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THE INFLUENCE OF FOLIAR FERTILIZING ON SOME CHEMICAL PARAMETERS OF THE BROCCOLI (*BRASSICA OLERACEA L. VAR. BOTRYTIS*)

Petar Petrov*, Vesna Markoska, Bojan Mitrovski

MIT University, Faculty of Environmental Resources Management, Skopje, Republic of Macedonia

Abstract. *The basic goal of this research is to determine the influence of foliar fertilization on the content of dry and mineral matter, vitamin C and total organic acids in broccoli. The experiment was set according to the random block-system, on fluvisol soil with a high concentration of available forms of nitrogen, phosphorus and potassium. It was performed during the vegetation period of 2014, on the territory of the village of Negorci, near Gevegelija (Republic of Macedonia) with five variants and three repetitions in fifteen rows. Each variant involved 180 plants in total. The experiment involved the following variants: 1. Control (Non-fertilized); 2. Bioflor; 3. Ingrasamant foliar; 4. Humustim and 5. Rhizoactive. During the vegetation period, a total of four treatments were performed by foliar feeding with 0.4% solution of the above-given fertilizers. Following the broccoli harvest, the average samples were taken for chemical analysis and, from the results of the analysis carried out, it was concluded that the foliar fertilizing and the high concentration of the available forms of nitrogen, phosphorus and potassium have positive effects on the chemical composition of the broccoli in all variants. The highest of the dry matter (14.31 %), mineral matter (1.40%), vitamin C (50.02 mg%) and total organic acid (0.48 %) content was achieved in the variant no. 5 Rhizoactive.*

***Key words*:** *Broccoli, chemical composition, foliar fertilizing, fluvisol soil*

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1. INTRODUCTION

Broccoli is a vegetable crop grown primarily for the use of the flower-heads in human nutrition. As a culture, it is classified amongst the cabbage family of plants and it has very similar morphological features of headed cabbage and cauliflower, but it still features a richer chemical composition. Cabbage crops can be successfully grown on all soil types with the exception of extremely light and sandy soils. Medium heavy soils with good air and water regime with sufficient nutrients are best for growing cabbage crops [5]. The plants are grown and developed in order to make a certain contribution of high quality and quantity. Soil is their environment. Each soil has its own potential, it determines the development of plants and the quantity and quality of yields. Plant nutrition is one of the main agro-technical measures which have a direct impact on the chemical composition of agricultural products.

Foliar nutrition represents the application of water soluble fertilizers directly through the leaf. Foliar fertilizers are quickly absorbed in plants and they are most frequently used as additional feeding for plants and alternative feeding in conditions when plants indicate the greatest need for nutrients or in cases of deficient soil fertility. The use of foliar fertilizers in agriculture is increasingly spreading and such fertilizers are environmentally friendly and target-oriented since, compared to soil fertilizers, they are absorbed directly into the organism in limited quantities. The effectiveness of foliar fertilizers is assessed on the basis of the absorption and availability of elements, reduction of phytotoxicity, deficit, impact of physiological processes over the yield and the quality of culture [8].

2. MATERIAL AND METHOD OF OPERATION

The scientific-research experiment was performed on the territory of the village Negorci, near Gevgelija (Republic of Macedonia), in an area which has been used for vegetable production for years, and was intensively fertilized with mineral and organic fertilizers. Irrigation system from individual well was secured on the surface, and the relief was flat. The size of the testing lot was 216 m^2. The research included broccoli (Brassica oleracea L. var. botrytis). The experiment was conducted during the vegetation period in 2014, following generally accepted norms and methods for setting up field experiments according to [3]. The experiment was set according to the random block-system, with five variants and three repetitions in 15 lines with a length of 24 m. The distance of transplanting was 0.6 m between rows and 0.4 m within the row. The foliar application of fertilizers was performed with 0.4% aqueous solution of the fertilizer by using a backpack sprayer every 20-25 days, four times during the vegetation. The first application of fertilizers was made around 30 days after transplanting, i.e. following the fully established leaf

