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YIELD AND CHEMICAL COMPOSITION OF CAULIFLOWER (*BRASSICA OLERACEA* L.VAR. *BOTRYTIS*) CULTIVATED USING MICROBIOLOGICAL FERTILIZER

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Abstract

As a result of the intensive tillage, application of various agrotechnical measures, the use of large amounts of fertilizers and pesticides, during the production of horticultural crops with relatively high yields, including the cauliflower, disrupts natural processes in the soil. The microbiological activity and fertility of the soil can be improved by using pure cultures of the microorganisms used for the production of microbiological fertilizers – bio -fertilizers, that create or improve conditions for microbiological activity in the rhizosphere, without disrupting the natural processes in the environments. This research was aimed at determining the impact of microbiological fertilizer Slavol, applied in two ways, foliar with dorsal sprinkler and through the drip irrigation system, on the yield and chemical composition (water, dry matter, fiber, protein and calcium) of cauliflower produced outdoors during 2011, 2012 and 2013. The results of this study showed that the application of Slavol significantly affected the yield of the cauliflower, especially when applying through the drip irrigation system. Chemical analyzes showed increased content of water, fiber, protein and calcium in the curds of the cauliflower treated with the microbiological fertilizer.

Keywords: *cauliflower, microbiological fertilizer, yield, chemical composition*

Introduction

Cauliflower is one of the popular winter season vegetable grown throughout the world. The edible curd is a rich source of protein, minerals and vitamins which protects human from certain cancers and heart diseases (Keck, 2004).

Intensification of the vegetable production in order to achieve high yield at the expense of the quality of the vegetables and environmental conditions, impose new trends in the agricultural production. These trends are including limitation of the application of fertilizers and pesticides whose uncontrolled use affects the microbiological and physical-chemical properties of the soil (Najdenovska and Ćolo, 2012) and their replacement with microbial fertilizers, which because of the ability of microorganisms to provide necessary food for plants, occupy a significant place in the vegetable production.

Soil is an essential precondition for the crop production and it is favorable environment for the development of various biochemical and microbiological processes. The soil contains a number of different groups of bacteria. Their number and activity in the soil is an important indicator for the fertility, for the growth and development of the plants, for the degradation of some inorganic substances and more. Their representation is conditioned by: climate characteristics, soil type, water-air regime, temperature, mechanical composition, the presence of organic matter, and more.

Knowing the role and the flow of the microbiological processes in the soil can be directed towards increasing the intensity of microbial activity and soil fertility, using the effective strains of azotobacter and phosphorus soluble bacteria that can replace or reduce the use of mineral fertilizers. The effect of use of bio-inoculants in cauliflower and its agronomic efficiency is not well known (Sharma et al., 2009). Further, the integrated use of different organic materials not only increase the nutrient status of agricultural soil but also help to improve various physical, chemical and biological properties of soil leading to improved soil fertility and also to increased fertilizer use efficiency (Dick and Greegorich, 2004).

The positive impact of the microbiological fertilizers is visible in the early stages of plant development through the improved process of germination, growth, increased activity of roots and activity of photosynthesis, improved plant nutrition with nitrogen, phosphorus, potassium and trace elements, increased yield for 10 to 25%, increased microbial biomass in the soil, improved water-air regime and reduced or eliminated negative impact of pesticides and mineral fertilizers. According to Bashyal L.N. (2011), biofertilizers increased the efficiency of nitrogen fertilizer, and subsequently increases the yield and quality of cauliflower.

The main objective of this research was aimed at determining the impact of microbiological fertilizer Slavol, applied in two ways, foliar with dorsal sprinkler and through the drip irrigation system, on the yield and chemical composition (water, dry matter, fiber, protein and calcium) of cauliflower produced outdoors during 2011, 2012 and 2013.

Material and method

The experiment was set near Skopje (Capital of Macedonia), in the village of Jurumleri, with coordinates 41°58'20,84" north and 21°33'24,44" east,276 m above sea level, on alluvium soil type, during the seasons in 2011, 2012 and 2013.

As research material was used cauliflower (*Brassica oleracea* L. var. *botrytis*), hybrid Barcelona F1.

