

# PROTEIN CONTENT IN BEAN GRAIN GROWN ACCORDING TO SUSTAINABLE ECOLOGICAL PRINCIPLES

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## Abstract

*The research has been conducted during a three-year period in order to determine the protein content in bean grains grown by organic principles and to choose more suitable variety for farming in organic production. The field experiment was set by a split-plot design in 4 repetitions on calcareous chernozem. The large plots were cropped with varieties Maksa and Zlatko, while control subplot was treated by agro-technical treatments permitted in organic production. In the research, the starting hypothesis was that the protein content in bean grains will depend on variety and applied agro-technics in organic bean growing technology. The protein content in bean grain was statistically significantly dependent on agro-ecological conditions during the production year, variety and applied agro-technics. For the production of bean by organic principles, Maksa variety is recommended. It is possible to achieve high protein content in beans grown in accordance with the principles of sustainable ecological development.*

**Key words:** sustainable ecological development, beans, protein content.

## Introduction

Beans occupy an important place in the diet of our population, as a protein plant, but also in agricultural production, as an economically viable plant species and

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a good pre-crop. Due to its adaptability, it can be successfully grown in different agro-ecological conditions. It is one of the vegetables with the richest nutrients, primarily due to its high protein content.

Using the principles of organic agriculture, they combine the traditional way of production with the use of scientific innovations, all with the aim of promoting correct relations and a good quality of life within the environment. It is very important to choose the right variety that will be grown according to ecological principles (Vasić, 2016).

Modern agriculture is returning to organic agro-technical methods and the application of organic fertilizers. Guanito is a fertilizer based on bat droppings and part of seabirds. Contains all the macro and micro elements required by plants in their natural form. Declared organic fertilizers include Guanito, which contains 13% nitrogen, 8% phosphorus, 2% potassium and 11 trace minerals (Lazić and Šikoparija, 2011). It is an extraordinary organic fertilizer that has a beneficial effect on the positive balance of nutrients in the soil. It exhibits fungicidal and nematicidal properties (Shrinidhi et al., 2013).

Guanito faster mineralized itself, and plants get quickly available biogenic elements necessary to achieve planned and economically viable yields. Replacement of nitrogen from mineral fertilizers with organic and biological nitrogen has an ecological effect and has a positive effect on the physical properties of the soil.

Liquid preparation with effective microorganisms (EM aktiv) is applied before sowing for soil treatment and foliar. It promotes seed germination, lush roots, flowers and fruits and improves soil fertility (Szymanski et al., 2003). The tendency is to introduce into production varieties that are tolerant to diseases and pests, especially in the organic system of cultivation.

The implementation and maintenance of all the principles of organic cultivation technology implies the use of fertilizers for plant nutrition that are allowed in organic plant production. There are microorganisms that have a defensive role, but also a stimulating effect on plants. One of those organisms are fungi of genus *Trichoderma* spp. This fungi performs possitive effect on growth, development of plants, but also manifest preventive protection in case of pathogens attack (Harman et al., 2004).

Based on this research, we try to make a harmonized agricultural technique, especially in the organic system of cultivation. According to ressearch we can give a recommendation to target group of producers, in order to contribute to

increasing the area under beans in the Republic of Serbia, as well as achieving stable yields with satisfying quality.

The aim of performed research is possibility to determine which variety is more adaptable to the conditions of organic sustainable production and which applied agrotechnics is better, but also the interaction between the examined factors that are determined on the protein content in bean grain. Also, the influence of weather conditions (years), different varieties and applied treatments on the organic pelleted fertilizer Guanita, *Trichoderma atroviride* (Tffi) and the microbiological preparation EM aktiv on the protein content in bean grain was observed.

### Materials and Methods

Two beans varieties created on the Institute of Field and Vegetable Crops in Novi Sad, has been used as material in the field experiment. Used variety in experiment are variety's Maksa and Zlatko and both are of determinable growth. Organic pelleted fertilizer (Guanito) was used with the formulation of nutritive elements  $N:P:K = 6:15:3 + 10Ca + 2Mg$ . Effective microorganisms (EM-aktiv) and *Trichoderma atroviride* (preparation Tiffi) were applied. EM-aktiv is a liquid concentrate that holds main antibiotic organisms which can be found naturally in soil (more than 80 strains). The preparation contains firm body of aerobic and anaerobic microorganisms, without any traces of genetically modified microorganisms. *Trichoderma atroviride* represents an integral part of the commercial bio preparation Tiffi which serves to control pathogenic fungi.

