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CONTENT OF MACRO, MICROELEMENTS AND PIGMENTS IN LEAVES OF ‘TEGERA’ AND ‘ELENA’ PLUM CULTIVARS IN DIFFERENT FERTILIZATION VARIANTS

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Abstract

At the Research Institute of Mountain Stockbreeding and Agriculture in Troyan, Bulgaria, in the period 2017-2018, the influence of different types of fertilization (conventional and organic) on the content of the basic nutrients (macro and microelements), as well as some pigments in the leaves of ‘Tegera’ and ‘Elena’ plum cultivars was studied. The established parameters and the dynamics of changes in the values of nutrients and pigments composition in the leaf samples, before and after the harvesting of fruits, significantly determine some of the characteristics of the physiology and genotypic specificity of the cultivars. It has been reported that the amount of pigment content of the fertilizer variants of ‘Tegera’ cultivar decreased after harvest and increased in the control trees. For ‘Elena’, after the harvest, the leaf mass in the conventional fertilization variant increased its percentage of nitrogen and phosphorus.

Key words: *plum, fertilization, leaves, nutrients, pigments.*

INTRODUCTION

It is well known that fertilizers are needed to improve vegetative activity and increase the productivity of fruit trees. Fertilization is one of the main agrotechnical events that increase the yield per unit area (Georgiev et al., 2019). In order to determine the optimal fertilizer rates/doses, it is important to identify first the nutritional needs of trees through plant and soil analysis.

Leaves are the main and most commonly used plant organ, so, analysing and determining their chemical composition give an idea of the degree of supply of plants with nutrients (Volodarsky, 1971; Guo-yi et al., 2015). According to Gorbanov (2018), foliar nourishment gives good results in a number of vegetable and fruit crops. To affect plants, leaf fertilizers must be easily absorbed, transported quickly, and easily release their ions (Larue et al., 1989).

The use of fertilizers for the purpose of improving the quality and yield has an effect on the pigments, macro and microelements contained in the leaf matter (Yancheva, 2002). Iron (Fe) complexes with protein forming important enzymes in plants are linked to chloroplasts, which play an essential role in chlorophyll synthesis. Chlorophyll is the main green photosynthetic pigment found in plants through which they absorb the light energy (Kiang et al., 2007). The macronutrients, such as potassium (K) and magnesium (Mg) are involved in the photosynthesis process and in a number of plant functions (Tränkner et al., 2018). This requires monitoring the nutrient content of the foliage of fruit species.

The aim of the present study is to evaluate of the content of the basic nutrients (macro and microelements), as well as some pigments in the leaf mass of four fertilization variants analyzed before and after harvesting of fruits of ‘Tegera’ and ‘Elena’ plum cultivars.

MATERIALS AND METHODS

Location of the experiment

The experiment was conducted in 2017-2018 at the collection plantation of the Research Institute of Mountain Stockbreeding and Agriculture - Troyan, Bulgaria.

Biological material

The plantation with both plums cultivars was created in the spring of 2001.

The trees were planted in trenches with organic stockpile fertilizing (130 kg/1 linear meter). Planting distances are 4/2.5 m.

The row spacing is grassed with tall fescue, and the intra row spacing is maintained in black fallow.

During the vegetation season, the necessary mowing in the interrows and digging in the intra rows were carried out, as well as other agrotechnical events such as pruning, plant protection etc.

The experimentally variants:

- **Variant I** - biofertilisation - including the following fertilizers: Agriful (soil) - 5 l/da, Tecamin Flower (foliar) - 0.3%, Tecnocel Amino Ca (foliar) - 0.4%;
- **Variant II –** conventional fertilisation - Yara Mila Complex (soil) - 0.500 kg/tree, YaraVita Frutrel (foliar) - 0.500 ml/da, Yara Vita Universal Bio (foliar) - 0.500 ml/da, ammonium nitrate - 0.200 g/tree;
- **Variant III** - organic fertilisation (granulated chicken manure - 0.500 kg/tree);
- **Variant IV** - Control (without fertilisation).

Fertilization periods:

- **Agriful** - applied five times from the beginning of vegetation over a period of 15-20 days;
- **Tecamin Flower** - 2 applications. Applied before blossoming and during the fruit-set formation;
- **Tecnocel Amino Ca** - 2 applications. Applied after blossoming and a month before harvesting;
- **Yara Mila Complex** - 1 application in 2018;
- **Ammonium nitrate** - 1 application in 2017;
- **YaraVita Frutrel** - four applications: at the phase of winter buds, at the phase of white button, at the fruit-set formation and a month after the harvest;
- **Yara Vita Universal Bio** - 3 applications: before and after blossoming, and after harvest;
- **Granulated chicken manure** - one application in 2018.

