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RESEARCH ARTICLE

THE EFFECT OF FOLIAR FERTILIZING ON THE CHEMICAL COMPOSITION OF LEAVES OF FERRAGNES ALMOND CULTIVAR GROWN IN VALANDOVO

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A B S T R A C T

The effect of foliar fertilizing on the chemical composition of leaves from ferragnes almond cultivar grown in Valandovo region in the period from 2012 to 2013 was determined. The experiment was set in four variants and three repetitions. The variants were: Control (untreated); NPK+Ever green co Me (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) and NPK+Oligomix (1.20% B, 0.10% Cu, 4% Fe, 1.50% Mn, 0.10% Mo, 2% Zn). The distance of fruit planting was 4.5 m row by row and 3.5 m in the rows. In each variant and repetition were included 60 plants, and total in all experiment were included 720. Three foliar treatments were applied with given above fertilizers at a concentration of 0.4%. In the end of the November, soil fertilization with the fertilizer Polyfeed NPK 11-44-11 in quantity amount of 450 kg ha^{-1} was done. Before setting up the experiment, soil agrochemical analyses were made, and was concluded good fertility with nitrogen, but medium fertility with phosphorus and potassium. The foliar fertilizing has a positive influence on the chemical content of almond leaves. The highest average content of nitrogen (3.66%), phosphorus (1.22%) and potassium (1.15%) were determined in the leaves from variant 3 NPK+Biolinfa (34% organic matter, 3% N, 5.80% K_2O). The highest average content of calcium (0.93%) and magnesium (0.42%) was determined in the leaves from variant 2 NPK+Ever green with Me (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). The highest average content of micro elements iron (245 mg kg^{-1}), manganese (170 mg kg^{-1}), boron (38.10 mg kg^{-1}), zinc (17.00 mg kg^{-1}), and copper (25.00 mg kg^{-1}) is determined in leaves from variant 4 NPK+Oligomix (1.20 % B, 0.10 % Cu, 4 % Fe, 1.50 % Mn, 0.10 % Mo, 2 % Zn).

INTRODUCTION

The aim of the modern agriculture is to get higher yield that will characterize with better quality. Plant nutrition is one of the most important agro-technical measures, that together with the others have to allow uninterruptible, high and economically production (Kester *et al.,* 1996; Datnoff *et al.,* 2007). The right plant nutrition regime is necessary for normal growth, yield and getting quality product (Marschner *et al.,* 1996; Domagalski *et al.,* 2008).

It means availability of all macro and micro biogenic elements in appropriate phenophase of plant growth. Each biogenic element has its specific influence on different parts of the plants. Plant nutrition has an influence on numerous physiological – biochemical processes, that affecting growth, development and yield (Glintic and Krstic, 1990; Dzamič and Stevanović, 2000).

Plants that have timely and right nutrition are getting fruits with characteristic shape, color, size and with typical organoleptic properties. Limited of the nutritious elements is happened because of the different reasons. Intensive agriculture and use of high productivity cultivars led to a continuous decrease in soil micronutrient content (Jekić and Brković, 1986; Sarić *et al.,* 1989).

Using of foliar fertilizers in the fruit cultures nutrition, has a big importance in getting higher yields as well as products with better quality (Weinbaum *et al.,* 1984). Foliar fertilizers allow direct supplying of leafs, flowers and fruits with nutritious elements in a period when they are necessary.

Foliar spray with fertilizers is necessary to further activity in the whole system of optimal mineral nutrition of plants (Taiz and Zeiger *et al.,* 2002; Kostadinov and Kostadinova, 2014). It provides more economical water regime of plants and allows overcoming the physiological disturbances caused by adverse soil conditions that hamper mobility and nutrients absorption.

In irregularly soil conditions, irregularly pH value, low or high soil temperature, fixation in different nutrients, the root cannot adopt the nutrients at all (Sarić *et al.,* 1986; Šaćiragić and Jekić, 1988). In such cases, the foliar nutrition has an important influence. It is an additional nutrition and measure that allow rapid and efficiency effect of correction of the plant nutrition (Velićković, 2002; Brown *et al.,* 2004).

