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Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 12, 2018, no. 1, p. 634-643
doi: https://doi.org/10.5219/928
Received: 11 April 2018. Accepted: 5 September 2018.
Available online: 28 September 2018 at www.potravinarstvo.com

ISSN 1337-0960 (online)

THE EFFECT OF FOLIAR FEEDING ON PHYSIOLOGICAL CONDITION OF APPLE TREES AND CHEMICAL CONTENT OF FRUITS

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ABSTRACT

Chemical content of leaves and fruits of the low growing apple trees on the rootstocks SK4 and M9 in the result of application of foliar feeding with water solutions of various mineral fertilizers was studied. Special ballastless multi-nutrient fertilizers in solid and liquid forms containing a wide range of chelated microelements were used. The effect of foliar feeding on the content in plants and fruits of macro- and microelements at the fruit maturity stage was estimated with the help of the method of leaf analysis. Significant stable increase of the content of nitrogen and potassium was observed in the leaves of apple trees on the rootstocks SK4 and M9. The content of potassium and calcium in apples became higher. With the help of statistical analysis it is shown that there exists close correlation between the content of elements in leaves and fruits: (N) r = 0.79; (K) r = 0.77; (Ca) r = 0.94; (Cu) r = 0.75; (Mn) r = 0.89; (Zn) r = 0.75; (B) r = 0.70. In the result of our physiological and biochemical tests positive effect of mineral feeding on the functional condition of apple trees during summer season when being subjected to intensive hydrothermal stress factors was established. The foliar feeding effect appeared as changing of the ratio of water fractions in the apple tree leaves at the background of increasing atmospheric drought, which in some years in July and August reached the criteria of "hazardous weather". Sufficient level of water content in the cells of apple trees on the rootstocks SK4 and M9 in case of foliar application of fertilizers was ensured as a result of bound water increasing. Statistic analysis of the experimental data showed significant changes in the ratio of bound and free water fractions. In August, in the environment of strong impact of negative abiotic factors, at higher level of water content in the tissues it was found that the content of pigments in leaves was much higher than in the reference version. The functional changes confirm that application of mineral nutrients contributes to activation of the adaptation mechanism. When foliar feeding is used the content of biologically active substances in apples is the highest: content of vitamin C increases by 13.6 – 15.2%, vitamin P – by 8.7 – 24.6%.

Keywords: apple tree; abiotic stress; foliar fertilizer; adaptability; quality of apples

INTRODUCTION

In the southern regions of Russia the period of summer vegetation of plants in the recent years is characterized by durable hyperthermia alongside with high insolation, drought conditions and dry hot winds. For perennial fruit plants negative impact of abiotic factors causes destruction of physiological homeostasis and results in shifts in the process of form-building, failure of reproductive function, decrease of fruits quality **(Gudkovsky, 2005; Nenko et al., 2014, 2015; Doroshenko, Zakharchuk and Ryazanov, 2000, 2010; Goncharova, 2011, Srinivasa Rao, Laxman and Shivashankara, 2016)**. Current importance of finding proper solutions for enhancement of the fruit plants adaptability under conditions of physical stresses is regularly covered in scientific literature **(Zhu, 1997; Vardanov, 2003; Wood, 2005; Šircelj, 2007; Shanker, 2011; Doroshenko, Chumakov and Maksimtsov, 2012; Yushkov, 2016, Sofo and Palese, 2012)**. One of the most efficient methods for normalization of functional status of perennial fruit plants consists in optimization of the content in plants of biogenic elements, participating in biochemical and physiological metabolism **(Trunov et al. 2009, 2011, Abilfazova and Belous, 2015)**. Based on the known mechanism of retention and transportation by leaves of ions from solutions of nutritive salts there was developed the method of foliar feeding, ensuring prompt introduction of mineral elements into metabolic processes at different stages of plant growing **(Rogachev, 2008; Nenko, 2015, Ryndin et al., 2017)**. Systematic implementation in the technological procedure of fruit plans growing of foliar feeding with the help of water solutions of macro- and microelements represents a perspective method for enhancement of the plants adaptability, stabilization of agrocoenosis functioning in general.

In the process of investigation of the possibility of actual controlling the physiological parameters of fruit plants under unstable environmental conditions with the help of foliar feeding method, during 2014 – 2017 we performed field tests with fruit-bearing low growing apple trees of a group of varieties.

Scientific hypothesis

The principal assumption taken as basis for the objective of the performed researches was the working hypothesis of regulatory function of nutritive salts on the adaptability of apple trees, which is of crucial importance for production of fruits of high quality having valuable economic traits.

