ACTA Acta Sci. Pol., Hortorum Cultus 11(1) 2012, 227-237

IMPACT OF CULTIVAR ON THE NUTRITIONAL STATUS OF THE YOUNG APRICOT TREES (*Prunus armeniaca* L.)

Ljiljana Bošković-Rakočević, Tomo Milošević, Jelena Milivojević, Gorica Paunović

[1]Faculty of Agronomy in Čačak, Serbia

[2]Center for Small Grains in Kragujevac, Serbia

Abstract. Mineral nutrition of apricot is very specific and depends on different factors such as soil fertility, soil pH, weather conditions, cultivars, rootstocks, fertilizers, age of trees etc. For these reasons, during 2008 and 2009 we evaluate nutrient status of five apricot cultivars (Vera, Aleksandar, Biljana, Harcot, Roxana) at 120 days after full bloom (DAFB) grown on acidic soil in the region of Čačak (Western Serbia). The results showed no statistically significant variations in the N, K and Ca content of apricot leaves among cultivars, as opposed to significant differences in the content of P, Mg, Fe, Mn, Cu, Zn and B. The ΣDOP index revealed that the average content of all macro- and micronutrients was below the optimum, except that of P in both years and that of Mn and Cu in the first year of the study. The insufficient nutrient supply of the test apricot cultivars requires adjustment of fertiliser types and application rates to this soil type according to foliar analysis.

Key words: DOP index, foliar analysis, macro- and micronutrients, ΣDOP

INTRODUCTION

Apricots (*Prunus armeniaca* L.) are widely grown in Serbia due to their high nutritional value. Nevertheless, irrespective of favourable agroenvironmental conditions for their successful cultivation, there are certain constraints to their production, most notably blossom kill from early spring frosts, premature wilting of apricot trees, choice of adequate rootstock, etc. Apricot cultivars differ in their ability to adapt to environmental conditions, which along with inadequate nutrition can lead to yield reduction and fruit quality deterioration. Balanced mineral nutrition complying with apricot tree nutrient

Corresponding author – Adres do korespondencji: Ljiljana Bošković-Rakočević, Department of Agrochemistry, Faculty of Agronomy, University of Kragujevac, 32000 Čačak, Cara Dušana 34, Republic of Serbia, e-mail: ljiljabr@tfc.kg.ac.rs

requirements, and soil fertility are important factors governing the productivity of this fruit species [Milošević et al. 2010]. The predominance of acid soils on over 50% of agricultural land in Western Serbia [Stevanović et al. 1987] necessitates organic fertilisation to increase soil pH [Ganzhara 1998, Milosevic and Milosevic 2009] as well as the use of physiologically alkaline mineral fertilisers, particularly during top dressing. This reduces the risk of blocking the nutrient uptake from the soil, while ensuring favourable conditions towards the attainment of both nutritional balance and good fruit quality. The content of macro- and micronutrients in the leaves is correlated with their soil content [Güleryüz et al. 1995, 1996, Yu-Yen 2006], as well as with fertilisation method [Treder and Olszewski 2004]. On fertile soils, apricot plants have a sufficient N supply throughout the year, N being particularly required during leaf formation and development, intensive vegetative growth and fruit development [Jakson 1970]. Deficiencies of P, Ca and Cu rarely occur in nature [Johnson 1993]. Conversely, less fertile soils most commonly experience deficiencies of K, Mg, Mn, Fe, Zn and B.

Leaf nutrient levels in apricots are non-uniform, showing seasonal variations [Leece and Van Den Ende 1975] and dependence upon cultivar [Bojić et al. 1999, Milosevic et al. 2010], rootstock [Rosati et al. 1997, Velemis 1999, Jiménez et al. 2004], interstock [Milosevic 2006, Milosevic et al. 2010, Milosevic and Milosevic 2011], fertilisation [Taylor and Goubran 1975, Szücs 1986] and soil levels [Liferdi et al. 2008]. Given the multitude of parameters that affect the nutritional status of apricot trees, it is necessary to determine the foliar nutrient supply status at 120 days after full bloom (DAFB) in order to eliminate potential signs of deficiency of certain nutrients. Numerous methods are used to this end, the commonest being Deviation From Optimum Percentage (DOP index and ΣDOP index) [Montañés and Sanz 1994, Lucena 1997].

The objective of this study was to evaluate the content of essential nutrients in leaves of young apricot trees of five cultivars at 120 days after full bloom (DAFB). The study was also aimed at assessing the use of leaf mineral analysis as a method of diagnosing the nutritional status in apricot trees.

