

THE INFLUENCE OF THE CONTENT OF TOTAL NITROGEN, POTASSIUM AND THE METHOD OF CULTIVATION ON SOME QUALITATIVE FEATURES OF STRAWBERRY

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Abstract

The qualitative composition of the ripe fruits of strawberry (hybrid variety- Alba) was examined on growing areas in Glumova (open field) and Shishova (in greenhouse conditions) in the municipality of Saraj- Skopje, with some different agrochemical characteristics, i.e. in Glumova the average total nitrogen values of 0.182% and potassium (K₂O) 29.50mg/100g soil were significantly higher than those found in Shishova (0.116% and 20.24mg/100g soil). In ripe strawberry fruits, the amounts of total sugars, ascorbic acid (vitamin C), total nitrogen and potassium found were significantly dependent on the agrochemical properties and the method of their cultivation. In strawberry fruits grown in greenhouse conditions (Shishova), the amount of total sugars 3.68%, ascorbic acid (64.57 mg/100g FW), total nitrogen 9.10 mg/g-1 DM and potassium (K) 1.64 % in DM were significantly lower in relation to the average values found in strawberry samples grown in an open field (Glumova).

Keywords: strawberry, agrochemical content, open field, greenhouse condition.

Introduction

The strawberry plant is a perennial, herbaceous plant that belongs to the family Rosácea and the genus *Fragaria* (9). The strawberry a short-day culture (27) requires special conditions of light, temperature and air humidity (28,24,42,41,10,36.).

The previous ones studies on the qualitative composition of the strawberry fruit determined a significant dependence in relation to the humidity and the content of soil nitrogen, potassium and other mineral nutrients (24, 10).

Nitrogen is a key nutrient in crop growth and yield, as it affects photosynthesis and dry matter distribution among organs (20, 39). Studies indicate the existence of a linear correlation between the supply of soil with N and its content in strawberry as a crop (2, 27). When growing strawberries in soil with a high supply of nitrogen, an enhanced potential of vegetative growth was found, while flowering, fruit yield and quality were reduced (21, 32).

Potassium as a macronutrient primarily has a significant effect on the activation of enzymes, protein synthesis, photosynthesis, stomatal movement and water relation in plants (25). Adequate K nutrition has also been associated with increased yields, fruit size, increased solute and ascorbic acid concentrations, improved fruit color, increased shelf life, and quality of many horticultural crops (8, 22, 15). When executed fertilization with K, a linear increase in their amount in strawberry fruits was observed (17). **Exceeding the optimal doses of K in strawberry cultivation can worsen the conditions for growth and development, which will undoubtedly affect the quantity and quality of fruit yield (37).** According to the research carried out (13, 14) in the case of potassium deficiency, a reduced synthesis of proteins is

observed in addition to the available amounts of nitrogen, that is, accumulation of nitrates, amides and soluble sugars.

The strawberry fruit is especially valued as a functional food primarily because of the high content of vitamin C, secondary metabolites and mineral substances (12, 5, 31, 24, 35). According to (5), obtained vitamin C contents in ripe strawberry fruits ranged from 39 to 89 mg/100 g in pulp, i.e. from 44 to 80 mg per 100 g of fresh weight, i.e. they belong to the category of fruits medium to high provided with vitamin C (31).

The content of total sugars in strawberry fruits (4.8–5.4 g/100 g FW) according to (29, 38) proved to be dependent on the variety, the stage of ripening, as well as on the supply of the soil, especially potassium, which participates in metabolic processes of synthesis and translocation of sugars and soluble substances (25, 8, 22).

The purpose of this research was also to examine the influence of the present amounts of total nitrogen and potassium in the soils of the experimental plots and the method of strawberry cultivation on the content of total sugars, proteins, and vitamin C of ripe strawberry fruits, as well as the amount of absorbed total nitrogen and available potassium from the soil.

Material and methods

The experimental strawberry (Alba variety) was grown in two localities of the municipality of Saraj-Skopje, namely in Glumovo on an experimental plot of 2500 m² in open field conditions and in the locality of Shishovo in greenhouse conditions (each greenhouse with an area of about 180 m²). In both localities, the irrigation of the cultivated strawberries is realized through an established drop-by-drop system.