MATERIAL AND METHODOLOGY

Experimental works were carried out with the help of field and laboratory research methods. For performance of field and analytical works there were used biological, agrochemical and physiological procedures. The field tests were located in the experimental production enterprise "Central" of the North-Caucasian Scientific Research Institute of Horticulture and Viticulture (Krasnodar) in the garden set out in 2009. Geographically, the experimental site is located in the central plains of the Krasnodar Territory. Height above sea level varies from 19 to 32 m. The climate is temperate-continental. In the southern part, there is a subtropical climate at times, especially in the summer and deep autumn. Winter is short and warm. Summer here is long and hot. In the off-season, rain falls often and the winds blow. The annual amount of precipitation is in the flat part from 400 to 600 mm. The average air temperature is +12.1 °C (in recent years, the average annual temperature is kept at 13.3 °C).

The object of researches in 2014 – 2015 were low growing apple trees on the rootstock SK4 (Idared, Prikubanskoe varieties), in 2016 – 2017 - apple trees on the rootstock M9 of Szampion variety (Figure 1).

The apple trees varieties and rootstocks were released for the regional conditions. The plantation of fruit-bearing apple trees occupies an even plot of land. The garden soils are represented by extra-thick low-humic leached chernozem. The key parameters of the garden soil are as follows: pH value of aqueous extract is neutral, 7.2 – 7.3 at the depth of 0 – 20 cm, 7.2 at the depth of 20 – 40 cm. Humus content in the surface soil is 2.9 – 3.3%. Content of nitrate nitrogen for (0 – 20 cm) is 5.4 – 5.5 $mg.kg^{-1}$; (20 – 40 cm) 0.9 – 2.4 $mg.kg^{-1}$. Quantity of labile phosphorus for (0 – 20 cm) is 385 – 397 $mg.kg^{-1}$; (20 – 40 cm) 304 – 308 $mg.kg^{-1}$. Content of exchangeable potassium for (0 – 20 cm) is 266 – 345 $mg.kg^{-1}$; (20 – 40 cm) 133 – 239 $mg.kg^{-1}$.

The tests were performed in four replications. For each replication there were 6 estimated plants. Trees were sprayed tree times with the help of a back-pack sprayer: 15 days after blossom, at the stage of fruit inception and growing, after the June fruit reduction.

In 2014 – 2015 the apple trees were sprayed with 0.5% water solution of polynutrient salts of "Aquarin" series (manufactured by JSC "Buisk chemical plant", Russia), having the following chemical compounds: N12P12K35Mg2S0,7. The fertilizers include chelated microelements of Fe, Cu, Zn, Mn, Mo.

In 2016 – 2017 there were applied foliar feedings with liquid polynutrient nitrogen-calcium fertilizer "SeliKa" (manufactured by LLC "Kuban-agro-humates") including: N18Ca19 + chelated microelements (Fe, Al, Ni, Mn, Zn, Mo, Co, Cu). The fertilizer dosage for trees spraying was as follows: 1 version – 10 $L.ha^{-1}$; 2 version – 15 $L.ha^{-1}$ at the consumption of spray solution 800 $L.ha^{-1}$.

As a reference version there was taken the version of spraying trees with pure water free of any fertilizers.

The chemical content of apple leaves and fruits was studied after accelerated wet ashing **(Voskresenskaya, 2006)**. In the ashed material the total content of nitrogen was measured with the help of chloramine-T method, of phosphorus – by "blue" phosphatomolybdic complex with colorimetric endpoint determination on photocolorimeter KFK-3-01 ("Zagorsk optical and mechanical plant", Russia), of potassium – using the method of flame photometry at the spectrophotometer PFA-354 (OOO "UNICO-SIS", Russia) of calcium and magnesium – with the help of complexometry **(Voskresenskaya, 2006)**.

Physical characteristics of the apple tree condition were determined with classical methods: the factor of thermal drought – by Kushnirenko **(Kushnirenko, 1986)** (Moisture Analyzer ML-50, A&D Company Limited, Japan), the content of photosynthetic pigments – with spectral method (UNICO 2800 SpectroQuest, UNITED PRODUCTS & INSTRUMENTS (USA)).

Statisic analysis

Content in apples of total sugars, organic acids, vitamin C, bioflavonoids was measured with the help of appropriate methodological guidelines **(Volobueva, 2008)**. Processing of experimental data was carried out by methods of correlation, regression and dispersion analysis out in compliance with the recommended procedures **(Volkov, 2005)**. All calculations were made with the help of Microsoft Office 2010 software package ("Microsoft, Inc.", USA).

Figure 1 The picture of Apple fruit researched in the experience.

RESULTS AND DISCUSSION

The intensity and duration of stress factors were reported on the basis of regular registration of variations of the daytime air temperature, quantity and periodicity of atmospheric precipitations falling during summer season. Observations showed that within the period of 2014 – 2015 the hydrothermal stress factors were increasing starting from June. Every year in the first decade of June the maximum daytime air temperature was about 28 – 31 °C. Minor precipitations were falling from time to time (0.3 – 10.3 mm), therefore during a month the air humidity sometimes increased.

At the beginning of the first decade of July the air temperature reached 31 – 32 °C. During the second and third decades it was sometimes above 34 – 36 °C. Precipitations fell with intervals of 3 – 5 days in quantity of 0.1 – 1.3 and 3.4 – 22.0 mm.

