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CONTENT OF MINERAL ELEMENTS IN THE LEAVES OF 'WILLAMETTE' AND 'MEEKER' RASPBERRY CULTIVARS

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Abstract

The scientific experiment was conducted during the period of 2018-2019 in a collection plantation of the Research Institute of Mountain Stockbreeding and Agriculture in Troyan with two introduced raspberry cultivars, 'Willamette' and 'Meeker'. The field experiment is based at intra-row spacings between plants (0.50 m and 0.30 m) and inter-row spacings of 3.00 m. The content of mineral elements in the leaves was found during the phenophases, such as full blossoming and fruit harvesting. The results show that 'Willamette' had the highest nitrogen content in the leaf samples in the variant of 0.50 m (3.37%) in 2019 during the phenophase of full blossoming of plants. The phosphorus amount had the highest value in the variant of 0.50 m in 'Meeker' cultivar, as it was 0.27% in the phenophase of full blossoming and 0.28% in fruit harvesting phenophase in the first experimental year. Of the studied elements, the highest content of potassium was reported during the fruit harvesting phenophase in 2018 for 'Willamette' and 'Meeker' at shorter planting distances (0.70%).

Key words*: raspberries, cultivars, agricultural techniques, mineral composition in the leaves.*

INTRODUCTION

Raspberry is a fruit species of great economic importance due to its high productivity and economic efficiency. It is widely used in the foothill and mountain regions of Bulgaria, where soil and climate conditions are largely favourable for its development. However, these areas are characterized by poorly productive, acidic and nutrient-poor soils, which requires the determination of nutrient content in both soil and leaves. Leaf diagnostics is a widely used method in fruit growing, which establishes a direct dependence between the mineral composition of the leaves and the growth and reproductive manifestations of plants. With its application it is possible to determine and control the need for different types of fertilizers. The concentration of mineral elements in leaves largely depends on growth conditions, abiotic or biotic stress, the content of mineral elements in the soil and agrotechnical methods of cultivation (Chaplin & Martin, 1980; Prive & Sullivan, 1994; Hargreaves et al., 2008; Koumanov et al., 2009; Dresler et al., 2015). The nutrient content of leaf tissues may change during the growing season (John et al., 1976). The most important mineral nutrients that stimulate yields for raspberry production are nitrogen (N) and potassium. Nitrogen determines vegetative growth, while potassium increases the cold tolerance and drought resistance of plants. The average content of both elements is usually at a similar level and can be up to eight times higher than the content of phosphorus (P) (Kowalenko 2005; Buskiene and Uselis 2008). Hart et al. (2006) reported that in raspberries, N content varies depending on the yield, growth and age of the plants, soil type, rainfall and cultivar. However, plant growth is an initial indicator of adequacy of N. Wright and Waister (1980) state tht the nutrient content of leaves decreases during the period of plant growth and during fruit formation.

According to Gorbanov (2018), the optimal values for the content of the three nutrients are as follows, for nitrogen in the range of 2.8 to 3.5%, phosphorus - 0.3-0.5% and potassium - 2.0-2.5%.

The objective of the present research is to study the content of some mineral elements in the leaves of raspberry cultivars in different agricultural techniques of plant cultivation.

MATERIALS AND METHODS

The experiment was conducted in the period 2018-2019, in a collection plantation of the Research Institute of Mountain Stockbreeding and Agriculture in Troyan. The objective of the study is the widely distributed raspberry cultivars, such as 'Willamette' and 'Meeker', which are distinguished by high fruitfullness. The area is maintained in black fallow in the intra-row spacings and with naturally grassed row spacing. Fertilization was carried out in the intra-row area to achieve optimal values of the individual nutrients for raspberry plants. They are grown at an altitude of 460 m, eastern exposure with drip irrigation applied. The variants of the experiment are the following:

I var. - planting at 0.50 m distance in the intra-row area;

II var. - planting at 0.30 m distance in the intra-row area;

In both variants the row spacing was 3.00 m.

Leaf samples were taken during the phenophases of full blossoming and fruit harvesting. The samples from the leaves were naturally dried, ground and prepared for analysis, and the following was laboratory tested:

- nitrogen content (according to the Keldal method, BDS - EN ISO 5983);
- phosphorus content - spectrophotometric (Colorimetric method of Guericke and Kurmis, AOAS, 2007);
- the content of potassium (by the method of Atomic absorption spectrophotometry, AOAS, 2007).

The methodology for studying plant resources in fruit plants was used to report the indicators (Nedev et al., 1979). Data processing was performed by the methods of two-way factor analysis of variance (Lidanski, 1988), using software product MS Excel-2010.