MATERIAL AND METHODS

Plant material. An experimental apricot orchard was established in spring 2007 and included three newly developed Serbian cultivars (Vera, Aleksandar, Biljana) and two introduced cultivars (Harcot, Roxana) grafted on Myrobalan rootstock (*Prunus cerasifera* Ehrh.) 60 cm above the ground level. Leaves were sampled from the middle part of one-year-old shoots at 120 DAFB to analyse the content of macro- and micronutrients.

Field trial. The trial was located in a commercial apricot orchard in Prislonica (43°57' N, 20°26' E, 344 m above sea level), near the town of Čačak in Western Serbia. The open vase training system at a spacing of 5.5 × 3.0 m was used. Orchard management was consistent with standard practice, except irrigation. The orchard was fertilised with organic fertiliser i.e. cowshed manure having on average N_{TOT} – 0.5%, P_2O_5 – 0.3%, K_2O – 0.6%, electrical conductivity – 6.32, organic matter – 25%, C:N ratio – 18:1 [Larney et al. 2006] at a rate of 5 kg m^{-2} applied in autumn 2007 and 2008. Manure was combined with compound NPK mineral fertiliser (15:15:15) used at a rate of 0.05 kg m^{-2}, whereas top dressing with Calcium Ammonium Nitrate (containing 27% of N_{TOT}) was applied at a rate of 0.03 kg m^{-2} in early spring i.e. before the onset of the growing season. The experiment was set up as a randomised block design in four replications with 5 trees each.

Soil chemical analysis was performed prior to trial establishment. The soil in the apricot orchard had a sandy loam texture, an acid pH [pH_{KCl} 4.86 (0–30 cm depth) and 4.33 (30–60 cm depth)], a moderate humus supply (3.2%), a good supply of total nitrogen (N_{TOT} 0.20%), available phosphorus and potassium (178 mg kg^{-1} and 220 mg kg^{-1}, respectively), and low levels of CaO and MgO (0.39% CaO and 6.2 mg kg^{-1} MgO). The soil showed wide variations in the content of available micronutrients [Ankerman and Large 1977], ranging from very high for Fe (78 mg kg^{-1}), high for Cu (1.6 mg kg^{-1}) and B (2.3 mg kg^{-1}), low for Mn (7.8 mg kg^{-1}) to very low for Zn (0.52 mg kg^{-1}).

Weather characteristics. There were not significant differences between the air temperatures obtained for the years of observation and the long-term averages for the region of Čačak and surrounding areas (tab. 1).

Table 1. Air temperature and precipitation from March to July in 2008 and 2009
Tabela 1. Temperatura powietrza i opady od marca do lipca 2008 i 2009 r.

Months Miesiące	Air temperature (°C) Temperatura powietrza			Precipitation (mm) Opady		
	2008	2009	normal** normalna	2008	2009	normal** normalne
March Marzec	8.5	8.1	6.8	53.5	42.5	53.8
April Kwiecień	13.7	14.8	11.5	35.5	12.5	57.8
May Maj	19.4	20.2	16.8	36.0	43.0	88.6
June Czerwiec	23.3	21.4	20.0	79.0	98.4	98.2
July Lipiec	23.5	24.0	21.5	95.6	41.0	76.0
Mean or total Średnia lub suma	17.7	17.7	15.3	299.6	237.4	374.4

*at a straight-line distance of 15 km (NE-direction) from the experimental field.
*w linii prostej odległość 15 km (kierunek północno-wschodni) od pola doświadczalnego
**normal refers to the long-term average (30-year average, i.e. 1961–1990 period).
** normalny odnosi się do średniej długoterminowej (średnia 30-letnia, tj. okres od roku 1961 do 1990).

In both years there was less rainfall, so the total precipitation lower than the long-term average (in 2008 was by 74.8 mm, in 2009 by 137.0 mm). The lack of rainfall during this period may have had a negative effect on the vegetative growth.

Leaf mineral analysis. Leaf nutrients were determined in 2008 and 2009. Leaf samples were collected from the middle part of one-year-old shoots of the trees of each cultivar within four blocks. Leaves were sampled for analysis at 120 days after full bloom (DAFB), carefully rinsed with deionised water and, after leaf area measurement, they were oven dried, weighed, ground to pass a 0.5 mm mesh and analysed for macronutrient content according to the guidelines of the Association of Official Analytical Chemists [AOAC 1990].