In 2014 and 2015 there were no rainfalls in August, for a long time the maximum air temperature was registered at the level of 34 – 40 °C, maximum air humidity sometimes was 12 – 14%.

The summer seasons of 2016 – 2017 were also characterized by hydrothermal stresses. In 2016, starting from the second decade of July till the second decade of September, the maximum daytime air temperature reached 34 – 38 °C. Duration of rainless period exceeded one and a half months. In 2017 from July till the end of August the air temperature regularly increased up to 33 – 40 °C. Rainless period lasted over 40 days. The atmospheric drought meeting the criteria of "hazardous weather" was reported.

Under such conditions at the initial stage of experiment the chemical content of indicative plant organs and content of mineral elements in apple fruits were analyzed in dynamics at the background of feeding with foliar-applied fertilizers **(Popova, 2014; Sergeeva, 2015; Yaroshenko, 2016)**. It was ascertained that the leaf-dressing with special mineral fertilizers had effect on the chemical content of apple leaves and fruits, analyzed at the maturity stage (Table 1). Such tendency was maintained within the whole period of researches. Stable significant increase of the content of nitrogen and potassium was found in the leaves of apple trees on the rootstocks SK4 and M9. For apple trees on the rootstock M9 the most increase of potassium in leaves was determined in case of feeding with aqueous solution of fertilizer at the dosage of 15 L.ha^{-1}. The highest as compared with the reference version increase of the content of potassium in apples was determined in all versions of the experiment with application of fertilizers. The content of

Table 1 Effect of fertilizers on the content of macronutrients in the leaves and fruits of apple, %.

Variation	N		P		K		Ca		Mg	
	Leaf*	**Fruit**	**Leaf***	**Fruit**	**Leaf***	**Fruit**	**Leaf***	**Fruit**	**Leaf***	**Fruit**
					Rootstock SK 4					
Control	2.0 ±0.05	0.45 ±0.019	0.21 ±0.002	0.021 ±0.001	1.0 ±0.026	0.68 ±0.015	2.2 ±0.05	0.18 ±0.001	0.30 ±0.003	0.083 ±0.001
N12P12K35Mg2S0,7+Fe, Cu, Zn, Mn, Mo, B	2.4 ±0.02	0.48 ±0.017	0.22 ±0.003	0.019 ±0.001	1.1 ±0.029	0.78 ±0.012	2,3 ±0.33	0.19 ±0.002	0.34 ±0.026	0.083 ±0.026
LSD ($p \leq 0.05$)	0.11	0.05	0.01	0.002	0.08	0.04	0.23	0.01	0.05	0.006
					Rootstock M 9					
Control	2.2 ±0.016	0.34 ±0.006	0.23 ±0.009	0.059 ±0.009	0.64 ±0.004	0.57 ±0.008	1.99 ±0.025	0.19 ±0.005	0.53 ±0.01	0.03 ±0.005
10 L.ha^{-1}	2.3 ±0.007	0.35 ±0.006	0.23 ±0.01	0.061 ±0.001	0.75 ±0.023	0.57 ±0.006	1.96 ±0.037	0.16 ±0.005	0.54 ±0.018	0.022 ±0.005
15 L.ha^{-1}	2.3 ±0.025	0.38 ±0.006	0.24 ±0.009	0.062 ±0.001	0.88 ±0.03	0.69 ±0.04	2.04 ±0.023	0.21 ±0.003	0.57 ±0.015	0.02 ±0.003
LSD ($p \leq 0.05$)	0.10	0.03	0.04	0.003	0.13	0.03	0.14	0.018	0.05	0.018

Note: * The content of mineral elements in leaves in the second decade of August, pouring fruit.

Table 2 Effect of fertilizers on the content of micronutrients in the leaves and fruits of apple, mg.kg^{-1}.

Variation	Cu		Zn		Mn		B		Fe
	Leaf*	Fruit	**Leaf***	Fruit	**Leaf***	Fruit	**Leaf***	Fruit	**Leaf***
				Rootstock SK 4					
Control	2.9 ±0.15	3.0 ±0.15	15.9 ±0.18	2.2 ±0.19	19.3 ±0.82	0.3 ±0.03	9.4 ±0.57	4.1 ±0.12	33.4 ±0.95
N12P12K35Mg2S0,7+Fe, Cu, Zn, Mn, Mo, B	3.1 ±0.1	2,9 ±0.2	15.5 ±1.07	2.5 ±0.39	19.7 ±0.35	0.5 ±0.33	10.7 ±0.15	4.5 ±0.17	34.4 ±0.80
LSD ($p \leq 0.05$)	0.4	0.5	2.1	0.8	1.8	0.1	1.2	0.4	2.4

Note: * The content of mineral elements in leaves in the second decade of August, pouring fruit.

calcium also increased (by 5.6%), but slightly. Foliar feeding had no effect on the content of phosphorus and magnesium in fruits. In apples of Szampion variety apparent increase of the content of nitrogen at the maturity stage was established only at the background of feeding with nitrogen-calcium fertilizer in the maximum dosage. Accumulation of nitrogen did not exceed the maximum permissive limits.

