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THE EFFECT OF FOLIAR FERTILIZING ON THE CHEMICAL COMPOSITION OF PEPPERS GROWN IN PROTECTED SPACES IN THE STRUMICA AREA IN THE REPUBLIC OF MACEDONIA

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ABSTRACT

The influence of foliar fertilizing on the chemical composition of peppers grown in protected spaces in the Strumica area was examined. The experiment was set in four variants and three repetitions. The variants used in the experiment were, as follows: Control (untreated variant); NPK+Ever green (55% organic matter, 2%w/w Mg, 2%w/w Fe, 2%w/w Zn, 2% w/w Mn, 0.5 %w/w Cu, 0.5 %w/w B); NPK+Biolinfa (34% organic matter, 3% N, 5.80 % K_2O); NPK+Oligomix (1.20 % B, 0.10 % Cu, 4 % Fe, 1.50 % Mn, 0.10 % Mo, 2 % Zn). The experiment was set in 18 rows, and each variant and repetition comprised 62 plants. During the vegetation period, 7 foliar treatments were made with listed fertilizers at a concentration of 0.4%. Before setting up the experiment, an agrochemical analysis of the soil was performed enabling the researchers to determine good soil fertility with available nitrogen and potassium, and average fertility with available phosphorus. Foliar fertilizing had a positive influence on the chemical composition of the peppers. In the variants treated with different organic fertilizers the researchers recorded a higher content of the analyzed parameters than in the control, untreated variant. The highest average content of dry matter (14.80%), the highest average content of ash (0.90%) and the highest average vitamin C content (120 mg/100g) were determined in the pepper in Variant 2. The highest average content of nitrogen (1.37%), phosphorus (0.53%), potassium (2.25%) and calcium (1.42%) was also determined in the pepper in Variant 2. The highest average magnesium (0.38%), iron (0.0067%) and manganese (0.0017 %) content was determined in the pepper in Variant 3.

Key words: *foliar fertilizing, peppers, protected spaces.*

INTRODUCTION

Plant nutrition is one of the most important agrotechnical measures in the agricultural production. Quality and well-balanced nutrition is one of the basic conditions for achieving high, stable and high-quality crop yields (Domagalski et al., 2008; Kannan 2010). Determination of doses and types of fertilizers, timing and method of use are based on the consumed nutrients from the soil (Datnoff et al., 2007). Intake of nutrients through the soil often does not give the expected results due to their unavailability for plants (due to drought, unfavorable soil properties, underdeveloped root system). Hence, foliar nutrition is of great importance for the successful cultivation of agricultural crops (Dzamić and Stevanović, 2000). According to numerous authors that plants can give the maximum of their genetic potential, a foliar nutrition is necessary (Jekić and Brković, 1986, Saciragić and Jekić, 1988). The advantage of foliar fertilizing compared to soil fertilizing is that the utilization of nutrients does not depend on the soil moisture content, the pH of the soil and other chemical and physical properties (Kostadinov and Kostadinova, 2014). The effects of foliar nutrition are rapid. After several days of using foliar fertilizers, the plants receive intense green color, their habitus is rapidly increasing, the formation of organic matter accelerates (Kerin and Berova, 2003). The development of the root system speed up, thus allowing better utilization of nutrients from the soil. In this way, plants become more resistant to adverse weather conditions, diseases and pests.

For the normal growth and development of agricultural crops, many macro and micro biogenic elements are of great importance (Sarić et al., 1989; Taiz and Zeiger, 2006). Each nutrient has its specific influence on the individual parts of the plant. Plant nutrition affects numerous physiological and biochemical processes as growth, development and fruit formation (Vukadinović and Loncarić, 1997, El-Bassiony et al., 2010). Plants that are timely and properly nourished produce fruits with characteristic shape, color and size, with typical organoleptic properties (Fageria, 2007; Fageria et al., 2009). The use of foliar fertilizer in the diet of garden crops is of great importance for obtaining higher yields but also products that are characterized with better quality (Epstein and Bloom, 2005, Fewzy et al., 2012).

The pepper (*Capsicum annuum L*) originates from South America. The Spaniards brought it to Europe in the 15th century, from where it spread to Turkey, and today it is mostly cultivated in Hungary.

In the Republic of Macedonia, pepper is one of the most common vegetable. It is a one-year culture of great economic significance. The fruits of the pepper vary in shape, color, but also in smell and taste. The fruits are characterized by high nutritional value. They are rich in many vitamins, organic and mineral substances (Kolota and Osinska, 2001). They also have great technological value.

The pepper contains about 89% water. It contains sugars from the group of monosaccharides and disaccharides. Of the monosaccharides, 90-98% contains glucose, the rest is fructose and sucrose. Of vitamins, the pepper contains mostly vitamin C. In the pepper there are also significant amounts of vitamin B, especially

B_1 and B_2. It contains vitamin E, pantothenic acid, and in the form of provitamin contains vitamin A, which is present as beta-carotene and cryptoxanthin (Karakurt et al. 2009, Nassar et al. 2001). Of minerals, pepper is the richest with potassium, phosphorus and iron (Youssef et al., 1996; Fawzy et al., 2005). The fruits are consumed both in fresh and processed form.