The total nitrogen content was determined in the soil samples of the experimental areas with strawberries (ISO -11261), potassium content (according to AL method (ammon lactate method, flame photometric) and pH value (pH value in water is determined according to MKC ISO 10390:2015);

Samples of fresh ripe strawberry fruits were collected during the month of May, during which their fresh mass was measured, to then determine the content of dry mass and the qualitative composition, i.e. the pH value (pH meter), total protein content (Kjeldahl method), of total sugars (according to Bertrand's method) and the content of vitamin C (titrimetric method using iodine dissolution), while the content of potassium (K₂O) in dry mass was determined using an atomic absorption spectrometer (Flame atomic absorption spectrometry, Agilent 55 A).

The data were reported as the means \pm the standard deviation (SD) experiments run in triplicate and were analyzed using SPSS 17.0 (34). A Pearson correlation test was conducted to determine the correlation between variables. Significance levels were defined $p < 0.05$.

Results and discussion

Total soil nitrogen content (%N)

The results for the amount of total nitrogen are listed in Table 1. From the data for the measured amounts in Glumovo locality of 0.182% and in Shishovo of 0.116% we can state that the soil in Glumovo is well supplied with total nitrogen, that is, in Shishovo it is moderately supplied (11). The amount of total nitrogen in the soil of Shishovo locality compared to the same one in Glumovo is significantly lower, i.e. by 36.3%.

The good provision of the soils with nitrogen indicates that the soils of both localities had favorable conditions for the mineralization of organic nitrogen forms in the soil.

Table 1. Chemical composition of soil from an experimental strawberry plot

Location	Depth /cm/	Soil				
		Total nitrogen (N%)		Potassium (Kmg/100g)		pH
Glumovo	0-20	0.230±0.03*		-		6.90
	20-40	0.132 ± 0.02		-		6.67
	Mean	0.182 ± 0.06	100.0	30.04±10.9	100.0	6.80 100.0
Shishovo	0-20	0.129±0.02*		-		6.20
	20-40	0.104 ± 0.01		-		6.18
	Mean	0.116 ± 0.01	63.7	20.24± 4.3	67.4	6.19 91.0

Significance by: * - $p \leq 0.05$ between Glumovo and Shishovo

Tests on the level of available potassium in experimental soils (Tab.1) showed a higher presence in the locality Glumovo (30.04 mg/100g) and Shishovo (20.24 mg/100g), i.e. well-supplied soils (11). The measured amounts of available potassium in Shishovo are significantly lower, i.e. by 32.6%, compared to the same found in the Glumovo locality.

pH reaction of the soil solution

From the performed tests of the substitution reaction (pH in KCl) of the soil (Tab.1), we can notice that the average value in the Glumovo locality is 6.80, that is, in the Shishovo locality, 6.19. According to the stated values, the soil conditions in terms of pH are favorable in terms of nitrogen and potassium uptake by the experimental strawberry (33).

Total nitrogen and potassium content of ripe strawberry fruits

The results of the measured amounts of nitrogen and potassium in the ripe fruits of nitrogen are given in tab. 2.

Table 2. Chemical composition of ripe strawberry fruits

Location	% moisture	Total nitrogen (%) DM		Potassium (K ₂ O) mg/100g DM	
Glumovo	92.16 ± 1.11	9.54 ± 0.23	100.0	2.01 ± 0.31	100.0
Shishovo	93.18 ± 1.14	9.10 ± 0.17	95.38	1.67 ± 0.07	83.08

It was in the ripe fruits of a strawberry from the Glumovo locality measured amount of total nitrogen of 9.54% in dry mass (7.84%), i.e. in the fruits of Shishovo locality total nitrogen content of 9.10% calculated on dry mass (6.82%). The obtained values in relation to the content of total nitrogen in fruits of both locations were within the limits that are consistent with data provided by other authors on nitrogen content in strawberry fruits (3). A positive correlation between the amount of nitrogen and potassium in the soil and the content of the same in the strawberry fruit was also established by (27, 1).

