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INFLUENCE OF ROOTSTOCKS ON MINERAL COMPOSITION OF APPLE CULTIVAR GRANNY SMITH

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Abstract

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The influence of nine dwarf apple rootstocks on vegetative and reproductive characteristics, yield efficiency, fruit quality and fruit ability to absorb and disseminate some 2) micro- and 1) macroelements from soil, through leaves in fruits, was evaluated on 'Granny Smith' apple variety in the region Prespa, Republic of Macedonia. The experimental orchard was established in 2004, with a planting distance 3.5 m×1.5 m. The study has been performed during three consecutive years (2008-2010). In this study, among the common major characteristics, the fruit quality was investigated as well. For that purpose, beside the common parameters such as firmness of the fruits, soluble dry matters and total acids, some macro and micro elements were analyzed. The obtained results showed that, regarding the macro elements, there were no significant differences between the investigated rootstocks. However, regarding the microelements, the results showed different behaviour in distribution of boron, zinc, copper, iron and aluminium. It was found that trees grafted on rootstock Mark 9 have higher content of the previously mentioned elements (B of 14.6 mg/kg, Zn of 58 mg/kg, Cu of 4.8 mg/kg, Fe of 108 mg/kg and Al 83.7 mg/kg). The correlation between the contents of microelements in leafs and apple fruits were also analyzed. The obtained results showed that Mg, B, Zn, Cu, Al, Mn and Fe in leaves, negatively relate with the content of Ca in the fruits. In contrary, N, P and K contents positively relate with the Ca concentration, which is very important for the firmness of the fruits.

Key words: apple; rootstocks; macroelements; microelements; firmness

Introduction

Apple is one of the most important fruit crops grown worldwide, as well as in Republic of Macedonia, with more than 95 000 t of fruit produced annually in the past 10 years. Considering this fact, the rootstock choice seems to be very important in terms of its adaptability to soil and climate conditions, resistance to disease, tree nutrition, productivity and yield efficiency. In that manner, many investigations on rootstock development have been performed recently. As a result, large number of different rootstocks are available on the market. Apple rootstocks vary in their adaptation to soil and climatic conditions (Anderson et al., 1984, Czynczyk and Holubowicz 1984), and resistance to diseases (Ferree et al., 1983). Furthermore, apple rootstocks affect tree size and vigor (Ferree and Carlson, 1987), tree nutrition (Stylianidis et al., 2002), productivity and yield efficiency (Ferree, 1980), photosynthetic rate (Schechter et al., 1991) and fruit size and quality (Daugaard and Callesen, 2002).

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Very often, firmness is parameter used for fruit classification and compared with sensory attributes as an instrumental method of texture evaluation. Many previous investigations related to apple firmness suggest that calcium importantly changes the cracking mode of tissue (Harker et al., 1997; Abbott, 1999; Cybulska et al., 2012). Taking into account the knowledge gained with those investigations, it is obvious that many of the unfavourable textural changes can be avoided using calcium for treatment of the fresh fruit.

In general, the information about the mineral components in apple fruits is very important in terms of their harvest time, post-harvest activities and nutrient importance. Thus, the content of Ca along with Mg and K in the mature apple fruits influences their storage life (Marcelle, 1995; Zavalloni et al., 2001). Also, there is intense competition between vegetation and fruit for available Ca in a tree, and vegetation is by far the stronger competitor. Anything that stimulates vegetative growth will influence against adequate fruit Ca levels. Boron plays a significant role in pollination success and it plays a role in the trees ability to translocate Ca from the roots to other parts of the tree. Zinc content has negative influence on fruit color. Zinc deficiencies result in reducing leaves size and leaves become narrow. The tissue between the main veins turns yellow and chlorotic. Shoot tips do not elongate fully, resulting in short internode lengths and a tuft or rosette of leaves at the terminal. Maintaining fair amounts of copper is important because it is an essential element for plant growth. Manganese deficiencies are more likely on alkaline soils (pH greater than 7.0) and more prevalent during dry seasons. Symptoms are similar to those of Mg deficiency, but they appear first on young leaves (Peterson and Stevens, 1991; Stiles and Reid, 1991; Hanson, 1996).