* petrovpetar2012@gmail.com

mass. During harvesting, average samples were taken from broccoli to carry out the chemical analyzes in the plant material. The experiment involved the following variants: 1. Control (variant without the application of an agro-technical measure – fertilizing); 2. Variant with the application of a foliar fertilizer – Bioflor; 3. Variant with the application of a foliar fertilizer – Ingrasamant foliar; 4. Variant with the application of a foliar fertilizer – Humustim; 5. Variant with the application of a foliar fertilizer – Rhizoactive. The fertilizer of the second variant, Bioflor, is categorized in the group of organic fertilizers and, according to the manufacturer's declaration, it is characterized by the following chemical properties: pH = 7.93, organic matter = 45.00%, dry matter = 27.00%, N = 1.80%, P_2O_5 = 0.42 %, K_2O = 0.33%, Ca = 0.10%, Mg = 0.03%, Fe = 0.002%, Cu = 0.002%, Mn = 0.0008%, Zn = 0.0001%. The third variant was performed by the application of a foliar fertilizer, Ingrasamant foliar, from the group of organic and mineral fertilizers and, according to the manufacturer declaration, it is characterized by the following chemical properties: N= 0 g/l, P_2O_5 =130 g/l, K_2O =130 g/l, ME in chelated form, plant extracts 0.005 g/l. The fertilizer of the fourth variant, Humustim, is categorized in the group of organic fertilizers and it is characterized by the following chemical properties: total organic matter = 58.63%, total dry matter = 12.38% humic acids = 20.40%, fulvic acids = 2.15%, N = 3.00%, P_2O_5 = 1.02%, K_2O= 7.92%, Ca= 3.70%, Mg= 1.03%. The chemical properties of the fertilizer are given in the manufacturer's declaration. The fifth variant includes the organic fertilizer Rhizoactive which, according to the manufacturer's declared values, is characterized by the following chemical properties: amide N = 6%, and humic and fulvic acids = 6.5%, seaweed extracts (Ascophdzllum nodosum) = 12.5%, inositol 5%, vitamins (B1, B2, B6, C, E), amino acids, niacin, folic acid, co-enzymes and carbohydrates.

Prior to setting the experiment, the average samples were taken at a depth of 0-20 cm and 20-40 cm for determining the chemical properties of the soil, and the analysis included:

- soil solution pH-reaction (in H2O and N KCl), determined with potentiometric titration using a pH meter with the combined glass and calomel electrode [1]
- carbonate content, determined by using Scheibler calcimeter and 10% HCl [6]
- content of organic carbon and humus, determined according to the Kotzmann method [1]
- total nitrogen content, determined according to the Tjurin method [1]
- content of physiologically available forms of nitrogen, determined by the Tjurin and Kononova method [1]
- content of physiologically available forms of phosphorus, determined according to the AL-method and the reading of the spectrophotometer [1]
- content of physiologically available forms of potassium, determined according to the AL-method and the reading of the flame photometer [1]
- determination of hydrolytic acidity and amount of base cations in absorbed carbonate-free soils according to the Kappen method [6]
- calculation of the cation absorption capacity and the degree of saturation of the soil with base cations [6]
- determination of the dry matter in the plant material [4]
- determining the content of the mineral matter in the plant material [5]
- determining the content of vitamin C in the vegetable material [7]
- determining the total amount of organic acids in plant material [7].

3. Results and discussion

Broccoli and other cabbage crops form a large vegetative mass with high yields, and therefore adopt and utilize nutrients from the soil well. Table 1 above presents of chemical properties of the soil. Broccoli development and yield are frequently conditioned by the pH reaction to the soil. For the normal growth and development of reach yields, the reaction to the soil should be neutral to slightly acidic [5]. Our research concerning the reaction of the soil solution indicated that the soil solution has a neutral reaction. The soil was characterized by a neutral pH reaction and it was moderately of humus origin. The soil was characterized by a high absorption capacity (>30eq.mmol/100g), absolutely dry soil and high saturation of the soil with base ions (Ca and Mg, more than 90%). From the analysis of soil fertility, we can conclude that the content of the three main macrobiogen elements (nitrogen, phosphorus and potassium) was relatively high. The situation with phosphorus was particularly alarming. The resulting values showed a huge imbalance of the nutrient regimen of the soil, which was caused by the prior unskilled and uncontrolled use of mineral fertilizers.