The amounts of potassium measured in ripe strawberry fruits in the Glumovo locality ranged from 1.65-2.37 mg/100g DM, that is, in Shishovo from 1.55-1.76 mg/100g DM. The average value for measured potassium in fruits from Shishovo (1.67 mg/100g DM) were significantly lower by 16.92% than those measured in fruits from Glumovo. (2.01 mg/100g DM). The values obtained for the potassium content in fruits are within the values obtained by other authors (17, 23). Satisfactory soil uptake of potassium indicates favorable agrochemical composition (6, 1).

The content of total proteins, sugars, and vitamin C

The results of research for the content of total proteins in the fresh mass of the ripe fruits are given in tab.3. According to tabular data noted that the average content of total proteins in fruits from Glumovo is 0.54g/100g FW, that is, in fruits from Shishovo 0.45g/100gFW. The measured values for the protein content are in accordance with the level of supply of the experimental soils with total nitrogen (30, 40).

Table 3. Nutritional composition of the fresh weight of ripe strawberry fruits

Location	Total proteins g/100g FW		Total sugars % FW		Vitamin C mg/100 g FW	
Glumovo		0.53		3.15		81.93
		0.54		4.46		82.85
		0.53		4.21		81.80
		0.55		4.02		74.40
	X	0.54 ± 0.01	100.0	3.96 ± 0.57 ^a	100.0	80.25 ± 3.92*
Shishovo		0.46		3.06		68.40
		0.45		3.77		68.60
		0.46		3.95		52.00
		0.44		3.95		69.30
	X	0.45 ± 0.01	83.3	3.68 ± 0.42	92.9	64.58 ± 8.39*

The measured amounts of total sugars in fresh mass (%FW) of fruits are given in the tab. 3. and for the same in the samples from Glumovo they ranged from 3.15-4.46% FW, that is, in those at Shishovo from 3.06-3.95% FW. According to the obtained average values (3.96% and 3.68% FW) for the content of sugars in the ripe fruits there are no significant differences. Our results are consistent with results obtained by other authors (29, 38, 36). The relatively higher contents of total N and especially of K in the soil of Glumovo (0.18% and 30.04%) did not show a special influence on the content of total sugars (18). The influence of potassium on the metabolism of sugars in vegetable crops is also indicated by the data of other authors (25, 32, 4).

The results of the tests on the content of vitamin C in the ripe fruits are given in tab.3. That is to say, in the samples from Gllumovo, the measured amounts range from 74.40-82.85 mg/100gFW, that is, in those from Shishovo, from 52.0-69.30 mg/100gFW. According to the average values (80.25 mg and 64.58 mg/100gFW) obtained for the content of total sugars in the fresh mass of the fruit, a significant difference is ascertained, i.e. in the samples from Shishovo there is a significantly lower content by 19.53%. The higher content of vitamin C in ripe fruits of Glumovo is correlated with adequate levels of soil supply with potassium (22, 7) as well as the efficient translocation of ascorbic acid from leaves to non-photosynthesizing tissues such as a consequence of the favorable concentration of potassium (7). The obtained high contents of vitamin C in strawberry fruits have been confirmed by other authors (19)

Conclusions

1. The lower quality of ripe strawberry fruits grown in Shisovo is the result of the difficult balance of moisture in the soil as well as the temperature conditions of greenhouses in addition to existing differences in the chemical composition of the soil.
2. Ripe strawberries from the Glumova locality grown on an open plot showed a simply significant content of potassium (2.01mg/100g DM), total sugars (3.96%) and vitamin C (80.25mg/100g/FW) compared to the same ones from the Shisovo in which the lowest values of the respective parameters were found (1.67mg/100g, 3.68 % 64.58mg/100g/FW).

3. The influence of present total nitrogen and available potassium in the soil on the quality of the strawberry is also dependent on other components in the soil, primarily the content of other macronutrients and the climatic conditions of the environment where the cultivation is carried out.

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