Total N was determined by Kjeldahl analysis (Gerhardt Vapodest); P was analysed spectrophotometrically by the phospho-vanadate colorimetric method (Hewlett Packard 8452A, UK); K was determined by flame photometry (Flapho 4, Carl Zeiss, Jena); and Ca, Mg, Fe, Mn, Cu and Zn by atomic absorption spectroscopy (AAS1N, Carl Zeiss, Jena). Boron was determined colorimetrically using quinalizarin (MK 6/6, Carl Zeiss, Jena). The data are given as percentage and mg kg^{-1} of dry weight for each macro- and micronutrient studied, respectively.

DOP index. The deviation from optimum percentage (DOP index) was estimated for the diagnosis of the leaf mineral status of trees according to Montañés et al. [1991]. The DOP index was calculated from the leaf analysis at 120 DAFB by the following mathematical expression:

$$DOP = \frac{C \times 100}{C_{ref}} - 100,$$

where: C is the minor element concentration in the sample to be studied, and C_{ref} is the minor nutrient concentration considered as optimum, with both values being given on a dry matter basis. The C_{ref} has been taken from optimum values, proposed by Leece and Van Den Ende [1975] for macro- and micronutrients. The ΣDOP is obtained by adding the values of the DOP index irrespective of sign. The larger the ΣDOP, the greater the intensity of imbalances among nutrients.

Statistical analysis. All data in the present study were subjected by analysis of variance (ANOVA) and mean were separated by LSD test at $P \leq 0.05$ using the MSTAT-C statistical computer package (Michigan State University, East Lansing, MI, USA).

RESULTS

Leaf of nutrient of apricot at 120 DAFB. The analysis of the macronutrient content in apricot leaves shows statistically insignificant differences in N, K and Ca among cultivars, whereas differences for P and Mg were significant (tab. 2). Moreover, variations in all macronutrients between years were not significant.

Regarding leaf P content in 2008, the highest value was found in Biljana, and the lowest in Harcot. In 2009, leaf P in Roksana was significantly higher then rest cultivars. In the case of Mg in first season, the higher content was recorded in Biljana and Harcot, whereas the lower contet observed in Roksana. In 2009, the highest leaf Mg was found in Harcot, and the lowest in Vera (tab. 2).

The data presented in table 3 show significant variations in the leaf micronutrient content across cultivars and years. The content of Mn and Cu was higher in 2008 than in 2009, whereas that of Fe, Zn and B in 2009 was higher than in the first season.

Table 2. Leaf macronutrient content of five apricot cultivars at 120 DAFB in 2008 and 2009
Tabela 2. Zawartość makroskładników odżywczych w liściach pięciu odmian moreli 120 dni po pełni kwitnienia w latach 2008 i 2009

Cultivar Odmiana	Macronutrient content (% of dry matter) Zawartość makroskładników odżywczych (% suchej masy)									
	N		P		K		Ca		Mg	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Vera	2.27 a	2.63 a	0.34 b	0.26 b	2.29 a	2.85 a	1.76 a	1.59 a	0.25 b	0.26 e
Harcot	2.29 a	2.61 a	0.20 e	0.26 b	2.40 a	2.55 a	1.76 a	1.68 a	0.28 a	0.39 a
Aleksandar	2.66 a	2.69 a	0.22 d	0.26 b	2.60 a	3.11 a	1.70 a	1.52 a	0.22 c	0.32 c
Biljana	2.38 a	2.46 a	0.38 a	0.26 b	2.07 a	2.37 a	1.94 a	1.89 a	0.28 a	0.34 b
Roksana	2.45 a	2.47 a	0.30 c	0.27 a	2.51 a	2.68 a	1.80 a	1.64 a	0.21 d	0.29 d
Average Średnia	2.41 A	2.57 A	0.29 A	0.26 A	2.37 A	2.71 A	1.79 A	1.66 A	0.25 A	0.32 A

The same letters in columns indicate non-significant differences among means at $P \leq 0.05$ by LSD test.
Te same litery w kolumnach wskazują na nieistotne różnice pomiędzy średnimi przy P ≤ 0.05 według testu LSD.
The same capital letters in row with average values for each nutrient indicate non-significant differences between years at $P \leq 0.05$ by LSD test.
Te same duże litery w rzędzie ze średnimi wartościami dla każdego składnika odżywczego wskazują na nieistotne róznice pomiędzy latami przy P ≤ 0.05 według testu LSD.