The aim of this research was to determine the impact of foliar fertilizing with various organic fertilizers on the chemical composition of fruit peppers grown in protected spaces in the Strumica region.

MATERIALS AND METHODS

In the Strumica region in the area of the village Kuklish, field crop experiment was set in the protected spaces of 300 m^2 during the 2013 and 2014.

The experiment was set in 18 rows. Four variants and three repetitions were included.

The material for the work was the pepper's variety *bela dolga*. The seedling was planted in rows with row by row distance of 60 cm, and between plants, 40 cm. The experiment was set in conditions of irrigation. During the vegetation period of peppers, basic agro-technical measures were applied. Before the planting took place, soil fertilization with mineral fertilizer NPK 6-10-30 + 2% MgO in the amount of 12 kg in the hall with an area of 300 m^2 was applied.

The variants in the experiment were:

1. Control (untreated);
2. NPK+Ever green (55% organic matter, 2%w/w Mg, 2%w/w Fe, 2%w/w Zn, 2% w/w Mn, 0.5 %w/w Cu, 0.5 %w/w B);
3. NPK+Biolinfa (34% organic matter, 3 %N, 5.80 % K_2O);
4. NPK+Oligomix (1.20 % B, 0.10 %Cu, 4 % Fe, 1.50 % Mn, 0.10 % Mo, 2 % Zn).

In each variant and repetitions, 62 plants were involved, and for the entire experiment 1116 plants were involved.

Each variant was treated with tasted foliar fertilizer in concentration of 0.4% solution. The application of fertilizers was done with hand sprayer, by spraying the leaves. During the vegetation seven foliar treatments were conducted, starting from the stage of growth of the first fruits. The harvest was done when the peppers were 18 cm long, separated in variants and repetitions. During the vegetation five harvests were done. The first harvest was done on the 23th of May, and the last one on the 12th of July.

During the last harvest, fruits were taken separately by variants and following parameters were performed:

- The content of hygroscopic water content was determined by drying the material in dryer on temperature of 105°C matters is deducted;
- The content of total dry matters was determined by calculation when from 100%, the percentage of hygroscopic water;
- The content of organic matter was determined by calculation when from 100% the percentage of total ash will be deducted.

- The content of total ash was examined by removing moisture from the prepared material, drier on temperature of 105°C. Then the rest was burned in electric oven by gradually increasing the temperature to 550°C. The burning was done until ashes became grey or white;
- The content of vitamin C was determined by method of Thilmans, which is based on the redox reaction between L-ascorbic acid and organic colour 2.6-dichlorophenolindophenol;
- The content of phosphorus (P_2O_5) was determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić et al., 1986);
- The content of potassium (K_2O) was determined by incineration of the material with concentrated H_2SO_4 and flame-photometer (Sarić et al., 1986);
- The content of calcium (SAT) was determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić et al., 1986);
- The content of magnesium (Mg) was determined by applying atomic; emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić et al., 1986);
- The content of iron (Fe) was determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić et al., 1986);
- The content of manganese (Mn) was determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić et al., 1986);
- The content of zinc (Zn) was determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić et al., 1986).

Before setting up the experiment, soil samples were taken for agrochemical analyses performed on the following parameters:

- pH value determined with pH meter (Bogdanović et al., 1966);
- Content of easy available nitrogen – chosen by method of Tjurin and Kononova (Bogdanović et al., 1966);
- Content of easy available phosphorus – chosen by AL method and reading of spectrophotometer (Bogdanović et al., 1966);
- Content easy available potassium – chosen by AL method and reading of spectrophotometer (Bogdanović et al., 1966);
- Content of carbonates – chosen with Schaiblerov Calcimetar (Bogdanović et al., 1966).

RESULTS AND DISCUSSION

For the achievement of high and quality yields, the pepper requires favorable soil and climatic conditions. Pepper that is grown in protected spaces has a greater need for nutrients, and in particular requires a greater amount of potassium (Lazić et al., 2001; Salama and Zake, 2000). In a short time, the pepper creates a massive vegetative mass, but there is a less developed root system. Therefore, it is necessary to grow on good fertile soils (Shafeek et al., 2014).

The best yields are obtained if the pepper is grown on deep and friable soils rich in easily accessible nutrients. The optimum soil reaction for the pepper is slightly acidic with a pH of 5.5 to 6.0.

