. New-made bean varieties have a yield potential of 3000-4000 kgha^{-1}. With our results, we can say that the genotypes do influence the yield. Similar results were obtained by Vasić (2007).

Tabela 5. Correlation between some examined characteristics.

Characteristics	PH	NLB	NM	NP	NG	GM	M1000	Y
PH	1.00							
NLB	-0.08	1.00						
NM	1.00	0.00	1.00					
NG	0.26	0.98	-0.18	0.45	1.00			
GM	0.95	0.24	0.97	0.92	0.06	1.00		
PM	0.82	0.50	0.87	0.99	0.34	0.96		
M1000	1.00	-1.00	0.00	-0.60	-0.98**	-0.24	1.00	
YIElD	0.76**	0.58*	0.81**	1.00**	0.43	0.93**	0.50*	1.00

*p<0.05; **p<0.01

In 2013 all differences between variants of the second examined factor (B) were statistically very significant ($p<0.01$), while in 2014 no statistically significant differences were recorded.

The AxB treatment was more significant in 2013, because at both vrieties, by a treatment with microbiological fertilizer during vegetation, a highly significantly higher yield was achieved compared to the microbiological fertilizer soil treatment and to the control. The BxA interaction was significant.

A correlational dependence between specific characteristics was calculated (Tab.5). On the basis of the obtained results, a positive correlation between the yield and the plant height (PH), the number of lateral branches (NLB), the nodule mass (NM) (symbiotic bacteria on the bean's root), the number of pods (NP) and the grain mass (GM) was established. Also, a negative correlation between the number of grains (NG) and the absolute grain mass (M1000) was recorded, which aims the conclusion that, the bigger the number of grains, the smaller the size, as well as the mass of 1000 grains.

4. CONCLUSION

Weather conditions during the years of examination were very different. That has reflected on the examined morphological characteristics and the bean yield. Both of the examined factors (varieties) and the use of microbiological fertilizer significantly influenced the examined factors, but not the number of lateral branches A positive correlation between the yield and the plant height, the number of lateral branches, the nodule mass (symbiotic bacteria on the bean's root), the number of pods and the grain mass was established.

A recommendation to producers, especially to those with an organic bean breeding technology, is to pay special attention to the variety election and to apply the suggested organic agrotechnique shown in this research by realizing the agroecological area of production.

Products, bean in this case, obtained by new, alternative breeding technologies are safe for human health. Ecological production contributes to the protection of the environment, and by that it is being based on the the modern scientific comprehension of ecology and agriculture.

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