The field experiment in dry vegetable farming was set on calcareous chernozem in the period of 2014-2016 in Bajša, municipality of Bačka Topola, by split-plot design in four repetitions. The preceding crop was onion. The first factor of examination was the year of research, the second (large plots) were varieties (Zlatko and Maksa), and the third factor (subplots) was fertilization with 5 treatments: 1 – control, 2 – treatment of soil using the EM-aktiv (7 days prior to sowing), 3 – treatment of soil using the *Trichoderma atroviride* (Tiffi) (7 days prior to sowing), 4 – treatment of soil with pelleted organic fertilizer Guanito + EM-aktiv (7 days prior to sowing) during the bean's blossoming and 5 – treatment of bean seeds immediately before sowing with *Trichoderma atroviride* (Tiffi).

After soil treatment by raking were fertilizer and preparations inserted into the sowing layer depth. Bean was manually sown in four five-meter-long rows. The first and the fourth row were used for isolation, and the two middle rows were used for sample collection of plants for further analysis. The size of the elementary plot was 10 m<sup>2</sup>.

In their physiological maturity, the plants from the middle rows were cut underneath the cotyledonal scar with vineyard scissors, carefully tied in bundles and the grains were manually detached from pods for determining the yield. A mass of 100 g was submitted to the Institute of Field and Vegetable Crops to determine the protein content of beans. The results were processed in Statistica 12 for the split-plot experiment design, by using the variance analysis, until the average values were tested using t - test with significance level of 5% and 1%.

### Weather conditions

Temperature and precipitation data were obtained from the valid meteorological station of the Agricultural Administrative and Professional Service Bačka Topola from Bačka Topola.

Temperatures for the bean's vegetation period have deviated from the perennial average – more than 1°C in the year 2015 and 0.8°C in in the year 2016, but in the year 2014, the temperature was below average for the same period when compared with the perennial average. Precipitation in 2014 was highest during the bean's vegetation period and it amounted to 371.2 mm, which was higher when compared with other examined years and the perennial average.

When compared with 2015, it was 208.3% higher, and when compared with 2016 it was 99.6% higher, while when compared with the perennial average it was 48.5% higher (Tab.1). On that basis, it was concluded that the year 2014 was the most favorable among the three examined years for bean growing without irrigation.

**Table 1.** Weather conditions during the vegetation period of bean

Precipitation/Temperature	Vegetation period				
	May	June	July	August	Sum/ Average
Precipitation 2014	168.0	48.0	88.2	67.0	371.2
Precipitation 2015	18.4	20.4	15.0	66.6	120.4
Precipitation 2016	31.2	66.4	26.6	61.8	186.0
Perennial precipitation average (1962-2016)	65.4	69.4	61.6	53.6	250.0
Temperature 2014	15.6	20.0	21.9	20.7	19.6
Temperature 2015	17.4	20.6	24.1	23.8	21.5
Temperature 2016	17.1	22.2	23.9	21.7	21.2
Perennial temperature average (1962-2016)	17.2	20.5	22.2	21.6	20.4

Source: Meteorological yearbook - climatological data (2014-2016); Republic Hydrometeorological Service of Serbia; \*- expressed in mm; \*\*- expressed in °C

## Research results with discussion

The average protein content in the research period 2014-2016 was 20.56% (Tab. 2), with the highest recorded protein content being 23.56% in 2014 for the variety Maksa in variant 5, and the lowest 17.03% in 2015 for varieties Zlatko in the control variant.

The highest protein content was in 2014 (22.47%), and the lowest in 2015 (18.79%), while in 2016 it was 20.42%. All differences in protein content measured in bean grain in the years of research were at the level of high ( $p < 0.01$ ) statistical significance (Tab. 2). In the examined varieties, there were differences in the protein content in the bean grain. The Maksa variety had a significantly higher protein content (21.05%) compared to the Zlatko variety (20.07%). That was 4.88% more.

In the control variant, a lower protein content was measured (19.37%), which was statistically very significant ( $p < 0.01$ ) compared to other variants used (20.95%, 20.84%, 20.56%), 21.08%), while between the applied variants from 2 to 5 there were no statistically significant differences in the mentioned measurement property.

The BxC interaction was significant, insofar as in both tested cultivars the lowest protein content was in the control, and the highest in variant 5.

The CxB interaction was significant only in the control variant, because the Zlatko cultivar had a significantly lower protein content compared to the Maksa cultivar.