Table 3. Leaf micronutrient content of five apricot cultivars at 120 DAFB in 2008 and 2009
Tabela 3. Zawartość mikroskładników odżywczych w liściach pięciu odmian moreli po 120 dniach od pełni kwitnienia w latach 2008 i 2009.

Cultivar Odmiana	Micronutrient content (mg kg^{-1}) Zawartość mikroskładników odżywczych									
	Fe		Mn		Cu		Zn		B	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Vera	87.5 b	92.5 bc	66.8 e	39.3 e	14.8 c	6.8 d	14.2 b	17.7 ab	26.9 bc	31.6 b
Harcot	95.2 a	99.4 ab	101.0 c	131.9 b	7.9 d	8.4 c	16.5 a	19.0 ab	23.1 c	34.0 b
Aleksandar	85.5 b	91.3 c	108.7 b	76.5 d	7.3 e	8.7 b	16.2 a	16.3 bc	45.0 a	20.2 c
Biljana	82.6 b	88.2 c	154.8 a	79.1 c	15.0 b	4.6 e	16.1 ab	19.9 a	33.8 b	45.0 a
Roksana	76.1 c	102.5 a	81.4 d	116.0 a	15.4 a	9.5 a	15.5 ab	14.0 c	28.1 bc	37.4 b
Average Średnia	85.38 B	94.78 A	102.54 A	88.56 B	12.08 A	7.6 B	15.7 B	17.38 A	31.38 B	33.64 A

The same letters in columns indicate non-significant differences among means at $P \leq 0.05$ by LSD test.
Te same litery w kolumnach wskazują na nieistotne różnice pomiędzy średnimi przy P≤ 0.05 według testu LSD.
The same capital letters in row with average values for each nutrient indicate non-significant differences between years at $P \leq 0.05$ by LSD test.
Te same duże litery w rzędzie ze średnimi wartościami dla każdego składnika odżywczego wskazują na nieistotne róznice pomiędzy latami przy P ≤ 0.05 według testu LSD.

As for cultivars, leaf Fe in the first season was highest in Harcot and lowest in Roxana. However, in the second year, the highest content of this nutrient was recorded in Roxana and Harcot, with no significant differences being observed, whereas the lowest content was found in Aleksandar and Biljana. Leaf Mn content was highest in Biljana in 2008 and Roxana in 2009, and lowest in Vera in both years. Roxana had the highest content of Cu in both years, as opposed to the lowest in Aleksandar in 2008 and Biljana in 2009. The leaf Zn content in 2008 was highest in Harcot and Aleksandar, and lowest in Vera. In 2009, the highest content of this nutrient was detected in Biljana, and the lowest in Roxana. As regards leaf B, the highest and lowest contents in the first season were determined in Aleksandar and Harcot, respectively. In the second season, the highest leaf B values were obtained in Biljana and the lowest in Aleksandar (tab. 3).

Deviation from Optimum Percentage (DOP index). The analysis of data given in Tables 4 and 5 relative to the reference values for apricot leaves reported in the literature [Leece and van den Ende 1975] suggests that the average content of all macro- and micronutrients was below the optimum, except leaf P in both years, and Mn and Cu in 2008. The leaf N content in all cultivars was below optimum levels, with a higher deficiency being observed in 2008, most notably in the leaf of Vera and Harcot, and the lowest in Aleksandar (tab. 4). The leaf P content in all cultivars was above optimum values. Accordingly, in 2009, a similar excess was found in all cultivars, whereas the highest and lowest values in 2008 were observed in Biljana and Harcot, respectively. K content was lower than optimum values in all cultivars excluding Aleksandar and Vera in 2009. In both years, all cultivars were found to contain the highest Ca and Mg deficiency.

Table 4. DOP index and ΣDOP determined for leaf macronutrients at 120 DAFB in five apricot cultivars in 2008–2009
Tabela 4. Wskaźnik DOP i ΣDOP wyznaczany dla makroskładników odżywczych w liściach pięciu odmian moreli 120 dni po pełni kwitnienia w latach 2008 i 2009