The almond, *Amygdalus communis*, is kernel fruit that bellows at the family of *Rosaceae*, and under family *Prunoidae*. It is old fruit culture that is counts in economically importance kernel fruit and has numerous positively characteristic, too.

The importance of almond is because of the kernel, which is very reach in fats, proteins, mineral matters, sugars, cellulose, vitamins and amino acids (Bulatović, 1985; Youssefi *et al.,* 2000). On the other hand, the almond has a big value for human nutrition, pharmaceutics, cosmetic industry and so.
The leaf is an organ in which the synthesis of organic matter takes place at most. The composition of leaf tissue and symptoms that occur in it are the best indicators for determining the level of nutrients in the soil, and thus the need for fertilization (Jekic and Brkovic, 1986; Marschner, 1996). The chemical composition of the leaves is variable.

The presence of certain nutrients in the leaves depends on the stage of taking a leaf samples, the type of plant, mineral nutrition and conditions of cultivation. In foliar nutrition, nutrients quickly come to chloroplasts where photosynthesis takes place and other physiological and biochemical processes. With faster foliar nutrition prevents deficiency in certain elements that occur in the leaves.

The aim of this research was to obtain the influence of soil and foliar fertilizing on the chemical composition of leaves by almond cultivar ferragnes*,* grown in Valandovo region, Republic of Macedonia.

MATERIALS AND METHODS

The field experiment with almonds was set in Valandovo region, Republic of Macedonia, during the years of 2011 and 2012. During the field experiment setting, the fruits were 7 years old. The material of work was almond cultivar ferragnes. The planting distance was 4.5 m row by row and 3.5 m in the rows. The nutritional area were 15.75 m^2, i.e. 635 fruits ha^{-1}. In the exploration were included 4 variants in 3 repetitions. In each variant and repetition were included 60 plants, or total in whole experiment the number of plants was 720. The field experiment was set in terms of watering in system drip. During the almond vegetation period were applied all basic agricultural measures.

Variants in experiment were

- Control (untreated);
- NPK+Ever green with Me (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).

NPK fertilizer (Polyfeed 11-44-11) was applicated by soil in the end of November in the quantity amount of 450 kg ha^{-1}. Each variant and repetition was treated foliar with 0.4% solution of the tasted fertilizers. The application of fertilizers was done with manually spraying the played leaves.

The treatments were made in the evening hours. During the vegetation period were conducted 4 foliar treatments. The first treatment was made 10-15 days before flowering, and the other treatments was made after flowering at a distance of 15-20 days. The harvesting was carried out separately by variants and repetitions. Before setting up the experiment soil samples were taken for agrochemical analyses and were performed on the following parameters:

- pH value - determined potentiometric with pH meter (Bogdanović *et al.,* 1966);
- Content of easy available nitrogen – determined by method of Tjurin and Kononova;
- Content of easy available phosphorus – determined by AL method and reading of spectrophotometer (Bogdanović *et al.,* 1966);
- Content of easy available potassium – determined by AL method and reading of spectrophotometer (Bogdanović *et al.,* 1966);
- Content of humus – determined by permanganese method of Kotzman (Bogdanović *et al.,* 1996);
- Content of carbonates– determined with Schaiblerov Calcimeter (Bogdanović *et al.,* 1966).
- In the leaves were determined the following parameters:
- Content of nitrogen (N) - determined using Kjeldal method (Sarić *et al.,* 1989);
- Content of phosphorus (P_2O_5) - determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić *et al.,* 1989);
- Content of potassium (K_2O) - determined by incineration of the material with concentrated H_2SO_4 and phlamenphotometar (Sarić *et al.,* 1989);
- Content of calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), boron, (B), zinc (Zn) and copper (Cu) - determined by applying atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić *et al.,* 1989).