Correlation analysis of quantitative parameters of the mineral content in apple leaves (X) and fruits (Y) revealed rather close interrelation between such values. The correlation factors are as follows: (nitrogen) r = 0.79; (potassium) r = 0.77; (calcium) r = 0.94.

Our researches have shown that for the apple trees on the rootstock CK4 certain accumulation of microelements was observed in the leaves and fruits in the result of application of the solution of special multi-nutrient fertilizer "Aquarin" (Table 2). Availability in the fertilizer formula of chelated microelements contributed to increasing the content in the leaves of ferrum (3%), copper (7%), manganese (2%), boron (14%). Apparent increase of the content of ferrum, copper and manganese in the leaves was not confirmed statistically, however in the apples at maturity stage there was measured significant increase of quantity of manganese and boron as compared to the reference version. The resulting experimental data were subjected to correlation analysis and interrelation between the parameters in the "leaf-fruit" system was established: (copper) r = 0.75; (manganese) r = 0.89; (zinc) r = 0.75; (boron) r = 0.70.

Further stage of researches was dealing with study of the effect of mineral foliar feeding and changes of the apple feeding schedule on physiological condition of apple trees and their functional stability during the period of summer abiotic stresses **(Popova, 2013, 2014, 2017; Yaroshenko, 2014, 2017; Sergeeva, 2014, 2015)**. The interrelation between increase of the content of macro- and micronutrients in the apple trees and dynamics of fractional water composition in the leaves under conditions of intensification of hydrothermal stress factors was analyzed (Table 3). Such parameter is helpful for identification of the water balance, it characterizes the level of water supply for an apple tree in the drought environment and can be regarded as a factor of plant stability. In May, in the absence of negative impact of abiotic factors, prior to application of water solutions of fertilizers to the apple trees on the rootstock CK4, the content of water in leaves of the reference version was much higher. The ratio of water fractions was 4.1 and 6.1 respectively. Already in June, after

Table 3 Seasonal dynamics of fractional water composition in apple tree leaves, %.

Variation	May		June		July		August	
	free form of water	bound form of water	free form of water	bound form of water	free form of water	bound form of water	free form of water	bound form of water
Rootstock SK 4								
Control	17.8	82.2	38.0	62.0	38.8	61.2	21.1	77.9
N12P12K35Mg2S0,7+ Fe, Cu, Zn, Mn, Mo, B	14.0	86.0	34.7	65.3	31.2	68.8	20.1	79.9
LSD ($p \leq 0.05$)	2.9	4.4	2.7	3.4	4.3	6.5	3.3	1.7
Rootstock M 9								
Control	-	-	30.3	69.7	49.0	51.0	25.6	74.4
10 L.ha^{-1}	-	-	32.7	67.3	41.1	58.9	22.2	77.8
15 L.ha^{-1}	-	-	35.0	65.0	34.1	65.9	20.8	79.2
LSD ($p \leq 0.05$)	-	-	3.9	4.0	6.3	7.4	3.4	4.7

Table 4 Characteristics of the pigmentary complex of apple leaves in connection with application of sheet dressings, mg.g^{-1} of dry matter.

Variation	May		June		July		August	
	chloro-phyll (a +b)	carotenoids	chloro-phyll (a +b)	carotenoids	chloro-phyll (a +b)	carotenoids	chloro-phyll (a +b)	carotenoids
Rootstock SK 4								
Control	2.49	1.62	3.59	1.83	4.05	1.91	2.66	1.49
N12P12K35Mg2S0,7+Fe, Cu, Zn, Mn, Mo, B	3.60	2.02	3.98	2.07	4.04	1.95	4.32	2.29
LSD ($p \leq 0.05$)	0.52	0.26	0.65	0.30	0.14	0.32	0.27	0.23
Rootstock M 9								
Control	-	-	5.16	1.77	4.32	2.11	3.69	1.77
10 L.ha^{-1}	-	-	5.38	1.81	4.54	2.11	3.90	2.01
15 L.ha^{-1}	-	-	5.68	2.07	5.17	2.30	4.10	2.13
LSD ($p \leq 0.05$)	-	-	1.20	0.36	0.67	0.40	0.42	0.35

application of foliar feeding, the content of free water increased by 2.5 times, which can be regarded as evidence of activation of physiological activity of plants. The ratio of free and bound water in the experimental versions was 1.6 and 1.9. During such period in the apple trees on the rootstock M9 at the background of mineral feeding the content of free water was much higher than in the reference version. Such value was substantially higher when maximum fertilizer dosage of 15 $L.ha^{-1}$ was applied. Correlation analysis of the results at this stage of researches established close direct interrelation between quantity of potassium in the leaves and content of free water. The correlation factor is: $r = 0.76 – 0.83$.