On the other hand, living organisms require varying amounts of "heavy metals" including iron, copper, manganese and zinc that are essential and required by humans as they play important roles in biological systems, though excessive levels may result in damaging effects to the organism. For example, the recommended dietary allowances (RDA) are 0.9, 8.0-18.0, 8.0-11.0 and 1.8-2.3 mg per day for Cu, Fe, Zn and Mn, respectively. This level is sufficient to meet the nutrient requirement of nearly all (97 to 98%) healthy individuals, in a particular life stage and gender group (Ross et al., 2011). Along with many other compounds, minerals in apple fruits are very important parameter which defines the nutrient value of this food for humans.

Granny Smith is very popular apple cultivar in Macedonia, but also in many western european countries. In order to encourage the producers and spread this cultivar, experimental orchard was established in the region of Prespa, the most suitable part of Macedonia for apple production (Gjamovski et al., 2013).

The aim of this investigation is to study the influence of nine dwarf apple rootstocks (M.9 T 984, M.9 T 337, Jork 9, Mark 9, Budagowski 9, M.9 EMLA, Pajam 1, Pajam 2 and Supporter 4) on fruit quality and tree ability to absorb and disseminate some micro- and macroelements from soil, through leaves, in fruits of cultivar Granny Smith apple. Since the market requirements are mainly pointed to fruit's shape, its firmness and storage ability, it is obvious that the choice of the rootstock, in the period of orchard establishment, is essential.

Materials and Methods

Plant growing conditions

The experimental orchard, located in Prespa region (south-western part of Macedonia) was established in 2004, in randomized block design, with drip irrigation system, tree spacing 3.5 m x 1.5 m, in four replicates. The orchard was managed in agreement with the standard commercial practice.

Soil samples were collected at 0-20 cm, 20-40 cm and 40-60 cm depth and analyzed following the procedures proposed by ISO 11464 and ISO 11047 standards.

Tissue analysis

Fully expanded, mature and healthy leaves were collected at the end of July for mineral analysis. The samples were dried at 70^{o}C for three days and ground to pass a 2 mm mesh screen. A laboratory microwave oven (CEM, USA) was employed for matrix destruction and atomic emission spectrometry with inductively coupled plasma (ICP-AES, Varian 715-ES) for element determination (Balabanova et al., 2010).

Similar method was used for fruit samples collection and analysis. Ten representative apples were selected from each replicate (rootstock/cultivar combination) during harvest, dried on 105^{o}C, and the samples were stored in paper bags. The grounded material was treated with 7 ml concentrated HNO_3 and 2 ml H_2O_2 into microwave digestion system. The element determination was carried out by atomic emission spectrometry with inductively coupled plasma (ICP-AES, Varian 715-ES).

Statistical analysis

Data were collected in 3 consecutive years. The statistical analysis of the data obtained were performed using a statistical program SPSS 14.0. The differences were evaluated by ANOVA analysis through General Linear Model procedure. After GLM analyses, post hoc comparison of means was calculated by LSD. Results were expressed at the $P < 0.05$ level of significance.

Results and Discussion

Plant growing conditions

Climate conditions and soil quality are the most important ecological settings for successful fruit growing management. Our experimental orchard is located in the south-western part of Macedonia, which is the most suitable region in Macedonia for such purpose.

In the frame of the large project, basic chemical and mechanical analyses were conducted in order to investigate the suitability of the soil. The results are presented in previously published article (Gjamovski and Kiprijanovski, 2011). According to WRB classification, the soil belongs to fluvisol type, dystric fluvisol subtype.

Based on many previous investigations (Ubavić et al., 2001) and agricultural practice, the optimal level of macro elements is established. In that manner, the concentration of available phosphorus should be not less than 15 mg/100 g of soil, the concentration of potassium should be in the range of 20 - 30 mg/100 g soil and the pH value should be in the range 5 -7.5. The previously performed investigations showed that the soil in the experimental orchard is highly well-appointed with these two elements which are essential for good agricultural practice and the pH value is optimal.

Tissue analyses

Tissue analysis can help to avoid deficiencies and associated losses by identifying problems before yields decline or symptoms appear. The standard sampling procedure is to collect mature leaves from the middle of shoots in late July or early August. Other procedures, such as early season fruitlet sampling may be useful, but interpretation of results is difficult due to lack of data. Field investigations and fruit growing experience resulted with optimal range establishment for some micro- and macroelements. For apple nutrition, optimal range is as follow: 2.0-2.6% for N, 0.16-0.30% for P, 1.3-1.5% for K, 1.1-1.6% for Ca, 0.3-0.5% for Mg, 25-50 ppm for B, 10-20 ppm for Cu, 150-250 ppm for Fe, 50-80 ppm for Mn and 20-40 ppm for Zn (Hanson, 2014). It is worth to be mentioned that the deficient level for Cu, Zn and Mn is not well defined.