Figure 1. Plum plantation with ‘Tegera’ and ‘Elena’ cultivars

The analysed parameters leaf samples were taken seven days before ripening of the fruit and immediately after harvest (following day).

- plant analysis
  - In 2017 years Macro- and micronutrients were determined by atomic absorption spectrophotometer. Sample burned in muffle furnaces and dissolution in 20% HCl (Mincheva and Brashnarova, 1975). In 2018 there were determined only macronutrients (N, P, K).
  - Total nitrogen-Kjeldahl method by digestion with concentrated H_2SO_4 and 30% H_2O_2.
- chlorophyll "a" (mg/g FW), chlorophyll "b" (mg/g FW) and β-carotene (mg/g FW) were determined by spectrophotometric analysis. Extraction of plant pigments was performed with 85% acetone.

Statistical analysis

The following statistical analyzes were used to process the data obtained from the experimental work of the examined varieties:

variational analysis, one-way ANOVA and correlation analysis.

RESULTS AND DISCUSSIONS

The experimental data in the 2017 years are presented in Table 1.

Table 1. Content of chlorophyllian pigments and β-carotene, micro and macroelements in the leaves of 'Tegera' and 'Elena' plum cultivars for 2017

Indicators	N	P	K	Ca	Mg	Zn	Cu	Mn	Fe	Chloro phyll "a"	Chloro phyll "b"	β-carote ne
	%				mg/kg FW					mg/g FW		
before fruit ripening												
'Tegera'												
I Biofertilizer	1.36	0.28	2.8	1.21	0.32	35	5	28	98	2.29	1.74	1.14
II Conventional	1.08	0.25	2.6	1.26	0.30	23	12	26	91	1.96	1.02	1.01
III Chicken manure	1.20	0.29	3.1	1.36	0.28	18	12	31	109	2.03	1.05	1.07
IV Control	1.09	0.29	2.9	1.24	0.29	19	8	32	88	1.86	1.07	0.97
St. error	0.06	0.01	0.10	0.03	0.01	3.90	1.70	1.37	4.66	0.09	0.17	0.03
St. Dev.	0.13	0.02	0.20	0.06	0.01	7.80	3.40	2.75	9.32	0.18	0.34	0.07
CV %	11.01	6.82	7.30	5.12	5.74	32.86	36.79	9.40	9.66	9.02	28.46	7.07
'Elena'												
I Biofertilizer	0.63	0.23	2.7	1.04	0.29	12	5	33	98	1.26	0.62	0.68
II Conventional	0.56	0.25	2.9	0.95	0.26	14	12	18	91	1.77	0.83	0.91
III Chicken manure	1.25	0.25	2.5	1.00	0.26	13	12	41	109	1.74	0.99	0.91
IV Control	1.16	0.30	2.8	1.15	0.26	11	8	13	88	1.37	0.88	0.71
St. error	0.17	0.01	0.08	0.04	0.01	0.64	1.70	6.49	4.66	0.12	0.07	0.06
St. Dev.	0.35	0.02	0.17	0.08	0.01	1.29	3.40	12.99	9.32	0.25	0.15	0.12
CV %	39.47	11.59	6.26	8.21	5.60	10.32	36.79	49.51	9.66	16.82	18.69	15.54
after fruit harvesting												
'Tegera'												
I Biofertilizer	0.70	0.25	3.0	2.72	0.36	30	16	25	115	1.63	0.80	0.87
II Conventional	0.90	0.20	2.6	3.22	0.37	39	7	21	97	1.89	0.96	0.99
III Chicken manure	1.12	0.33	3.3	3.10	0.36	28	21	15	171	1.51	0.77	0.80
IV Control	1.16	0.32	1.8	3.02	0.41	19	8	47	132	2.11	1.55	1.07
St. error	0.10	0.03	0.32	0.10	0.01	4.10	3.34	6.97	15.79	0.13	0.18	0.06
St. Dev.	0.21	0.06	0.65	0.21	0.02	8.20	6.68	13.95	31.58	0.26	0.36	0.12
CV %	21.98	22.31	24.29	7.06	6.34	28.29	51.41	51.67	24.53	15.04	35.59	12.93
'Elena'												
I Biofertilizer	0.53	0.42	3.4	2.24	0.37	14	39	15	133	0.92	0.72	0.55
IIConventional	0.69	0.20	3.8	2.06	0.33	22	17	7	104	1.04	0.61	0.58
III Chicken manure	0.76	0.29	3.1	2.43	0.28	14	42	18	105	1.48	0.78	0.79
IV Control	0.55	0.39	3.3	1.96	0.31	14	16	7	102	0.71	0.43	0.42
St. error	0.05	0.05	0.14	0.10	0.01	2	6.95	2.80	7.35	0.16	0.07	0.07
St. Dev.	0.11	0.10	0.29	0.20	0.03	4	13.91	5.61	14.71	0.32	0.15	0.15
CV %	17.52	30.82	8.65	9.53	11.70	25	48.82	47.82	13.26	31.32	24.20	26.20