RESULTS AND DISCUSSIONS

During the first experimental year the nitrogen content (%) in the raspberry leaves during the period of full blossoming of the plants in the tested cultivars was in the range 0.91-1.09%. It is noteworthy that in 'Willamette', the element has a higher value in the second planting variant, and in the 'Meeker' the element had a higher value in the first planting variant (Table 1). The differences between cultivars and variants for the nitrogen content in the leaves were statistically unproven. According to Kessel (2003) and Methodology (2010), the optimal nitrogen level in raspberry leaves is 2-3.5%. Anonymous (1996) states that the critical level of nitrogen in the leaves is < 2.00%, the optimal - 2.75%, and the excess nitrogen is at > 4.0%. The present study showed that 'Willamette' and 'Meeker' contained insufficient amounts of nitrogen - 2-3 times lower than necessary.

Table 1. Mineral composition of raspberry leaves in 2018 during the period of full blossoming of plants

Cultivars/indicators	N (%)	P (%)	K (%)
'Willamette'- 0.50 m	0.91	0.23	0.60
'Willamette'- 0.30 m	1.09	0.21	0.60
'Meeker'- 0.50 m	1.07	0.27	0.45
'Meeker'- 0.30 m	0.96	0.21	0.45
x ± SE	0.034	0.012	0.037
St. Dev.	0.098	0.033	0.104
VC %	9.71	13.33	23.11
Minimum	0.91	0.21	0.45
Maximum	1.09	0.27	0.60
Level of significance among the variants (P)	n.s	n.s	n.s
Level of significance among the cultivars (P)	n.s	$p < 0.05$	$p < 0.05$

The phosphorus content (%) was higher at longer planting distances, 0.23% at Willamette (0.50 m) and 0.27% at Meeker (0.50 m), respectively. Both cultivars had the same content of the element at a shorter planting distances (0.21%). The difference between the cultivars regarding the phosphorus content in the leaves was statistically significant ($p < 0.05$), and between the agricultural techniques it was unproven. According to Kessel (2003), the optimal level of phosphorus in raspberry leaves is 0.30%. These values indicate that symptoms of insufficient phosphorus were observed in the present study.

The potassium content in leaves was 0.60% in both variants with 'Willamette' and 0.45% in both variants 'Meeker'. The difference between the cultivars in terms of potassium content in the leaves was statistically significant ($p < 0.05$). Kessel claims that the optimal level of potassium in raspberry leaves is between 1-2%. According to Anonymous (1996), the optimal potassium content is 1.5%. These values indicate that symptoms of potassium deficiency have been observed.

Table 2. Mineral composition of raspberry leaves in 2018 during the period of fruit harvesting

Cultivars/indicators	N (%)	P (%)	K (%)
'Willamette' - 0.50 m	0.98	0.25	0.60
'Willamette' - 0.30 m	1.15	0.22	0.70
'Meeker' - 0.50 m	0.85	0.28	0.60
'Meeker' - 0.30 m	0.86	0.26	0.70
x ± SE	0.07	0.01	0.02
St. Dev.	0.19	0.023	0.06
VC %	17.95	9.62	9.85
Minimum	0.85	0.22	0.60
Maximum	1.15	0.28	0.70
Level of significance among the variants (P)	n.s	n.s	$p < 0.05$
Level of significance among cultivars (P)	$p < 0.05$	$p < 0.05$	n.s

Table 2 presents the results of the nutrients in the leaf samples of the raspberry cultivars during the fruit harvesting period. The data show that the nitrogen content was higher in the variants of 'Willamette' in the period of full blossoming and had the highest value (1.15%) in the second variant. A significant reduction of the element from the first variant was observed in 'Meeker', with a reported value of 0.85%. A lower one was also reported for the second variant of the cultivar - 0.86%. In the statistical processing of data, it became clear that in terms of nitrogen content in the leaves, the differences between the cultivars were significant ($p < 0.05$).

With regard to phosphorus, an increase in its content in the leaves was found during the fruit harvesting phenophase. Its values ranged from 0.22% for 'Willamette' 0.30 m to 0.28 for 'Meeker' from the other variant. The difference between the cultivars was statistically proven ($p < 0.05$).

During the fruit harvesting period, the potassium content in the leaves compared to the phenophase of full blossoming increased only in 'Meeker' and was respectively 0.60% in the first variant and 0.70% in the second variant of the cultivar. The difference between the cultivars in terms of phosphorus content in the leaves was statistically significant ($p < 0.05$).