The results for the content of macro- and microelements (N, P, K, Ca, Al, B, Cu, Fe, Mg, Mn, Na and Zn) are presented in Table 1.

Compared with the values proposed as optimal for different elements, it can be concluded that all requirement are satisfied, except for the content of P, K and Cu. Since the results are very similar and there are no significant differences between the rootstocks, it is obvious that the soil is poor with available P, K and Cu as it was shown in our previous study (Gjamovski and Kiprijanovski, 2011). The statistical analyses indicate that different rootstocks do not affect the uptake of N, P, K, Ca, Cu and Na. However, the content of Mg ranges from 1870 mg/kg (at Bud. 9) to 2449 mg/kg (at Mark 9), which is statistically proven difference. The leafs collected from rootstock Mark 9 also showed highest content of Fe, Zn, Cu, B, Mn and Al, which proves its best ability for mineral uptake from the soil.

The results from the correlation analyses between the macro- and microelements in leaves are presented in Table 2. As it can be seen, the content of Al is strongly correlated with the contents of Ca, Fe, Mg and Na, as well as with those of Mn, K and P, which are strong but negative correlations. Strong negative correlations were observed between the content of Ca and K, Mn and P, and positive correlations with the content of Fe, Mg and Na.

According to Stiles and Reid (1991) and Ubavić et al. (2001) the normal leaf Ca content ranges from 1.0%-2.0%, however values above 1.5% are generally required to minimize low Ca related fruit problems. Being a major cation,

Table 1
Macro and micro element content in leafs

Rootstock	%				mg/kg							
	N	P	K	Ca	Al	B	Cu	Fe	Mg	Mn	Na	Zn
M.9 T 984	2.33^{a}	0.10^{bc}	0.69^{ab}	0.96^{b}	62.1^{ab}	13.7^{ab}	4.1^{b}	87.5^{b}	2164^{b}	70.8^{b}	35.1^{a}	46.5^{b}
M.9 T 337	2.39^{a}	0.10^{bc}	0.71^{ab}	1.12^{ab}	65.1^{ab}	12.5^{b}	4.1^{b}	96.7^{ab}	2066^{bc}	83.0^{ab}	38.7^{a}	55.1^{ab}
Jork 9	2.38^{a}	0.11^{ab}	0.80^{a}	1.08^{ab}	65.4^{ab}	13.9^{ab}	4.7^{a}	93.8^{ab}	2173^{b}	92.0^{a}	44.3^{a}	56.7^{ab}
Mark 9	2.40^{a}	0.11^{abc}	0.65^{b}	1.11^{ab}	83.7^{a}	14.6^{a}	4.8^{a}	108.2^{a}	2449^{a}	88.3^{ab}	43.4^{a}	58.0^{a}
Bud. 9	2.43^{a}	0.11^{abc}	0.68^{ab}	1.19^{a}	74.5^{ab}	12.5^{b}	4.0^{b}	98.8^{ab}	1870^{c}	75.0^{b}	43.4^{a}	48.7^{ab}
M.9 EMLA	2.43^{a}	0.11^{abc}	0.74^{ab}	1.08^{ab}	83.1^{a}	13.3^{ab}	4.5^{ab}	103.7^{ab}	2196^{b}	70.4^{b}	40.3^{a}	50.5^{ab}
Pajam 1	2.48^{a}	0.10^{bc}	0.67^{b}	1.07^{ab}	60.0^{ab}	12.0^{b}	3.7^{b}	83.2^{b}	2102^{b}	73.4^{b}	38.3^{a}	50.5^{ab}
Pajam 2	2.65^{a}	0.11^{abc}	0.76^{ab}	1.04^{ab}	60.1^{ab}	12.6^{b}	3.8^{b}	90.7^{ab}	2274^{ab}	74.0^{b}	45.6^{a}	46.5^{b}
Supporter 4	2.55^{a}	0.12^{a}	0.81^{a}	0.98^{b}	55.8^{b}	14.3^{a}	4.5^{ab}	90.1^{ab}	1980^{bc}	77.5^{b}	41.2^{a}	52.9^{ab}