The results from 2017 with respect to the basic nutrients in the leaves before fruit ripening determine that nitrogen was in the range of 0.56% (conventional fertilization of 'Elena' cultivar) to 1.36% (biofertilization of 'Tegera'). The variation coefficient of that element in the cultivars before ripening is from low to medium and after ripening from medium to high. Decreases in that macroelement were also reported in 2018 after fruit harvesting (Table 2). According to Dinkova (2009), the optimal levels of nitrogen and phosphorus in the leaves should be at the intervals: for N (2.5-3.2%) and P_2O_5 (0.38-0.48%). Similar is Kvong (1973) opinion that nitrogen reserves in leaves should be 2.1%. The inverse dependence was found in the phosphorus content. After fruit harvesting in 2017, the amount of the element increased in 'Tegera' up to 0.32-0.33% in the chicken manure variants and the control. Phosphorus content in 'Elena' cultivar was increased to 0.42% in the variant with application of biofertilizers.

Table 2. Content of chlorophyllian pigments, β-carotene and macroelements in leaves of ‘Tegera’ and ‘Elena’ cultivars for 2018

Indicators	N	P	K	Chlorophyll "a"	Chlorophyll "b"	β-carotene
	%			mg/g FW		
before fruit ripening						
‘Tegera’						
I Biofertilizer	1.10	0.13	2.0	1.35	0.79	0.73
II Conventional	0.97	0.08	1.4	1.07	0.74	0.62
III Chicken manure	0.95	0.10	1.6	1.32	0.89	0.72
IV Control	0.89	0.12	1.5	1.19	0.72	0.67
St. error	0.04	0.01	0.26	0.06	0.03	0.02
St. Dev.	0.08	0.02	0.13	0.12	0.07	0.05
CV %	9.04	20.62	16.18	10.44	9.67	7.39
‘Elena’						
I Biofertilizer	0.85	0.39	2.7	1.26	0.73	1.59
II Conventional	0.56	0.31	3.1	1.03	0.51	1.38
III Chicken manure	0.76	0.54	3.4	1.08	0.51	1.34
IV Control	0.90	0.55	2.6	1.01	0.45	1.32
St. error	0.07	0.05	0.18	0.05	0.06	0.06
St. Dev.	0.14	0.11	0.36	0.11	0.12	0.12
CV %	19.54	26.21	12.53	10.39	22.41	8.82
after fruit harvesting						
‘Tegera’						
I Biofertilizer	0.90	0.74	4.3	1.26	0.67	0.70
II Conventional	0.69	0.53	3.8	0.96	0.65	0.54
III Chicken manure	0.73	0.84	4.3	1.25	0.67	0.69
IV Control	0.83	0.65	3.8	1.62	1.21	0.86
St. error	0.04	0.06	0.14	0.13	0.13	0.06
St. Dev.	0.09	0.13	0.28	0.27	0.27	0.13
CV %	12.10	19.11	7.12	21.23	34.18	18.74
‘Elena’						
I Biofertilizer	0.74	0.48	2.6	1.25	0.48	1.55
II Conventional	0.57	0.36	2.4	1.05	0.35	1.25
III Chicken manure	0.76	0.55	3.4	1.11	1.26	1.33
IV Control	0.74	0.62	3.1	0.71	0.28	0.93
St. error	0.04	0.05	0.22	0.11	0.22	0.12
St. Dev.	0.08	0.11	0.45	0.22	0.45	0.25
CV %	12.64	22.06	15.90	22.25	76.39	20.30

The analysis conducted in 2018 reports an increase in the amount of phosphorus in all variants for both plum cultivars. A slight difference was found in the potassium content in the second experimental year among the different cultivars and variants, before and after fruit ripening. Its amount for 2017 was in the range of 1.8% (nontreated control ‘Tegera’, after fruit harvesting) to 3.8% (conventional fertilization of ‘Elena’, after fruit ripening). The lowest potassium content was registered in 2017 in all variants of fertilization before fruit ripening of ‘Elena’.