**Table 2.** Influence of research factors on grain protein content (%)

Year (A)	Variety (B)	Fertilization (C)					$\bar{x}_{AB}$	$\bar{x}_A$
		1	2	3	4	5		
2014	Zlatko	20.37	22.42	22.47	21.89	22.51	21.93	22.47
	Maksa	21.97	23.38	23.08	23.03	23.56	23.00	
	$\bar{x}_{AC}$	21.17	22.90	22.78	22.46	23.03		
2015	Zlatko	17.03	18.75	18.79	18.31	18.82	18.34	18.79
	Maksa	18.37	19.55	19.31	19.26	19.70	19.24	
	$\bar{x}_{AC}$	17.70	19.15	19.05	18.79	19.26		
2016	Zlatko	18.52	20.38	20.43	19.90	20.46	19.94	20.42
	Maksa	19.97	21.25	20.99	20.94	21.42	20.91	
	$\bar{x}_{AC}$	19.24	20.82	20.71	20.42	20.94	$\bar{x}_B$	
$\bar{x}_{BC}$	Zlatko	18.64	20.52	20.56	20.03	20.60	20.07	
	Maksa	20.10	21.39	21.12	21.08	21.56	21.05	

Year (A)	Variety (B)	Fertilization (C)					$\bar{x}A$
		1	2	3	4	5	
	$\bar{x}C$	19.37	20.95	20.84	20.56	21.08	
Average 2014 -2016							20.56
LSD		Faktor					
A		B	C	AxB	AxC	BxC	AxBxC
p<0.05		0.09	0.57	0.66	0.69	1.02	1.54
p<0.01		0.15	0.86	0.88	1.04	1.36	2.06

Source: Current research results

The protein content is influenced by the weather conditions that characterized the production year for beans, the choice of variety, but also the application of specific agricultural techniques (certain treatments) before sowing and during the growing season. Similar results state Dozet (2006, 2009), Cvijanović et.al. (2016), Dozet et al. (2020). In 2014, when there was the most precipitation and when the highest yield per hectare was, then the highest protein content in bean grain was measured, by 11.86%, respectively 10.04%, compared to 2015 and 2016. Differences between cultivars existed, which indicates that the property of protein content is also defined by genetic influence. Such results in the examination of protein content in soy are reported by Dozet (2009). According, in a three-year study, the protein content was higher in the grain of the Maksa variety, which also had a higher yield compared to the Zlatko variety. In their research in Argentina, Sammán et al. (1999) have come to similar results, and found differences in the protein content between different varieties of beans in the interval from 18 to 22%. Different protein content between cultivars was also found in soybeans by Đukić et al. (2018). Similar results in a study of 106 wild and 99 primitive varieties of beans are reported by Gepts et al. (1986). The positive impact of microbiological preparations in their research is stated by Dozet et al. (2015, 2016).

## Conclusions

Based on the examination of the influence of the year of the variety, organic fertilizer and microbiological preparations on the protein content in beans (*Phaseolus vulgaris* L.) grown according to ecological principles, the following can be concluded:

- The protein content was very significantly influenced by the examined factors, years, variety and application of Guanite, EM aktiv and Trichoderma.

- The interactions that were significant were BxC and CxB, while the others were not statistically significant.
- The average protein content in the research period 2014-2015 was 20.56%, with the highest recorded protein content being 23.56% and the lowest 17.03%. The highest protein content was in 2014 (22.47%) and the lowest in 2015 (18.79%).
- All differences between the years were at a level of high statistical significance. - In the control and the other 4 variants, there were very significant differences between the examined varieties with the correct trend, because in all variants the Maksa variety achieved higher protein content in the grain compared to the Zlatko variety.

Modern agriculture is returning to organic agrotechnical methods and the application of organic fertilizers, which includes Guanito fertilizer.

To determine the most optimal period for production, it is necessary to use the findings on the impact of climate change on the behavior of cultivated plants in the initial stages of growth, as well as on the quality of the obtained grain. In that way, it will be possible to adapt to the new conditions, as well as production in the months with the smallest moisture deficit.

For the determination of efficient agricultural system is crucial to understanding the agroecosystem. The future in the production of healthy food lies in the application of agronomic and environmental performance, while preserving water and the environment, as well as protecting the environment.

The key for determined most efficient farming systems lies in understanding how agroecosystems works. For the future production of healthy food it is necessary to perform ecological principles and that is produced according to ecological principles and unequivocally affects the protection of water, the environment, as well as the environment and humanity. It is possible to achieve high protein content in beans grown according to the principles of sustainable ecological development.

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