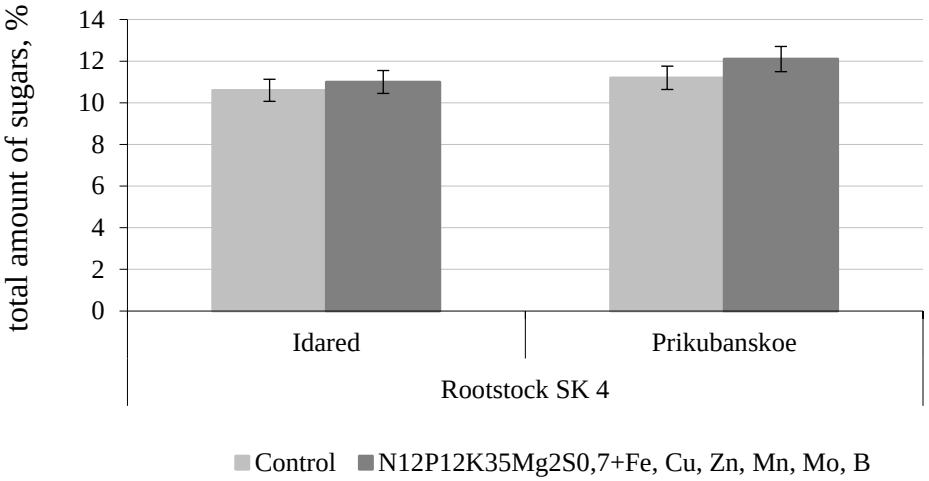

Figure 2 The total amount of sugars in apples per 100 g of raw material, LSD ($p \leq 0.05$) = 0.76 (Idared); 0.40 (Prikubanskoe).

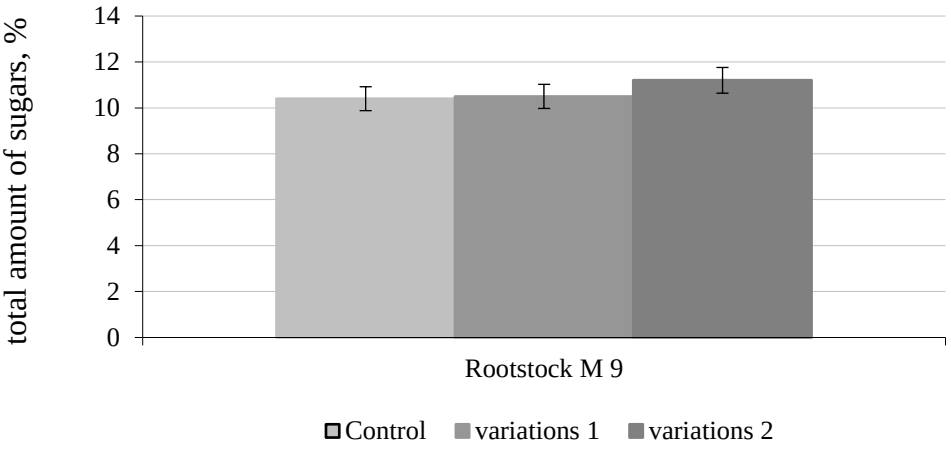

Figure 3 The total amount of sugars in apples Szampion per 100 g of raw material, LSD ($p \leq 0.05$) = 1.23.

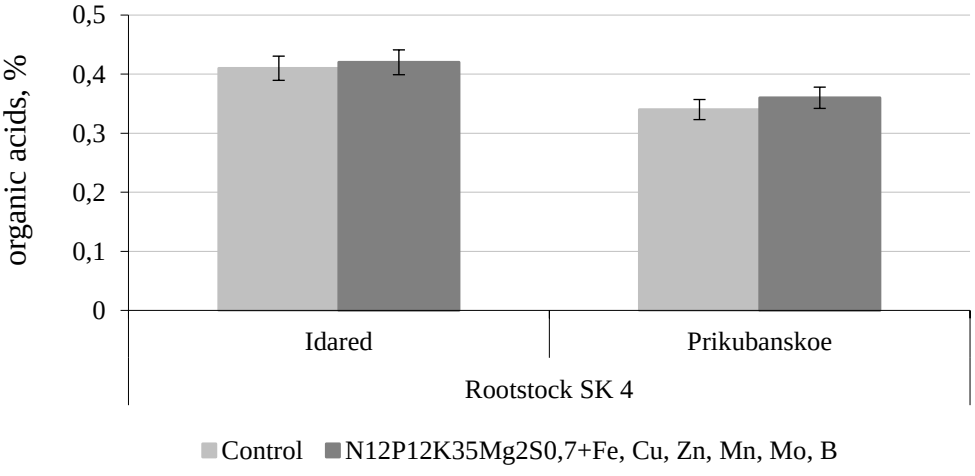

Figure 4 The content of organic (titrated) acids in apples per 100 g of raw material, LSD ($p \leq 0.05$) = 0.03 (Idared); 0.06 (Prikubanskoe).