RESULTS AND DISCUSSION

Climate is one of the most important environmental factors which affect the success of cultivation of all fruit kinds without excluding the almonds (Šoškić, 1996). The influence of climate elements manifest through the time of vegetation of fruit as well as through the separate phenophases.Valandovo region is known as region with lot of shiny days. Temperature requirements of almond for growth and development in the period of standby are large. It is enough in sequel of 100 hours, temperature variations from 0 to 6^{o}C for almond awakening. The average year temperature of the air in the Valandovo region is 15^{o}C. Sensibility of low temperatures is variety characteristic. Almond varieties that blooming early are more sensitive than others. Bulatović (1989) found that unopened blossoms can be damaged on -3°C to -4°C, opened on -1.5 to - 2.8°C, and just planted fruit on - 1 to -1.5°C. Almonds are sensitive on very high atmospheric humidity, suffer from diseases and in that ways don't give good yields.

The average year relative humidity in Valandovo region is 71 % with maximum of 80 % in November, December and January. Soil conditions have an especially importance for growing, developing and fruits quality. The almond has the best growth and yield in deep, alluvial - diluvial, loamy - sandy, humus carbonate soils with significant content of lime (Ubavić *et al.,* 2001). Particularly suitable are soils with neutral reaction and good penetration of water and air. Salty and acidic soils or wet and clay are unsuitable for growing almonds.

Table 1 Agrochemical analyses of soil

Lab. No.	Depth cm	pH KCl	pH H_2O	Available mg/100g soil N	P_2O_5	K_2O	Humus %	$CaCO_3$ %
1	0-20	7.14	7.62	14.70	6.60	20.00	1.86	1.30
2	20-40	7.19	7.98	15.26	6.20	17.00	1.90	1.02
3	40-60	7.05	7.86	11.48	5.00	17.00	1.80	2.50
Average 0-60		7.13	7.83	16.20	5.93	18.00	1.85	1.61

From data shown in Table 1, can be concluded that soil in which the field experiment was set, has neutral pH value, good fertility with available nitrogen, but a medium fertility with available phosphorus and potassium. It has medium fertility with humus, too. There is low presence of carbonates.

Table 2 Content of macro elements in leaves in % of dry matter (average 2011/2012)

Variant	N	P_2O_5	K_2O	CaO	MgO
1	3.25	0.99	1.02	0,85	0.37
2	3.32	1.04	1.08	0.93	0.42
3	3.66	1.12	1.15	0.89	0.38
4	3.53	1.11	1.12	0.90	0.40

Table 3 Content of micro elements in leaves in mg kg^{-1} of dry matter (average 2011/2012)

Variant	Fe	Mn	B	Zn	Cu
1	233	152	34.00	14.90	23.00
2	236	169	37.00	15.50	24.20
3	237	158	36.50	15.80	24.50
4	245	170	38.10	17.00	25.00

From data shown in Table 2 and Table 3, can be concluded that soil and foliar fertilizing have positive influence on the chemical content of leaves.

In all of the variants treated with different kinds of fertilizers, analyzed parameters have higher value compared with the control, untreated variant.

The highest average content of nitrogen (3.66%), phosphorus (1.12%), and potassium (1.15%) is determined in leaves from variant 3. Holevas *et al*. (1985) observed that the content of nitrogen in almond leaves is 2.95%.

According to Bulatović (1985) the content of phosphorus in the almond leaves is 1.10%, while the content of potassium is 1.05-1.10%. The highest average content of calcium (0.93%) and magnesium (0.42%) is determined in the leaves from variant 2. Dinesh and Ahmed (2014) found that the content of calcium in the almond leaves is 1.10%, but the content of magnesium is 0.45%.

Statistical significant differences were obtained for the content of nitrogen in all treated variants compared to the control one. Statistical significant difference was obtained for the content of potassium in the variant 2 compared to the control variant.

The highest average content of micro elements iron (245 mg kg^{-1}), manganese (170 mg kg^{-1}), boron (38.10 mg kg^{-1}), zinc (17.00 mg kg^{-1}), and copper (25.00 mg kg^{-1}) is determined in the leaves from variant 4.

According to Bybordi and Malakouti (2006) the average content of micro elements boron and zinc in the almond leaves is 30 mg kg^{-1} i.e. 20 mg kg^{-1}. On the other hand, Datnoff *et al*. (2007) observed that the content of manganese is 160 mg kg^{-1} and the content of copper is 24 mg kg^{-1}. For the content of manganese and boron statistically significance differences are determined in all of the variants at both levels.