The cauliflower was cultivated from seedlings produced in cold beds, transplanted on open field.

During 2011 and 2012, the sowing of the cauliflower was performed on May 20^{th}, while in 2013 sowing was on May 25^{th}. The germination of 50% of the seeds was observed for 5 to 7 days after sowing.

The transplantation of the seedlings was on open field in experimental plots with size of 3,2 m^2, distributed according to a random block system (method of Fisher) in three variants, with four repetitions. The seedlings ware planted at a distance of 0,5 m in the row, and 0,8 m between the rows, which means that in each experimental plot has 8 plants.

The variants ware set according to the time and way of treatment with the microbiological fertilizer Slavol, which is a combination of 6 bacteria: *Azotobacter chrococcum* (10^8 cfu/mL), *Azotobacter vinelandii* (10^8 cfu/mL), *Derxia sp.* (10^8 cfu/mL), *Bacillus licheniformis* (10^9 cfu/mL), *Bacillus suptilis* (10^9 cfu/mL) and *Bacillus megaterium* (10^9 cfu/mL). It also contains natural vitamins, enzymes and biostimulants.

The variants were set in the following order:

1. Ø control - without application of microbial fertilizer;
2. Variant 1 (V-1) - treatment of the seedlings by dipping in a solution of 5 L of water and 50 mL Slavol for 5 minutes and treatment of the plants during the vegetation through the leaves with dorsal sprinkler every seven days with a solution of 2 mL Slavol dissolved in 2 L of water, and
3. Variant 2 (V-2) - treatment of seedlings by dipping in a solution of 5 L of water and 50 mL Slavol for 5 minutes and then treatment of the plants during the vegetation through the drip irrigation system with a solution of 150 mL Slavol, dissolved in 150 L of water, with floodplain rate of drop per rate of 2 L per hour, every two days.

The time of the treatment with dorsal sprinkler in the three years of research is given in Table 1, while treatment by drip irrigation system is given in Table 2.

Table 1. Time of treatment with dorsal sprinkler by year

Year of research	July			August					September			
2011	19	26		2	9	16	23		6	13		
2012	21	28		4	11	18	25		1	8	15	22
2013	20	27		3	10	17	24	31	7	14	21	

Table 2. Time of treatment by drip irrigation system

Year of research	July				August					September				
2011					2	4	6	8	10	1	3	5	7	9
	25	27	29	31	12	14	16	18	20	11	13	15	17	
					22	24	26	28	30					
2012	18	20	22	24	1	3	5	7	9	2	4	6	8	10
	26	28	30		11	13	15	17	19	12	14			
					21	23	25	27	29					
					31									
2013	21	23	25	27	2	4	6	8	10	1	3	5	7	9
	29	31			12	14	16	18	20	11	13	15	17	
					22	24	26	28	30					

After harvesting the curds of the cauliflower was measured the weight of each curd by using a scale, while the total yield per hectare was calculated by multiplying the average yield of the plant with the number of plants per hectare (25 000 plants).

The analysis for the chemical composition of the curds are made by the following methods:

- Total content of water and dry matter in the curds is determined by drying the fresh plant material at a temperature of 105°C to constant weight (Sarić, 1990);
- Proteins are determined by the method of Kjeldahl (Sarić, 1990);
- The content of fiber is determined gravimetric;
- The total protein content is determined accrual % of total nitrogen x 6.25 (Jekic, 1988);
- Calcium is determined by atomic absorption spectrophotometry (Sarić, 1990).

Statistical analysis were made with a computer program SPSS, v19.0.

Results and discussion

Harvesting cauliflower can be done by uprooting the whole plant, then cut the leaf stalks, outer leaves are cut at the base, leaving 3 to 5 leaves for protection of the curd. Harvesting is successive, and the yield ranges from 20 to 50 t/ha (Đurovka, 2008). The average yield in the three years of testing in our research showed highly statistically significant differences between all variants. The average yield of the curds of the cauliflower in the three years of testing ranged from 34 161,46kg/ha for the control, 40 824,22 kg/ha for V-1 and the B-2 average yield was 46 548 18 kg / ha.