During the second half of summer, alongside with increasing stress of hydrothermal factors, the content of free water in the leaves after being subjected to mineral feeding was decreasing at the highest rate. Such tendency was maintained during the whole period of researches for the apple trees on the rootstocks SK4 and M9. Under conditions of maximum intensity of hydrothermal stress factors (in August) sufficient water content in the cells of apple trees on the rootstocks SK4 and M9 upon foliar application of fertilizers was ensured due to increase of bound water. Statistic analysis of the experimental data showed significant changes in the ratio of bound and free water fractions. The correlation factor during such period in the reference version and in the version with application of fertilizers was already respectively 3.7 and 4.0 (for apple trees on the rootstock CK4); 2.9 and 2.5 – 3.8 (for apple trees on the rootstock M9). The functional changes in the apple trees ascertained under impact of abiotic stress characterize application of foliar

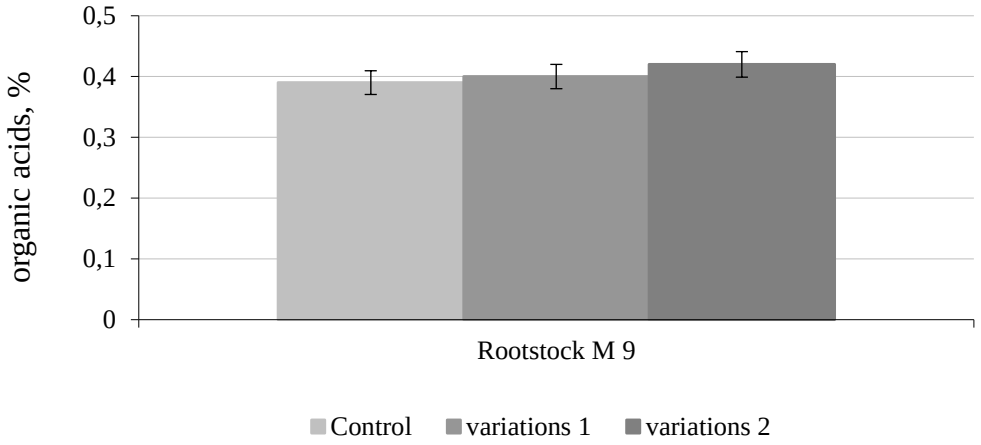

Figure 5 The content of organic (titrated) acids in apples Szampion per 100 g of raw material, LSD ($p \leq 0.05$) = 0.05.

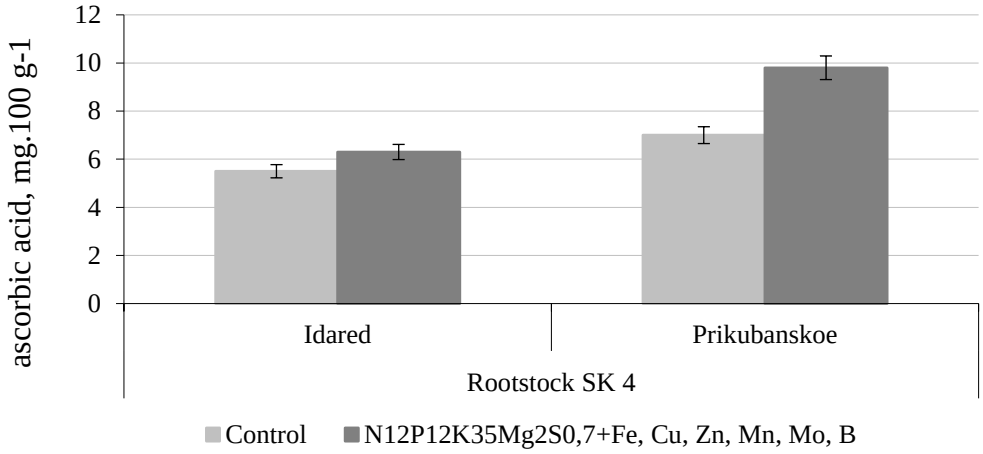

Figure 6 The content of ascorbic acid (vitamin C) in apples per 100 g of raw material, LSD ($p \leq 0.05$) = 0.42 (Idared); 0.29 (Prikubanskoe).