Calcium and manganese content increased after fruit harvesting in the year 2017. Calcium content before ripening was about 1 mg/kg FW and after harvest about 2-3 mg/kg FW for both cultivars in the four variants. The analysis shows that the microelements content, such as zinc and copper increased significantly after the harvest. Zinc content was higher in the conventional fertilizer variant for all tested plum cultivars, and copper content reached 42 mg/kg FW in ‘Elena’ cultivar. Manganese content over the experimental period varied significantly from 7 to 41 mg/kg FW. The iron content also increased in the leaves after fruit harvesting, most strongly in ‘Tegera’ ranging from 88 mg/kg FW to 171 mg/kg FW.

Chlorophyll "a" in 2017 ranged from 1.37 mg/g FW (‘Elena’) to 2.29 mg/g FW (‘Tegera’). After fruit harvesting, its content decreased to 0.92 mg/g FW (in the biofertilization variant, ‘Elena’ cultivar).

In the following year, lower chlorophyll "a" content was again reported after harvesting. Chlorophyll "b" pigment had similar values throughout the experimental period, before and after fruit ripening.

The green pigments chlorophyll "a", chlorophyll "b", and β-carotene in 2017 and 2018, before ripening and after harvesting, had higher values for 'Tegera' in comparison with 'Elena'.

Table 3. Correlation dependences between chlorophyllian pigments, β-carotene and basic macroelements in the leaves analyzed before and after fruit harvesting of 'Tegera' and 'Elena', average for the period 2017-2018

Cultivar		N, %	P, %	K, %	Chlorophyll "a", mg/g FW	Chlorophyll "b", mg/g FW	β-carotene, mg/g FW
'Tegera'	**before harvesting**						
	N, %	1.00					
	P, %	0.37	1.00				
	K, %	-0.40	0.67	1.00			
	Chlorophyll "a", mg/g FW	0.96	0.53	-0.27	1.00		
	Chlorophyll "b", mg/g FW	0.98	0.51	-0.23	0.95	1.00	
	β-carotene, mg/g FW	0.92	0.53	-0.27	0.99	0.90	1.00
	after harvesting						
	N, %	1.00					
	P, %	0.52	1.00				
	K, %	-0.75	0.02	1.00			
	Chlorophyll "a", mg/g FW mg/gFW	0.71	-0.05	-1.00	1.00		
	Chlorophyll "b", mg/g FW mg/gFW	0.74	-0.10	-0.99	0.99	1.00	
	β-carotene, mg/g FW	0.70	-0.05	-1.00	1.00	0.98	1.00
'Elena'	**before harvesting**						
	N, %	1.00					
	P, %	0.98	1.00				
	K, %	-0.36	-0.34	1.00			
	Chlorophyll "a", mg/g FW mg/gFW	-0.36	-0.40	0.95	1.00		
	Chlorophyll "b", mg/g FW mg/gFW	0.45	0.34	0.47	0.61	1.00	
	β-carotene, mg/g FW	-0.69	-0.79	0.58	0.76	0.30	1.00
	after harvesting						
	N, %	1.00					
	P, %	0.13	1.00				
	K, %	0.25	-0.34	1.00			
	Chlorophyll "a", mg/g FW mg/gFW	0.65	-0.40	-0.17	1.00		
	Chlorophyll "b", mg/g FW mg/gFW	0.91	-0.04	-0.04	0.90	1.00	
	β-carotene, mg/g FW	0.43	-0.31	-0.48	0.94	0.77	1.00

The correlation dependences were made between the pigment's composition and the main macroelements in the leaves of 'Tegera' and 'Elena' plum cultivars before and after harvesting (Table 3). They showed that nitrogen in the leaves, before and after ripening of 'Tegera', correlated positively with pigments, such as chlorophyll "a", chlorophyll "b" and β-carotene. After fruit harvesting of 'Elena', a high variation coefficient was reported between nitrogen and chlorophyll "b" (r = 0.91).

CONCLUSIONS

A comparative study was conducted on the effect of different types of fertilization (conventional and organic) on the content of basic nutrients (macro and microelements) chlorophyllian pigments and β-carotene in the leaves of 'Tegera' and 'Elena' plum cultivars. It was found that the values of macroelements and pigment composition in the leaf samples are variable during pre- and post-harvesting periods for the individual elements and to a large extent determined some characteristics of the physiology and genotypic specificity of the cultivars.

It was found that the amount of chlorophyllian pigments content in the fertilizing variants with 'Tegera' cultivars decreased after harvesting and increased for control trees. Nitrogen and phosphorus increased their content in the leaves of 'Elena' after fruit harvesting in the variant with conventional fertilization.

'Elena' showed a decrease in the values of the pigment content in the leaves after the harvest of the fruit with some exceptions, with a slight increase in the amount of chlorophyll "b" from the 2017 version of biofertilization and significantly larger differences in the same pigment from the chicken manure variant for 2018 (before-0.51 and after fruit harvesting -1.26).

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