Table 3. Average values and standard error for the average yield in cauliflower in kg/ha

Variants	Mean	Standard deviation	Error of the mean (± SE)
Control	34 161,46	5920,83	604,29
V-1	40 824,22	5961,40	608,43
V-2	46 548,18	9195,66	938,53

Analysis of the values for the yield of the cauliflower per hectare between the variants made by the method of analysis of variance showed highly statistically significant differences ($p < 0.01$) between all of the factors of variation.

Table 4. Results of the analysis of variance for the average yield in cauliflower with different ways of applying the microbiological fertilizer

Source of variation	Sum of squares (SS)	Degrees of freedom (df)	Mean square (MS)	F	Sig.
Between groups	7 378 780 056,424	2	3 689 390 028,212	71,336	0,000***
Within groups	14 739 714518,229	285	51 718 296,555		
Total	22 118 494574,653	287			

Table 5. LSD - test for the average yield in cauliflower

Dependent variable			Difference between means	Standard error	Sig.	Confidence interval 95%	
						Lower bound	Upper bound
Yield	Control	V-1	-6662,76*	1038,01	0.000	-8705,90	- 4619,62
		V-2	-12386,71*	1038,01	0.000	-14429,86	-10343,58
	V- 1	Control	6662,76*	1038,01	0.000	4619,62	8705,90
		V-2	-5723,95*	1038,01	0.000	-7767,10	-3680,82

The data in Table 5 show a statistically significant difference ($p < 0.001$) between all tested variants.

Bambal et al. (1998) has studied the effect of bio fertilizers (by dipping of seedlings) and nitrogen on the growth and yield of cauliflower. Different treatments were applied using *Azotobacter* and *Azospirillum* individually and in combination with different doses of nitrogen, 0, 50, 75 and 100% of the recommended doses of 125: 75: 60 kg/ha N: P_2O_5 and K_2O. In addition, treatment

with *Azospirillum* and *Azotobacter* and 100% of nitrogen, has resulted with obtaining the highest yield (29,64 t/ha) and the shortest vegetation period.
Islam et al. (2014), in their research for the effect of the bioinoculantson the characteristics of the cauliflower found that dipping of the root seedlings in bio-fertilizer significantly impacts on the growth and yield of the cauliflower. They assume that increased growth and yield is due to increased availability, solubility and mobility of nutrients,because of the made bioinoculation of the the seedlings.
Cauliflower features a slightly higher nutritional value than the cabbage. The water content in the cauliflower curds is around 92%, carbohydrates around 5.3%, 1.98% protein and contains very little fat around 0,10% (Červenski and Gvozdenović, 2007). In addition, cauliflower contain quite minerals and vitamins. From the minerals highestcontainedare potassium, sulfur, phosphorus and calcium, while from the vitamins the vitamin C is present with the highest content.
The results of the analyses for the percentage of water in curds of the cauliflower during the three years of research are presented in Table 6.

Table 6. Average values for the water content in % in the curds of the cauliflower for the three variants in 2011, 2012 and 2013

Year	Control	V-1	V-2
2011	92,37	93,63	93,14
2012	92,04	90,49	92,34
2013	91,73	90,28	91,41
Average	92,04	91,46	92,29

During the three years of research lowest percentage of water content was obtained in the curds of theV-1 from 90.28% in 2013, while the highest percentage of water from 93.63% was also obtained in the curds of V-1 in 2011. The highest average water content for the three years of research was obtained in the curds of V-2 from 92.29%, and the lowest from 91.46% in V-1. According to Lešič et al. (2002), the cauliflower contains a relatively high percentage of water from 90.9 to 94.5%.
From technological aspect, the content of dry matter in plant products is a major factor in determining the quality characteristics of the products themselves.