Cultivar Odmiana	N		P		K		Ca		Mg		ΣDOP index
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	
Vera	-15.9	-2.6	+74.4	+33.3	-16.7	+3.6	-41.3	-47.0	-54.5	-52.7	342.0 a
Harcot	-15.2	-3.3	+2.6	+33.3	-12.7	-7.3	-41.3	-44.0	-49.1	-29.1	237.9 d
Aleksandar	-1.5	-0.4	+12.8	+33.3	-5.4	+13.1	-43.3	-49.3	-60.0	-41.8	260.9 c
Biljana	-11.8	-8.9	+94.9	+33.3	-24.7	-13.8	-35.3	-37.0	-49.1	-38.2	347.0 a
Roksana	-9.2	-8.5	+53.8	+38.5	-8.7	-2.5	-40.0	-45.3	-61.8	-47.3	315.6 b
Average Średnia	-10.7	-4.8	+48.7	+34.3	-13.8	-1.4	-40.3	-44.7	-54.5	-41.8	-

Leaf composition standards for apricot trees based on mid-shoot leaves sampled at 120 DAFB (Leece and van den Ende, 1975).
Standardy składu liści dla drzew morelowych na podstawie liści w połowie pędu, pobranych w 120 dni po pełni kwitnienia (Leece i van den Ende)
(-) indicates lower than optimum content. (+) indicates higher than optimum content.
(-) wskazuje zawartość niższą niż optymalna. (+) wskazuje zawartość wyższą niż optymalna
The different small letters in the last column indicate significant differences among cultivars for ΣDOP at $P \le 0.05$ by LSD test.
Różne małe litery w ostatniej kolumnie wskazują znaczące różnice między odmianami dla ΣDOP przy $P \le 0.05$ według testu LSD.

As regards micronutrients (tab. 5), the DOP index shows a high deficiency of both Fe and Zn. The highest deficiencies relative to optimum values were determined for leaf Zn, being higher in 2008 than in 2009, similar in the first season and highest in Vera. In 2009, the highest leaf Zn deficiency was observed in Roxana. Leaf Fe exhibited a similar tendency, with the highest deficiency being detected in cv. Roxana in 2008 and cv. Biljana in 2009. The DOP index shows excessive values of Mn content in 2008 in cv. Biljana but a deficiency in cvs. Vera and Biljana. In 2009, cv. Vera had a highest deficiency, as opposed to the excessive levels in cv. Harcot. The content of Cu in 2008 was below optimum values in cvs. Harcot and Aleksandar, and showed a deficiency in 2009 in all cultivars. B deficiency was identified in all cultivars other than Aleksandar in 2008 and Biljana in 2009.

Table 5. DOP index and ΣDOP determined from leaf micronutrients at 120 DAFB in five apricot cultivars in 2008–2009
Tabela 5. Wskaźnik DOP i ΣDOP wyznaczany dla mikroskładników odżywczych w liściach pięciu odmian moreli w 120 dni po pełni kwitnienia w latach 2008 i 2009

Cultivar Odmiana	Fe		Mn		Cu		Zn		B		ΣDOP index
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	
Vera	-50.0	-47.1	-33.2	-60.7	+40.9	-35.2	-59.4	-49.4	-32.8	-21.0	429.7 a
Harcot	-45.6	-43.2	+1.0	+31.9	-24.8	-20.0	-52.8	-45.7	-42.2	-15.0	322.2 d
Aleksandar	-51.1	-47.8	+8.7	-23.5	-30.5	-17.1	-53.7	-53.4	+12.5	-49.5	347.8 c
Biljana	-52.8	-49.6	+54.8	-20.9	+42.8	-56.2	-54.0	-43.1	-15.5	+12.5	402.2 b
Roksana	-56.5	-41.4	-18.6	16.0	+46.7	-9.5	-55.7	-60.0	-29.8	-6.5	340.7 c
Average Średnia	-51.2	-45.8	+2.5	-11.4	+15.0	-27.6	-55.1	-50.3	-21.6	-15.9	-

*For explanation of character symbols, see table 4.
*Wyjaśnienia znaków, patrz: tabela 4.

The highest ΣDOP index values in macronutrients (tab. 4) were determined in Biljana and Vera, suggesting a high leaf nutrient imbalance, whereas the lowest values were obtained in cv. Harcot at $P \leq 0.05$. In micronutrients (tab. 5), the ΣDOP index was highest in cv. Vera, resulting in the highest imbalance in terms of the content of the above nutrients. The lowest ΣDOP index i.e. the most strongly balanced micronutrient content was determined in cvs. Aleksandar and Roxana.