* Values followed by the same letter in a column were not statistically different ($P \leq 0.05$)

Table 2
Correlation between macro and micro elements in leaves

	N	Al	B	Ca	Cu	Fe	K	Mg	Mn	Na	P	Zn
N	1	-.366	-.063	-.071	-.12	-.29	.235	.01	-.061	-.191	.287	.441(*)
Al		1	.214	.708(*)	.278	.929(*)	-.662(*)	.549(*)	-.522(*)	.617(*)	-.555(**)	-.242
B			1	.131	.752(*)	.252	.014	.302	-.163	.302	.291	.307
Ca				1	.219	.850(*)	-.854(*)	.743(*)	-.872(*)	.549(*)	-.649(**)	.299
Cu					1	.332	-.065	.340	-.155	.199	.178	.272
Fe						1	-.825(*)	.672(*)	-.752(*)	.587(*)	-.665(**)	.006
K							1	-.712(*)	.859(*)	-.312	.854(**)	-.186
Mg								1	-.715(*)	.370	-.530(**)	.294
Mn									1	-.354	.680(**)	-.491(**)
Na										1	-.175	-.148
P											1	.075
Zn												1

* Correlation is significant at 0.05 level
** Correlation is significant at 0.01 level

calcium availability is related to the soil conductivity and pH values, and it is in competition with other major cations such as sodium (Na^{+}), potassium (K^{+}), magnesium (Mg^{2+}), ammonium (NH$_4^{+}$), iron (Fe^{2+}), and aluminium (Al^{3+}) for uptake by the crop. High K applications have been known to reduce the Ca uptake in apples, which are extremely susceptible to poor Ca uptake and translocation within the tree.

A positive correlations were observed also between the content of Mg with the content of Fe and Na, between the content of K with those for Mn and P and between the content of Mn and P. Strong negative correlations were detected between the contents of Fe with K, Mn and P, between K and Mg and between P and Mg. Considering the negative correlation between the content of K and Mg, it could be concluded that these results indicate that leaf levels of Mg can decrease in the presence of increased K levels in case of excessive treatments with this element.

Adequate potassium contributes to improved fruit size, color and flavor. It is also a major factor in reducing winter injury, spring frost damage to buds and flowers, and generally reduced incidence of diseases. The benefits of adequate potassium amount can be lost however, if the leaf ratio of nitrogen to potassium (N divided by K) is too high (Fallahi et al., 2010; Hanson, 2014).

As stated earlier, the growers should use routine leaf analysis and visual inspection to monitor an orchards nutrient status, and make appropriate changes to the nutrient program. This is the only way that the optimum crop performance and profits can be attained.

Similar analyses were performed with apple fruits collected at harvest from different rootstock combinations. The results obtained are presented in Table 3.

The macroelements level (N, P, K, Ca and Mg) didn't show any significant differences between those for the