Cabbage cultures cope well with the high concentrations of nutrients in the soil [5]. According to the same author, average cabbage crops should be fertilized with 120-130 kg ha^{-1} of phosphorus and 130-140 kg ha^{-1} of potassium. In our case, at extremely high concentrations of nutritive elements in the soil, the application of soil fertilizers would have a negative effect and would further deteriorate the current soil fertility, including the negative influence on other components of the environment. Having in mind the ultimate goal in vegetative agricultural production (obtaining higher yields characterized by the better quality), only the application of foliar fertilizers and cultivation of cultures for which other soil properties would be primarily fitting would satisfy these needs while maintaining a clean environment [9]. Yields and quality of plants depend on the biological properties of different plant species, climate and soil conditions, as well as the correct and controlled plants' food. Plant nutrition affects numerous physiological and biochemical processes that influence the growth, development and fertilization. Table 2 results are interpreted from the content of dry and mineral matter, vitamin C and the total amount of organic acids, expressed in percentages sequentially in broccoli variants. From the obtained results, it can be concluded that there is a certain difference in the chemical composition between the variants in all parameters. Variant No. 5, Rhizoactive, is significantly

featured in the content of the investigated chemical parameters compared with other variants. The average content of dry matter in all variants is 13.05%. The highest content of dry matter of 14.31% was obtained for Variant No. 5. Variant No. 4 contains 13.95%, and Variant No. 3 contains 13.47%. Variation No. 2 and control Variant No.1 are featured with significantly lower dry matter content. Variant No. 2, Bioflor, contains 11.90% of the dry matter, whereas the control variant contains 11.55% of the dry matter.

Table 1. Chemical properties of the soil

Depth in (cm)	pH		%			Available forms in mg/100 g soil			eq.mmol/100g			%
	H_2O	N KCl	$CaCO_3$	Humus	Total N	N	P_2O_5	K_2O	H^*	S^*	T^*	V^*
0-20	7.35	6.71	0.00	3.30	0.20	13.61	126.00	65.35	1.39	41.64	43.03	96.77
20-40	7.40	6.73	0.00	2.61	0.16	12.44	122.33	64.28	2.45	57.01	59.44	95.91
Average	7.38	6.72	0.00	2.96	0.18	13.03	124.17	64.82	1.92	49.33	51.24	96.34

Table 2. Content of dry and mineral matter, vitamin C and total organic acids of broccoli

Variant	*Dry matter %*	*Mineral matter %*	*Vitamin C mg%*	*Total organic acids %*
1 Control	11.55	1.21	43.03	0.31
2 Bioflor	11.90	1.23	44.07	0.31
3 Ingrasamant foliar	13.47	1.33	48.28	0.46
4 Humustim	13.95	1.27	47.03	0.44
5 Rhizoactive	14.31	1.40	50.02	0.48
LSD 0.01	0.2401	0.0534	2.51	0.0504
LSD 0.05	0.1688	0.0376	1.7647	0.0355

In terms of mineral matter, the lowest content was determined in Variant No. 1, 1.21%, and the highest content was determined again in Variant No. 5, 1.40%. Variant No.3 was featured with 1.33% of mineral matter. Variant No. 4 contained 1.27% while Variation No. 2 contained 1.23% of mineral matter.

Cabbage cultures are known for a relatively high content of vitamin C. In our tests, Variant No. 5 was characterized with the highest content of 50.02 mg%. The same variant also had the highest content of total organic acids, 0.48%. Variant No. 3, Ingrasamant foliar, contained 48.28 mg% of vitamin C and 0.46% of total organic acids, whereas the negligible content of less than 47.03 m% of vitamin C and 0.44% of total organic acids was featured by Variant No. 4, Humustim. Variant 2 contained 44.07 mg% of vitamin C and 0.31% of total organic acids. The lowest vitamin C content of 43.03 mg% was featured by the control variant. It contained 0.31% of total organic acids. According to the research [10], broccoli contains 8.37 to 8.81% of dry matter and 60.06-72.81 mg/100 g of vitamin C. Our research showed relatively higher values for the content of dry matter while, according to the author, the content of vitamin C was lower. In terms of the content of total organic acids, broccoli [2] investigation showed that raw broccoli contained from 0.2 to 1.8%, which is relatively congruent with our own research.

4. Conclusion

Based on the survey results, we can conclude that:

The application of foliar fertilizers in previously established soil conditions has a positive impact on the chemical composition of broccoli.

Compared to the untreated referent variation, the highest values of dry content and minerals, vitamin C and total organic acids were achieved in variation with the application of Rhizoactive organic fertilizer. Compared to other fertilizers included in the research, the fertilizer Rizoactive is distinguished with the richest chemical composition of physiological active substances that stimulate growth and development of plants.

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