DISCUSSION

Evaluation of leaf nutrient content at 120 DAFB. The results obtained in this study indicated normal values of the N and K content in apricot leaves in all cultivars, below-optimal values of Ca and Mg and above-optimal values of P, relative to the previously reported reference values for apricot [Leece and Van Den Ende 1975]. Relative to a somewhat wider range of the optimum nutrient supply of apricot leaves reported by Bergman [1983], the content of all macronutrients in the present study was within optimum values, with only the content of Mg in 2008 being deficient. Similar values for the leaf N content in apricots were obtained by Almaliotis et al. [2006], whereas the content of P and K in their research was lower, and that of Ca and Mg higher as compared to the results of the present study. Milošević et al. [2010] analysed the mineral status in apricot cv. Vera and obtained a lower leaf N supply, a better Mg supply and the values for P, K and C being similar to those of this study. A similar range of variations in the macronutrient content in cv. Roxana was obtained by Bojić et al. [1999]. In addition, Szücs [1986] found a positive effect of the optimal N:K ratio in the apricot leaf of 0.8–1.2 on apricot growth, flowering and fruit yield, the ratio being also observed in the present study. A comparison of the leaf macronutrient content with the soil content suggests a direct dependence, given the good soil supply with N, P and K resulting in their uptake by the plant, as opposed to the low content of Ca and Mg and, hence, an insufficient leaf supply with these nutrients. Ca and Mg deficiencies in the soil were induced by the acid reaction of the soil used in the experiment [Glisic et al. 2009]. A positive correlation between the content of K and Mg in the soil and that in the apricot leaf was previously determined by Güleryüz et al. [1995]. Bas and Paydas [1999] established that a K-Mg and K-Ca imbalance in apricot leaves was also affected by the mutual antagonism of these nutrients, which may also account for the deficiency of Ca and Mg in the present study, as the K content was within a range of good values.

The leaf micronutrient content showed substantial cultivar-dependent variations. As in the case of macronutrients, Bergman [1983] provided wider limits for micronutrients as compared to the reference values used in this study. When compared with them, the content of all micronutrients in this study was within optimum values for all cultivars. A comparison of the Fe and Zn content in the apricot leaf in all cultivars with the reference values reported by Leece and Van Den Ende [1975] suggests a deficiency of these nutrients and optimum values for the content of Mn, Cu and B. The deficiency of Fe and Zn can be attributed to the antagonistic effect of P:Fe and P:Zn, as previously reported by Murphy et al. [1981]. Furthermore, regardless of the typically very high content of Fe in the acid soil, this nutrient was not uptaken by the plant. This negative correlation was previously determined by Güleryüz et al. [1995]. The marked solubility of Zn compounds in acid soils contributed to a very low Zn content in the soil, which adversely affected Zn leaf levels. However, the content of Fe and Zn in the present study was similar to the values obtained by Almaliotis et al. [2006]. The levels of Mn, Cu and B were within normal supply values, but closer to the lower optimum supply limit determined by Leece and Van Den Ende [1975]. Similar tendencies were reported by Almaliotis et al. [2006]. The normal leaf supply with these nutrients was an expected result, given the acid reaction of the soil in the apricot orchard as well as the fact that acid soils are the most favourable environment for the uptake of these micronutrients from the soil [Tyler and Olsson 2001]. The considerably lower leaf Fe and Zn content in 2008 was attributed to the antagonistic effect of P which was found to be present at higher levels in this year than in 2009 [Murphy et al. 1981].

DOP index. The DOP index results presented in Tables 3 and 4 suggest below-optimal values for the content of all macronutrients excepting P and all micronutrients other than Mn and Cu in 2008 [Leece and Van Den Ende 1975]. Among macronutrients, the highest deficiency was observed in Ca and Mg, being induced by the acid soil reaction and their deficiency in the soil, as previously found by Liferdi et al. [2008]. Although no severe deficiency of N and K was observed, adequate fertilisation should be used to correct the lack of these nutrients, specifically focusing on excessive P levels that may block the uptake of Mg, Fe, Zn and Cu thereby disrupting the nutrient balance of apricot trees, as previously reported by Milošević et al. [2010] and Milosevic and Milosevic [2011].

As regards micronutrients, the highest deficiency was observed in Fe and Zn, being due to insufficient amounts of these nutrients introduced into the soil through organic and mineral fertilisation along with their limited uptake by the plant due to the antagonistic effect on P or Zn deficiency in the soil. Similarly to Fe and Zn, the DOP index showed deficient values for Cu, Mn and B in the apricot leaf. This suggests that regardless of the soil pH being favourable for the micronutrient uptake [Leece and Van Den Ende 1975], the specific nature of this soil necessitates not only organic, compound NPK and nitrogen fertilisation but also the use of micronutrient-containing fertilisers. Liming is another operation required for this soil.