Table 7. Average values for the dry matter content in % in the curds of the cauliflower, for the three variants in 2011, 2012 and 2013

Year	Control	V-1	V-2
2011	7,63	6,37	6,86
2012	7,96	9,59	7,66
2013	8,27	9,72	8,59
Average	7,95	8,56	7,70

From the data in Table 7 for the content of dry matter in the curds of the cauliflower, can be seen that the lowest content was 6.37% in V-1 in the year 2011, and the highest was 9.72% also in V-1 in 2013. The average content of dry matter in the three years of testing was highest in V-1 where it was 8.56%, while the lowest it was in the V-2 from 7.70%.

From the scientific research for the application of bio-fertilizers combined with mineral fertilizers, Khurana et al. (2009), determined the effect on the increase of the dry matter in the curds of the cauliflower. The highest content was determined in the curds where it was applied *Azotobacter* with a recommended dose of a mineral fertilizer (N: P: K 120 60 60 kg/ha), where the percentage of dry matter was 8.33% in 2007 to 9.30% in 2008.

Fiber found in fruits, vegetables, grains and legumes are characterized as a kind of carbohydrates that are not absorbed by the body. There are two types of fiber, soluble and insoluble.

Table 8 shows the average values for the content of fiber in the curds of the cauliflower in the three years of research for the three variants.

Table 8. Average values for the fiber content in % in the curds of the cauliflower, for the three variants in 2011, 2012 and 2013

Year	Control	V-1	V-2
2011	20,60	26,15	26,69
2012	31,37	26,98	31,07
2013	27,30	28,22	29,08
Average	26,42	27,12	28,95

The content of fiber in the curds of the cauliflower has the lowest with the control in 2011 from 20.6% of, and the highest was also in the control in 2012 from 31.37%. According to the average values for the three years of research, the percentage of fiber was highest in V-2 with 28.95%, while lowest it was in the control with an average value of 26.42%.

Plant proteins are containing many amino acids, but not a single plant product contains all of the essential amino acids. The average protein content in curds of the cauliflower according to Tudzarov (2011), is around 3.3%, while according to Lešič et al. (2002) the proteins are present from 1.5 to 2.72%.

Table 9 shows the percentages of protein per year and the average protein content in the three years of research.

Table 9. Average values for the proteins content in % in the curds of the cauliflower, for the three variants in 2011, 2012 and 2013

Year	Control	V-1	V-2
2011	1,92	2,03	2,20
2012	1,98	2,08	2,28
2013	2,30	2,34	2,72
Average	2,07	2,15	2,40

The lowest percentage of protein from 1.92% was observed in the control in 2011, while the highest from 2.72% was in V-2 in 2013. According to the average values for the three years of testing, protein content was the lowest in the control from 2.07%, then in V-1 from 2.15% and inV-2 it was highest with 2.4%.

The calcium content in the curds of cauliflower, according to Lešič et al. (2002), ranges from 17 to 31 mg/100 g, and according to Tudzarov (2011) the content of calcium in the cauliflower is 53 mg/100 g.

Table 10. Average values for the calcium content in mg/100 g in the curds of the cauliflower, for the three variants in 2011, 2012 and 2013

Year	Control	V-1	V-2
2011	50,00	70,00	112,00
2012	87,00	69,00	113,00
2013	96,00	99,00	150,00
Average	87,60	79,30	125,00

From Table 10 may be noted that the content of calcium in the cauliflower's curds was highest in V-2 with 150 mg/100 g in 2013, while the lowest calcium content was noted in the control from 50 mg/100 g in 2011. From the data it can be seen that in 2013 the three variants have significantly higher calcium content than previous two years. The average values for the three years showed that V-1 has the lowest calcium content of 79,3 mg/100 g, while V-2 has the highest content of calcium of 125 mg/100 g.

Conclusions

From the results obtained in the three years research for the impact of the microbiological fertilizer Slavol on the important economic properties of the cauliflower (*Brassica oleracea* L.var. *botrytis*), we can make the following conclusions:

- The average yield of the curds for the three years of testing ranged from 34 161,46 kg/ha for the control, 40 824,22 kg/ha for V-1 and 46 548,18 kg/ha forV-2. Statistical analysis of the data showed highly statistically significant differences among the three studied variants.
- The average content of water, fiber, calcium and protein was highest in the curds of V-2;
- The average dry matter content was highest in the curds of V-1.

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