Table 3
Macro and micro element content in apple fruits

Rootstock	In %				In mg/kg							
	N	P	K	Ca	Mg	Fe	Zn	Cu	B	Mn	Na	Zn
M.9 T 984	2.02^{a}	0.041^{ab}	0.43^{ab}	0.038^{ab}	326^{ab}	8.21^{a}	1.66^{a}	1.28^{a}	8.42^{b}	2.23^{ab}	43.04^{ab}	3.32^{a}
M.9 T 337	2.12^{a}	0.042^{ab}	0.46^{ab}	0.034^{ab}	350^{ab}	9.24^{a}	1.21^{a}	1.97^{a}	7.65^{bc}	2.39^{ab}	40.96^{ab}	6.55^{a}
Jork 9	2.00^{a}	0.044^{ab}	0.47^{ab}	0.037^{ab}	339^{ab}	9.28^{a}	0.78^{a}	1.32^{a}	8.36^{b}	2.21^{ab}	45.83^{a}	4.44^{a}
Mark 9	1.92^{a}	0.049^{a}	0.51^{a}	0.042^{a}	396^{a}	11.03^{a}	1.45^{a}	1.38^{a}	11.22^{a}	2.44^{a}	43.57^{a}	8.03^{a}
Bud. 9	1.97^{a}	0.037^{b}	0.38^{b}	0.033^{ab}	307^{b}	6.40^{a}	0.62^{a}	1.07^{a}	8.06^{b}	2.14^{ab}	40.22^{ab}	3.61^{a}
M.9 EMLA	2.01^{a}	0.038^{b}	0.38^{b}	0.035^{ab}	307^{b}	7.76^{a}	1.86^{a}	1.40^{a}	6.33^{c}	1.87^{ab}	24.39^{b}	6.33^{a}
Pajam 1	2.14^{a}	0.042^{ab}	0.45^{ab}	0.032^{ab}	321^{ab}	6.98^{a}	0.39^{a}	1.13^{a}	7.52^{bc}	2.00^{ab}	36.66^{ab}	2.99^{a}
Pajam 2	2.07^{a}	0.041^{ab}	0.43^{ab}	0.037^{ab}	346^{ab}	8.19^{a}	1.60^{a}	2.11^{a}	7.75^{bc}	2.04^{ab}	37.83^{ab}	6.84^{a}
Supp.4	2.11^{a}	0.041^{ab}	0.42^{ab}	0.028^{b}	304^{b}	7.08^{a}	0.77^{a}	1.21^{a}	8.15^{b}	1.76^{b}	35.84^{ab}	3.26^{a}

* Values followed by the same letter in a column were not statistically different ($P \leq 0.05$)

Table 4
Correlation between macro and micro elements in apple fruits

	N	Al	B	Ca	Cu	Fe	K	Mg	Mn	Na	P	Zn
N	1	-.176	.006	.006	.325	.077	.167	.261	.165	.368	.245	.157
Al		1	.346	.540(**)	.131	.272	.511(**)	.380	.472(*)	.046	.427(*)	-.037
B			1	.707(**)	.121	-.007	.658(**)	.647(**)	.704(**)	.469(*)	.845(**)	.119
Ca				1	.072	-.305	.405(*)	.347	.546(**)	.292	.684(**)	.090
Cu					1	.365	.307	.487(**)	.495(**)	.307	.337	.716(**)
Fe						1	.528(**)	.585(**)	.386(*)	.136	.118	.446(*)
K							1	.829(**)	.765(**)	.466(*)	.828(**)	.207
Mg								1	.825(**)	.512(**)	.746(**)	.409(*)
Mn									1	.436(*)	.753(**)	.364
Na										1	.558(**)	.188
P											1	.235
Zn												1

* Correlation is significant at 0.05 level
** Correlation is significant at 0.01 level

rootstocks. However, the fruits collected from Mark 9 rootstock showed highest content of P, K, Ca and Mg. These results are in agreement with the results from the previous investigations (Marcelle, 1995; Zavalloni et al., 2001; Daugaard and Callesen, 2002; Cybulska et al., 2012).

Concerning the microelements, similar findings were obtained. Fruits collected from rootstock Mark 9 showed the highest contents of Fe, B, Mn and Al and these values are significantly different compared to Budagowski 9 (for Fe), M.9 EMLA (for B), Supporter 4 (for Mn) and Pajam 1 (for Al). The results from correlation analyses are presented in Table 4.

It can be seen that strong significant positive correlation at 0.01 level was observed between the content of B with those for Ca, K, Mg, Mn and P. Also, strong correlation was observed for the content of P and B, Ca, K, Mg, Mn and Na. It is worth to be mentioned that most of the correlations, strong or weak, are positive.

Several mineral nutrients can influence fruit quality and disorders of apple. Among these, nitrogen, potassium, phosphorous, calcium and boron are most often correlated to apple fruit quality and disorders (Fallahi et al., 2010). Using fruit analysis alone or in combination with leaf analysis often permits more precise prediction of fruit quality. Increasing fruit nitrogen content is inversely related to fruit yellow or red color and positively associated with fruit respiration. Fruit calcium tends to be imprecisely related to bitter pit and fruit firmness. Potassium fertigation increases fruit size, yield, acidity, and color, but decreased firmness at harvest. General relationships between mineral nutrition and fruit quality are reviewed with special emphasis on apple fruit (Khalifa et al., 2009). Yet, good eating quality and long storage quality are not really compatible from the point of view of the mineral content of fruit. Normally, fruit growers have to find the best compromise between both requirements. In order to examine the relationship between the mineral levels in leaves and fruits, correlation analyses were conducted for the investigated rootstocks. The results obtained are presented in Table 5.