Overall, the ΣDOP index revealed an insufficient supply of apricot trees with the required nutrients in all cultivars, suggesting inadequacy of the organic and mineral fertilisation employed in this study.

CONCLUSIONS

1. The apricot cultivars analysed in this study exhibited statistically significant differences in the leaf content of P, Mg, Fe, Mn, Cu, Zn and B at 120 DAFB and no significant variations in the content of N, K and Ca.

2. Leaf nutrient accumulation was non-uniform, being cultivar-dependent, and resulted in nutrient deviation from optimum values.

3. The ΣDOP index showed a strong nutrient imbalance in all cultivars, suggesting that inadequate organic and mineral fertilisation was employed in this study.

REFERENCES

Almaliotis D., Velemis D., Bladenopoulou S., Karapetsas N., 2006. Apricot yield in relation to leaf nutrient levels in Northern Greece. Acta Hortic., 701, 669–673.

AOAC, 1990. In: Helrich K. (eds): Official Methods of Analysis of the Association of Official Analytical Chemists. Washington DC.

Ankerman D., Large R., 1977. Minor elements. In: Soil and Plant Analysis, Madison, WI: Soil Science Society of America/SSSA, pp. 34–45.

Bas M., Paydas S., 1999. Effect of different rootstock on the bud-take, nutrient absorption rate and growth of some apricot cultivars. Acta Hortic., 488, 501–506.

Bergmann W., 1983. Ernáhrugnstörungen bel Kulturpflanzen. VEB Gustav Fischer Verlag. Jena.

Bojic M., Milosevic T., Rakocevic L., 1999. Macro and microelement content of leaves of the apricot cv. Roxana grafted on two rootstock. Acta Hortic., 488, 543–546.

Ganzhara N.F., 1998. Humus, soil properties and yield, Eurasian Soil Sci., 31, 738–745.
Glisic P.I., Milosevic M.T., Glisic S.I., Milosevic T.N., 2009. The effect of natural zeolites and organic fertilizers on the characteristics of degraded soils and yield of crops grown in Western Serbia. Land Degrad. Dev., 20(1), 33–40.
Güleryüz M., Bolat I., Pirlak L., Esitken A., Ercisli S., 1995. Seasonal variations in the amount of plant nutrient elements (PNE) in leaves and their relationship with PNE in soil in apricot orchard (cv. Salak). Acta Hortic., 384, 441–448.
Güleryüz M., Bolat İ., Pirlak L., Eşítken A., Ercíşlí S., 1996. Investigations on determination of nutritional status of apricot (cv. Hasanbey) grown in Erzincan, Turkey. J. Agric. Forest., 20(6), 479–487.
Jakson D.I., 1970. Effects of temperature and nutrition on growth and flower-bud initiation in apricots. N. Zeal. J. Agr. Res., 13(3), 726–734.
Jiménez S., Garín A., Gogorcena Y., Betrán A.J., Moreno A.M., 2004. Flower and foliar analysis for prognosis of sweet cherry nutrition: Influence of different rootstocks. J. Plant Nutr., 27(4), 701–712
Johnson R.S., 1993. Stone fruit: peaches and nectarines. in: Bennett W.F. (Eds.). Nutrient deficiencies and toxicities in crop plants. APS Press, Minnesota, 171–175.
Larney F.J., Buckley K.E., Hao X., McCaughey W.P., 2006. Fresh, stockpiled and composted beef cattle feedlot manure, J. Environ. Qual., 35(5), 1844–1854.
Leece D.R., Van Den Ende B., 1975. Diagnostic leaf analysis for stone fruit. 6. Apricot. Aust. J. Exp. Agric. Anim. Husb., 15(72), 123–128.
Liferdi R., Poerwanto R., Susila D.A., Idris K., Mangku W.I., 2008. Correlation test of leaf phosphorus nutrient with mangosteen production. Indonesian J. Agric. Sci., 1(2), 95–102.
Lucena J.J., 1997. Methods of diagnosis of mineral nutrition of plants, a critical review. Acta Hortic., 448, 179–192.
Milosevic T., 2006. Effect of interstock on seasonal changes in microelement concentrations in apricot leaf. Acta Hortic., 701, 719–722.
Milosevic T., Milosevic N., 2009. The effect of zeolite, organic and inorganic fertilizers on soil chemical properties, growth and biomass of apple trees. Plant Soil Environ., 55(12), 528–535.
Milošević T., Milošević N., Glišić I., Paunović G., 2010. Diagnosis of nutritional status of apricot on the basis foliar analysis: Impact of different interstocks. Zbornik naučnih radova Instituta PKB Agroekonomik, 16(5), 31–41. [in Serbian]
Milosevic T., Milosevic N., 2011. Seasonal changes in micronutrients concentrations in leaves of apricot trees influenced by different interstocks. Agrochimica, 15(1), 1–14.
Montañés L., Heras L., Sanz M., 1991. Desviacién del óptimo porcentual (DOP): nuevo índice para la interpretación del análisis vegetal. An. Aula Dei, 20(3–4), 93–107.
Montañés L., Sanz M., 1994. Prediction of reference values for early leaf analysis for peach trees. J. Plant Nutr., 17(10), 1647–1657.
Murphy L.S., Ellis R., Adriano D.C., 1981. Phosphorus-micronutrient interaction effects on crop production. J. Plant Nutr., 3(1–4), 593–613.
Rosati A., DeJong T.M., Southwick S.M., 1997. Comparison of leaf mineral content, carbon assimilation and stem water potential of two apricot (*Prunus armeniaca*) cultivars grafted on 'Citation' and 'Marianna 2624' rootstock. Acta Hortic., 451, 263–268.
Stevanović D., Marković N., Martinović Lj., 1987. A contribution to the study of soil acidification in Serbia without provinces. Agrohemija, 6, 427–431. [in Serbian]
Szücs E., 1986. Effects of fertilization on nutrient supply, yield, growth and frost hardiness of apricot trees. Acta Hortic., 192, 137–142.