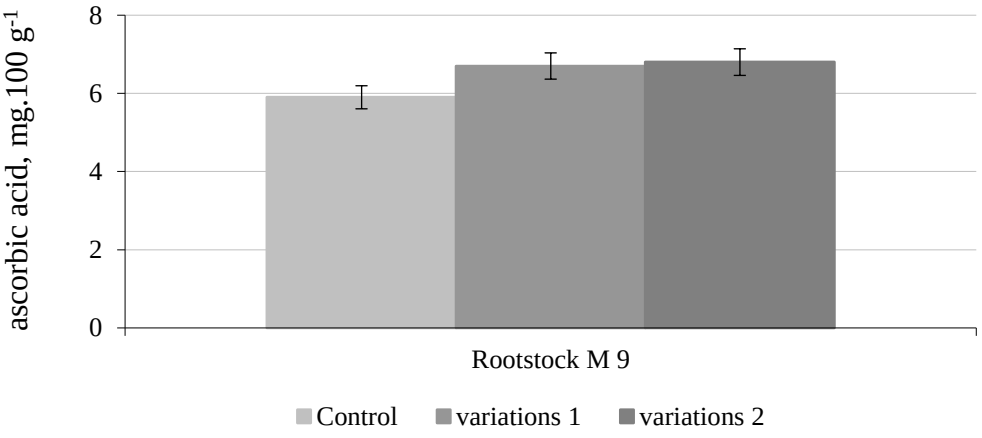

Figure 7 The content of ascorbic acid (vitamin C) in apples Szampion per 100 g of raw material, LSD ($p \leq 0.05$) = 0.34.

feeding with special mineral fertilizers as a factor, increasing resistance of plants.

Seasonal dynamics of fractional water composition in apple leaves had influence on the intensity of synthetic processes. Photosynthetic activity of plants was studied (Table 4).

After foliar application of mineral fertilizer solutions in May the apple trees on the rootstock SK4 formed better pigmentary complex. In July, during the period of differentiation of fruit buds, the content of chlorophyll and carotinoids in apple leaves became approximately equal in the reference and experimental versions. In August, at the background of intensive negative impact of abiotic factors, at higher level of water content in tissues the content of pigments in leaves was much higher than in the reference version. The established functional changes give evidence of more intensive activation of adaptation mechanism under the influence of mineral feeding.

For the apple trees on the rootstock M9 application of mineral feeding already in July caused significant increase of the content of chlorophyll in leaves as compared to the reference version. In August the content of chlorophyll increased less, however the content of carotinoids increased substantially.

Activation of the adaptive system of apple trees for overcoming abiotic stress conditions upon application of mineral feeding facilitated enhancement of the reproductive function. Average growth of productivity for the apple trees on the rootstock SK4 was 10 – 12 %, on the rootstock M9 – up to 22%.

At the maturity stage the properties of apples, characteristic of specific taste and nutritive value of the fruits, were analyzed. It was found that variation of some parameters of qualitative characteristics of apples to a greater extent was dependent on the variety. Apples of Idared and Prikubanskoe varieties from the apple trees on the rootstock SK4 in the reference version had various content of total sugars (Figure 2).

Upon application of mineral feeding to the trees the content of sugar in the fruits was higher, however slightly. And the sugar-acid index (SAI) in the experimental versions was for the Idared variety: 25.8 in the reference samples, and upon application of feedings – 26.2; for the Prikubanskoe variety: 32.9 in the reference samples, and upon application of feedings – 33.9. For the apple trees of Szampion variety the total sugar content slightly changed in various versions of tests (Figure 3). SAI varied within the range of 26.2 – 26.7.

The content of organic acids in apples had less variations (Figure 4). In the fruits of Prikubanskoe apple trees on the rootstock SK4 the annual total quantity of acids in apples at the maturity stage was 14 – 17% less than as compared with

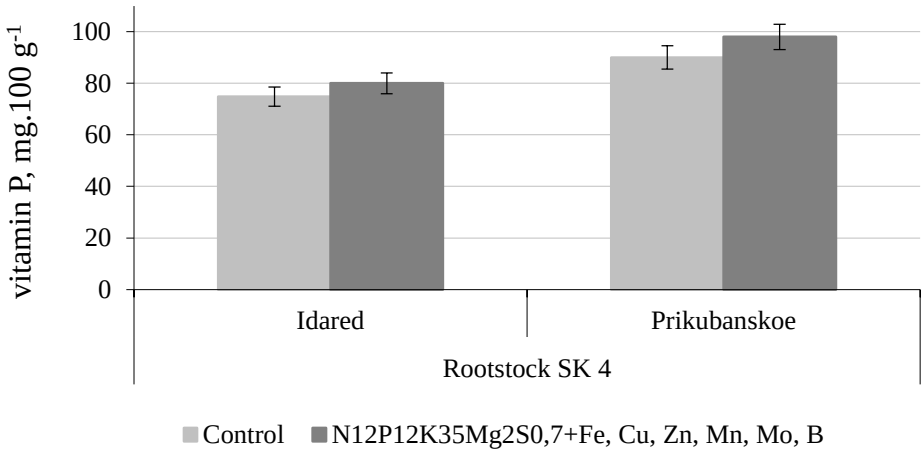

Figure 8 The content of bioflavonoids (vitamin P) in apples per 100 g of raw material, LSD ($p \leq 0.05$) = 5.02 (Idared); 8.42 (Prikubanskoe).