Statistical significant differences for the content of manganese were obtained in the variants 2 and 4 compared to the control variant.

The higher content of tested elements in all of the variants, compared to the control variant is a result of the chemical composition of used foliar fertilizers as well as their absorption in the plant organs, i.e. kernels.

Macro and micro biogenic elements in the content of used fertilizers have an influence on numerous physiological – biochemical processes that are of vital importance in plant vegetation cycles.

In Table 5 are shown correlations between the content of determined macro and micro elements in the leaves from the almond cultivar ferragnes in determined variants treated with different kinds of fertilizers.

Between analyzed macro elements was noted statistical correlation relationship between the content of nitrogen and phosphorus with the content of potassium in the leaves.

Between the content of potassium and nitrogen there was high possitive correlation (r=, 757) at the level 0.01, while between potassium and phosphorus was determined medium positive correlation (r=, 577) at level 0.05.

Table 4

Вар.	N	P_2O_5	K_2O	CaO	MgO	Fe	Mn	B	Zn	Cu
1	3,257 d	0,987 a	1,023 bc	0,853 a	0,377 a	233 a	151,66 b	36,33 a	14,93 a	23,16 a
2	3,317 c	1,037 a	1,08 ac	0,927 a	0,42 a	236,33 a	169,33 a	37,66 a	15,56 a	24,23 a
3	3,663 a	1,123 a	1,15 a	0,917 a	0,38 a	237,33 a	158,33 ab	36,56 a	15,8 a	24,5 a
4	3,533 b	1,113 a	1,123 ab	0,903 a	0,4 a	245,66 a	170 a	38,1 a	17 a	25,16 a

Values followed by the same letter are not statistically significant at the probability level (P≤0, 05)

Table 5 Correlation relationships between content of macro and micro elements in the leaves of ferragnes almond cultivar

	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium	Iron	Manganese	Boron	Zinc	Copper
Nitrogen	1	,533	,757**	,104	(,167)	,377	,083	(,056)	,219	,299
Phosphorus		1	,577*	,252	,357	,310	,263	,055	,120	,125
Potassium			1	,228	(,048)	,206	,283	(,244)	,070	,517
Calcium				1	,461	,273	,686*	,685*	(,178)	,275
Magnesium					1	,181	,656*	,498	(,120)	,363
Iron						1	,461	,289	,329	,477
Manganese							1	,590*	,213	,588*
Boron								1	(,073)	,073
Zinc									1	,279
Copper										1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

In analyzed variants, the content of calcium had statistical significant medium correlation dependence with the content of manganese (r=, 686) and borron (r=, 685) at level 0.05. Positive correlation was determined between the content of magnesium and manganese (r=, 656) at level 0.05.

The higher content of tested elements in all of the variants, compared to the control variant is a result of the chemical composition of used foliar fertilizers as well as their absorption in the plant organs, i.e. kernels.

Macro and micro biogenic elements in the content of used fertilizers have an influence on numerous physiological – biochemical processes that are of vital importance in plant vegetation cycles.

CONCLUSION

Based on the obtained results for the influence of foliar fertilizing on the chemical composition of almond leaves from ferragnes cultivar grown in Valandovo region, Republic of Macedonia can be concluded that using of foliar and soil fertilizing has an important influence on increasing the content of macro and micro elements in the leaves from the almond cultivar ferragnes. The highest average content of nitrogen (3.66%), phosphorus (1.12%), and potassium (1.15%) is determined in the leaves from variant 3 NPK+Biolinfa (34% organic matter, 3% N, 5.80% K_2O). The highest average content of calcium (0.93%) and magnesium (0.42%) is determined in the leaves from variant 2 NPK+Ever green with Me (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). The highest average content of micro elements iron (245 mg kg^{-1}), manganese (170 mg kg^{-1}), boron (38.10 mg kg^{-1}), zinc (17.00 mg kg^{-1}), and copper (25.00 mg kg^{-1}) is determined in the leaves from variant 4. NPK+Oligomix (1.20% B, 0.10% Cu, 4% Fe, 1.50 % Mn, 0.10% Mo, 2% Zn);

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