Taylor K.B., Goubran H.F., 1975. The phosphorus nutrition of the apple tree. I. Influence of rate of application of superphosphate on the performance of young trees. Australian J. Agric. Res., 26(5), 843–853.

Treder W., Olszewski T., 2004. The estimation of the influence of the way of fertilization on the content of nitrogen in the leaves of apple trees. Acta Sci.Pol., Hortorum Cultus, 3(2), 111–122.

Tyler G., Olsson T., 2001. Concentrations of 60 elements in the soil solution as related to the soil acidity. European J. Soil Sci., 52(1), 151–165.

Velemis D., Almaliotis D., Bladenopoulou S., Karayiannis I., 1999. Growth and nutritional status of twelve apricot varieties grafted on two rootstocks. Acta Hortic., 488, 489–494.

Yu-Yen L., 2006. Seasonal changes in the foliar nutrients of major species in three topographic types of Fushan. PhD Theses. School of Forestry and Resource Conservation, Taiwan.

WPŁYW ODMIANY NA POZIOM ODŻYWIENIA MŁODYCH DRZEW MORELI (*Prunus armeniaca* L.)

Streszczenie. Odżywianie mineralne moreli jest bardzo specyficzne i zależy od różnych czynników, takich jak: żyzność gleby, pH gleby, warunki pogodowe, odmiany, kłącza, nawozy, wiek drzew, itp. Z tych powodów, w latach 2008 i 2009 oceniamy poziom odżywienia pięciu odmian moreli (Vera, Aleksandar, Biljana, Harcot, Roxana) w 120 dni po pełni kwitnienia (DAFB), hodowanych na glebie kwaśnej w regionie Čačak (Serbia Zachodnia). Wyniki nie wykazywały statystycznie istotnych odchyleń w zawartości N, K i Ca w liściach moreli różnych odmian, w przeciwieństwie do znaczących różnic w zawartości P, Mg, Fe, Mn, Cu, Zn i B. Wskaźnik ΣDOP wykazał, że średnia zawartość wszystkich makro- i mikroskładników odżywczych była poniżej optymalnej, oprócz P w obu latach oraz Mn i Cu w pierwszym roku badań. Niedostateczne zaopatrzenie w składniki odżywcze testowych odmian moreli wymaga dostosowania typów nawozów i zastosowanych dawek do typu gleby, zgodnie z analizą liści.

Słowa kluczowe: Wskaźnik DOP, analiza liści, makro- i mikroelementy (makro- i mikroskładniki odżywcze), ΣDOP

ACKNOWLEDGEMENTS

This work was part of a research project TR 31064 and TR 31059 funded by the Republic of Serbia, Ministry of Science. Financial assistance from the Ministry is gratefully acknowledged. Special thanks to Ms. Jelena Krstić, Faculty of Agronomy, Cacak, for translating the paper into English.

Accepted for print – Zaakceptowano do druku: 1.12.2011