Analyzing the results given in Table 5, negative correlation was observed between the content of Ca in leaves with the contents of B, Ca, Fe and P in fruits. This information confirms the pervious findings about the competition between vegetation and fruit for available Ca (Peterson and Stevens, 1991; Marcelle, 1995). Taking into account that the content of Ca in the fruits has strong influence on their firmness and storage life (Stiles and Reid, 1991; Khalifa et al., 2009), it is obvious that regular analyses of leaves are required in order to improve the quality and enlarge the storage of fruits. Many conditions affect apple Ca status such as: low soil Ca levels, low soil pH high levels of competitive cations, fertilization and pruning practices, soil management, growing excessively large fruit etc. In order to achieve best results, balanced activities should be implemented. Soil application is long term measure, but foliar spraying 4 and 2 weeks before harvest can provide satisfactory good results concerning the fruit firmness and storage life.

Further analyzing, the presented results show strong positive correlation between the content of Mn in leaves with the content of Al, B, Ca and P in fruits and negative correlation with Fe which indicates that increased amount

Table 5
Correlation between element content in leafs and apple fruits

Leaves	Apple fruits											
	N	Al	B	Ca	Cu	Fe	K	Mg	Mn	Na	P	Zn
N	-.095	.030	.004	.422(*)	-.059	.000	.086	-.082	.424(*)	.166	.242	.481(*)
Al	-.479(*)	.002	-.493(**)	-.594(**)	-.255	.394(*)	-.162	-.255	-.318	-.575(**)	-.541(**)	-.110
B	-.178	-.147	.254	-.123	.142	.239	.200	.237	.094	.149	.189	.270
Ca	-.178	-.295	-.593(**)	-.821(**)	.080	.518(**)	-.203	-.077	-.289	-.218	-.585(**)	.111
Cu	-.311	.031	.162	-.111	-.066	.248	.165	.188	.000	.137	.114	-.039
Fe	-.342	-.131	-.568(**)	-.764(**)	-.186	.512(**)	-.201	-.186	-.370	-.435(*)	-.614(**)	-.054
K	.173	.251	.556(**)	.772(**)	.192	-.502(**)	.252	.106	.347	.291	.646(**)	.053
Mg	-.204	-.153	-.297	-.569(**)	.111	.536(**)	.023	.155	-.204	-.148	-.325	.182
Mn	-.068	.449(*)	.602(**)	.895(**)	-.044	-.521(**)	.236	.044	.359	.063	.551(**)	-.127
Na	-.491(**)	-.065	-.300	-.475(*)	.035	.184	-.087	-.164	-.270	-.311	-.324	.031
P	.190	.081	.613(**)	.661(**)	.176	-.364	.300	.227	.285	.369	.670(**)	.179
Zn	.466(*)	-.447(*)	.007	-.281	.344	.287	.095	.376	.086	.645(**)	.125	.329

* Correlation is significant at 0.05 level
** Correlation is significant at 0.01 level

of Mn can improve the firmness of the fruits. In this case, additional fertilization with Mn should be very carefully applied due to the negative correlation with Fe.

On the other hand, strong positive correlation between the content of Mg in leaves and of Fe in fruits at 0.01 level was observed, which indicates that appropriate foliar fertilization in the pruning period practice can improve the nutrition value of the fruits.

A practical service of fruit analysis giving advice on the quality and storability of fruit is, in our opinion, a very good tool for helping fruit growers to make the good choice and provide suitable agricultural practices.

Conclusions

This paper presents original data concerning the content of twelve micro- and macroelement in apple cultivar Granny Smith grafted on nine dwarf apple rootstocks. The element analyses were conducted in leaves and apple fruits. The results obtained showed insignificant influence of the rootstocks. However, rootstock Mark 9 showed highest amount of Fe, Zn, Cu, B, Mn and Al in leafs, which proves its best ability for mineral uptake from the soil. Concerning the macro- and microelements in apple fruits, similar findings were obtained. Rootstock Mark 9 showed best ability for mineral translocation in fruits, compared to other rootstocks. The correlation analyses proved the strong connection between the element levels in leaves and fruits. This information is very important in order to establish the most suitable agricultural practices and gain the balance between the fruit quality, optimal yield and to enlarge their storage life.

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