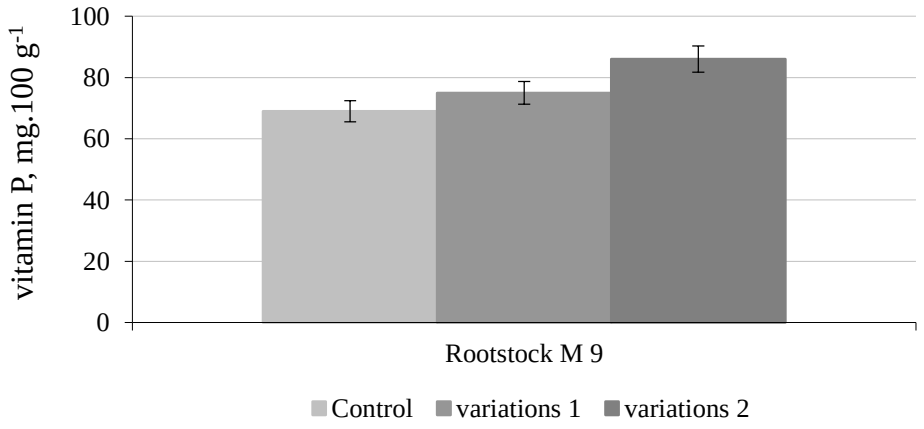

Figure 9 The content of bioflavonoids (vitamin P) in apples of the grade Szampion per 100 g of raw material, LSD ($p \leq 0.05$) = 6.22.

the Idared variety. Meanwhile according to the tasting assessment results the apples at the eating-ripe stage had quite balanced taste. For Szampion apple trees stable content of organic acids in fruits was typical annually. No significant variations of such parameter were measured for different versions (Figure 5).

Analysis of the content of ascorbic acid in the apples of Idared and Prikubanskoe varieties revealed significant advantage of the apples in the version with application of multi-nutrient mineral fertilizer "Aquarin" as foliar feeding (Figure 6). Growth of the content of vitamin C in the apples of Szampion variety was not confirmed statistically (Figure 7).

The effect of foliar feeding resulted in increase of the content of such important for a human food antioxidants as bioflavonoids in the apples of Idared variety (Figure 8). The quantity of biologically active substances in the apples of Prikubanskoe variety increased to a lesser extent.

In the fruits of Szampion variety considerable growth of the content of vitamin P as compared to the reference samples was found in the version with application of the maximum fertilizer dosage of 15 $L.ha^{-1}$ (Figure 9).

CONCLUSION

Thus, experimental testing of the efficient method for optimization of physiological condition of apple trees subjected to negative physical factors during summer season allowed to ascertain that it is possible to enhance adaptability of such plants with the help of regular application of foliar feeding with water solutions of mineral fertilizers. It was established that in the result of application in 2014 – 2015 of the multi-nutrient fertilizer "Aquarin" with the formula N12P12K35Mg2S0,7 + micronutrients on the low growing apple trees engrafted on the rootstock SK4 facilitated higher accumulation of nitrogen and potassium in the leaves, increase of the content of bound water in the tissues of leaves during the period of maximum stress of hydrothermal factors. In the same version a stronger pigmentary complex was formed. Foliar feeding ensured substantial as compared to the reference version accumulation of potassium in the fruits, the content of ferrum, copper, manganese increased slightly. Nutritive value of the fruits was improved due to significant increase of the content of vitamin C and bioflavonoids.

Usage during 2016 – 2017 for foliar feeding of a multi-nutrient liquid potassium-and-calcium fertilizer with a wide range of microelements also facilitated enhancement of the adaptability of apple trees on the rootstock M9. The best efficiency was ensured in case of application of fertilizers in the dosage of 15 $L.ha^{-1}$, which resulted in growth of the content of nitrogen and potassium in the leaves. At the maturity stage the content of nitrogen in the fruits increased within the tolerable limits in comparison with the reference samples, the content of calcium increased by 5.6%.

Changing of the schedule of feeding for the apple trees on the rootstock M9 was connected with activation of physiological processes during summer season. In the first half of summer, in the absence of negative impact of any physical factors, the free water content in the apple leaves of Szampion variety at the background of application of mineral feeding was much higher than that in the reference version. Upon enhancement in August of the stress impact of drought the ratio of bound and free water fractions changed significantly, thus providing evidence of activation of the adaptation mechanism under the influence of mineral nutrients. More intensive photosynthetic activity of the plants was observed during the whole period of researches.

Application of fertilizers in the experiments had no apparent effect on the content of sugars and organic acids in the apples. The highest content of biologically active substances was measured in the apples of the version subjected to foliar feeding: the content of vitamin C increased by 13.6 – 15.2%, vitamin P – by 8.7 – 24.6%.

Based on the results of the researches it can be concluded that regular foliar application of multi-nutrient fertilizers, including macro- and microelements, has effect on the functional condition of low growing apple trees and stabilization of the production processes in general.

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