Table 1. Agrochemical soil analysis

Order No.	**Plot**	**Depth cm**	**pH**		**Available form (mg/100 g soil)**			**$CaCO_3$ %**
			H_2O	**KCl**	**N**	**P_2O_5**	**K_2O**	
1	Pepper 1st part	0-20	7.35	6.65	9.55	18.30	21.20	/
2		20-40	7.40	6.64	10.20	14.20	17.00	/
Average			**7.37**	**6.64**	**9.87**	**16.25**	**19.10**	**/**
3	Pepper 2nd part	0-20	7.43	6.70	8.90	15.25	23.10	/
4		20-40	7.40	6.60	9.70	17.00	20.50	/
Average			**7.41**	**6.65**	**9.30**	**16.12**	**21.80**	**/**

From the data in Table 1, it can be concluded that the soil on which the experiment was set, has a neutral pH, good fertility with nitrogen and potassium, and medium fertility with available phosphorus. There is no presence of carbonates.

Table 2. Chemical content of pepper fruit in % of dry matter, average 2013/2014

Variant	**Hygroscopic water %**	**Dry matter %**	**Organic matter %**	**Ash %**	**Vitamin C mg/100g**
1	90.30	9.70	99.40	0.60	103.50
2	85.20	14.80	99.10	0.90	120.00
3	87.00	13.00	99.37	0.63	105.10
4	90.20	9.80	99.25	0.75	115.00

Table 3. Chemical content of pepper fruit in % of dry matter, average 2013/2014

Variant	**N**	**P_2O_5**	**K_2O**	**Ca**	**Mg**	**Fe**	**Mn**
1	**1.22**	0.43	1.95	1.25	0.29	0.0053	0.0011
2	**1.37**	0.53	2.25	1.42	0.30	0.0062	0.0015
3	**1.28**	0.49	2.07	1.33	0.38	0.0067	0.0017
4	**1.32**	0.47	2.15	1.32	0.32	0.0058	0.0012

LSD 0.05=0,062 LSD 0.05=0.065 LSD 0.05=0.103 LSD 0.05=0.103 LSD 0.05=0.101 LSD 0.05=0.00086 LSD 0.05=0.0004

LSD 0.01=0,090 LSD 0.01=0.091 LSD 0.01=0.145 LSD 0.01=0.145 LSD 0.01=0.142 LSD 0.01=0.00120 LSD 0.01=0.00060

From the data in Table 2 and Table 3 it can be concluded that foliar fertilization had a positive influence on the content of the examined parameters in pepper fruits. In all variants, the analyzed parameters gave better results compared to the untreated control variant.

The highest average content of dry matter (14.80 %), the highest average content of ash (0.90%) and the highest average vitamin C content (120 mg/100g) were determined in the pepper fruits in the variant 2.

The content of hygroscopic water is in correlation with the dry matter content and it is the highest in the control variant (90.30 %). The content of organic matter (99.40 %) was highest in the control variant. The highest average content of nitrogen (1.37), phosphorus (0.53 %), potassium (2.25 %) and calcium (1.42 %) was determined in the pepper fruits in the variant 2. The highest average magnesium (0.38 %), iron (0.0067 %) and manganese (0.0017 %) content is determined in pepper fruits in variant 3. The positive foliar effect of the used organic fertilizers on the yield of peppers is the result of their chemical composition. The organic matter in the fertilizer is of great importance for the intensification of all the processes taking place in the individual organs of the plant. It participates in many biochemical and oxidative processes. It affects the migration and redistribution of elements in plants, too. Through these processes it affects the general growth, development and the increase both in yield quantity and quality. The presence of micro elements in the composition of the analyzed fertilizers is of great importance for the correct growth, development and fruit formation of peppers. These elements influence numerous physiological and biochemical processes that are vital in the vegetative cycle of culture. Statistically significant differences compared to the control variant were obtained for the nitrogen content of variants 2 and 4 at both examined levels. There is no statistically significant difference in phosphorus content. For potassium content, there are statistically significant differences in variants 2, 3, and 4 at the two levels. For the content of calcium, statistically significant differences in the two levels are found in variant 2. For the content of manganese, the statistically significant difference is found in variant 3 at the LSD level of 0.05. For iron content statistically significant difference at LSD level 0.05 is found in variants 2 and 3, and at LSD level 0.01 in variant 3.

CONCLUSIONS

Based on the obtained results for the influence of foliar fertilizing on the chemical composition of pepper fruits grown in protected spaces, can be concluded that in all variants treated with foliar fertilizers, higher content of the tested elements has been determined compared to control variant. The highest average content of nitrogen (1.37), phosphorus (0.53 %), potassium (2.25 %) and calcium (1.42 %) was determined in the pepper fruits in the variant 2. The highest average magnesium (0.38 %), iron (0.0067 %) and manganese (0.0017 %) content is determined in pepper fruits in variant 3. The highest average content of dry matter (14.80 %), the highest average content of ash (0.90%) and the highest average vitamin C content (120 mg/100g) were determined in the pepper fruits in the variant 2. For future used, variant 2 is recommended (NPK+Ever green (55% organic matter, 2%w/w Mg, 2%w/w Fe, 2%w/w Zn, 2% w/w Mn, 0.5 %w/w Cu, 0.5 %w/w B);

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