In the second experimental year in the full blossoming phenophase, the nitrogen content in the leaf samples was reported to be 2.72% for 'Meeker' at a planting distance of 0.30 m to 3.37% for 'Willamette' 0.50 m (Table 3). In all variants of the genotypes, the element was in higher quantities compared to the previous year of the same phenophase. According to Anonymous (1996), the nitrogen content in the leaves of the studied varieties of raspberries is in optimal values. Mathematically, the differences were proved between the cultivars ($p < 0.05$).

Table 3. Mineral composition of raspberry leaves in 2019 during the period of full blossoming of plants

Cultivars/indicators	N (%)	P (%)	K (%)
'Willamette' - 0.50 m	3.37	0.18	0.36
'Willamette' - 0.30 m	2.94	0.15	0.38
'Meeker' - 0.50 m	2.92	0.12	0.32
'Meeker' - 0.30 m	2.72	0.09	0.37
x ± SE	0.16	0.02	0.01
St. Dev.	0.46	0.04	0.02
VC %	16.2	31.34	6.58
Minimum	2.72	0.09	0.32
Maximum	3.37	0.18	0.38
Level of significance among the variants (P)	n.s	n.s	n.s
Level of significance between cultivars (P)	$p < 0.05$	n.s	n.s

The phosphorus content was highest in 'Willamette' (0.18% and 0.15%) and significantly less in 'Meeker' (0.30 m) - 0.09%. Potassium levels were approximately the same in both genotypes and variants. The highest level was found in 'Willamette' (0.30 m) (0.38%), while the lowest content was found in 'Meeker' - (0.32%). Statistically, the differences are unproven between the variants and the cultivars.

The content of mineral elements in the leaves of raspberries during the fruit harvesting phenophase is presented in Table 4. A significant reduction of nitrogen in the variants was reported in both cultivars. Overall, the presence of the element has approximately the same values, which varied from 2.06% in 'Meeker' (0.30 m) to 2.66% in 'Willamette' (0.50 m). Mathematical differences between cultivars and variants in terms of nitrogen content are unproven.

The phosphorus content (%) in the raspberry leaves was 0.11% for 'Willamette' (0.30 m) and higher 0.16% for the other variant of the cultivar. In 'Meeker' the values are almost the same in both variants - 0.14% (0.30 m), 0.15% (0.50 m). The differences between the cultivars and the variants for the phosphorus content in the leaves are statistically unproven.

It is noteworthy that the amounts of potassium are higher at short planting distances and are respectively 0.37% for 'Willamette' and 0.36% for 'Meeker'. The lowest value of the element was found in 'Meeker' (0.50 m) - 0.32% There was no evidence regarding the potassium content in raspberry leaves during the fruit harvesting phenophase between cultivars and variants. Kessel claims that the optimal level of potassium in raspberry leaves is between 1.0-2.0%. These results show insufficient potassium levels.

Table 4. Mineral composition of raspberry leaves in 2019 during the period of fruit harvesting

Cultivars/indicators	N (%)	P (%)	K (%)
'Willamette' - 0.50 m	2.66	0.16	0.36
'Willamette' - 0.30 m	1.98	0.11	0.37
'Meeker' - 0.50 m	2.37	0.15	0.32
'Meeker' - 0.30 m	2.06	0.14	0.36
x ± SE	0.09	0.01	0.01
St. Dev.	0.27	0.03	0.02
VC %	10.92	17.42	6.99
Minimum	1.98	0.11	0.32
Maximum	2.66	0.16	0.37
Level of significance among the variants (P)	n.s	n.s	n.s
Level of significance between cultivars (P)	n.s	n.s	n.s

CONCLUSIONS

A study was made on the dynamics in the values of the nutrients, such as nitrogen, phosphorus and potassium in leaf samples of 'Willamette' and 'Meeker' raspberry cultivars.

The results of the study show that 'Willamette' and 'Meeker' contain an insufficient amount of nitrogen, which was 2-3 times lower than the allowed in the first year. In the second year, the content of the element, due to the applied fertilization, was significantly higher in the variants of the two genotypes in the two phenophases. Only 'Willamette' reached optimal values in the period of full blossoming (3.37%) in the first variant.

In both experimental years, the phosphorus was lower than the reference values for the studied crop.

The highest potassium content was reported during the fruit harvesting period in the variants with the shorter planting distance of the plants in both genotypes in the first experimental year. In general, the values of the element are low and below the allowable.

During the two-year period, a higher percentage of statistical difference between the values of the nutrients was reported between the cultivars. An exception is observed in the potassium content between the variants in the first year of the fruit harvesting phenophase.

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