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FACTORS INFLUENCING MINERAL COMPOSITION OF PLUM FRUITS

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Abstract

The study has been based on a three-factor field experiment (two rootstocks – Myrobalan and Stanley seedlings, two cultivars – Čačanska lepotica and Čačanska najbolja, three years – 2006, 2007 and 2008) set up according to the method of randomized blocks with four replications. The aim of this work was to evaluate the mineral composition of plums in Serbia. The results indicated that levels of fruit ash and minerals, except nitrogen, significantly differed between the treatments. The average content of ash in plum fruits reached 4.54%, nitrogen – 0.78%, phosphorus – 0.06%, potassium – 1.45%, calcium – 0.07%, magnesium – 0.16%, iron – 19.37 μg g^{-1}, manganese – 10.21 μg g^{-1}, copper – 3.21 μg g^{-1}, zinc – 19.29 μg g^{-1} and boron – 22.83 μg g^{-1} of dry matter. A strong rootstock/cultivar/year interaction was found for most of the minerals. Between ash and manganese or zinc, and between manganese and zinc in plums, significant correlations were observed. On the basis of the analysis of major components, we concluded that Stanley rootstock had better ability to accumulate ash and most of the minerals in fruits of both cultivars than Myrobalan rootstock.

Key words: cultivar, fruits, minerals, Myrobalan, *Prunus domestica* L., Stanley.

CZYNNIKI WPŁYWAJĄCE NA SKŁAD MINERALNY OWOCÓW ŚLIW

Abstrakt

Badania wykonano na podstawie trójczynnikowego doświadczenia polowego (dwa podkłady z sadzonek odmian Myrobalan i Stanley, dwie domiany Čačanska lepotica i Čačanska najbolja oraz trzy lata: 2006, 2007 i 2008), założonego zgodnie z metodą losowych bloków w czterech powtórzeniach. Celem pracy było ocenienie zawartości składników mineralnych w owocach śliw rosnących w Serbii. Wykazano, że zawartość popiołu oraz składników mi-

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neralnych w owocach śliw, z wyjątkiem azotu, różniła się istotnie w poszczególnych obiektach doświadczenia. Średnia zawartość popiołu w śliwkach wynosiła 4,54%, azotu – 0,78%, fosforu – 0,06%, potasu – 1,45%, wapnia – 0,07%, magnezu – 0,16%, żelaza – 19,37 μg g^{-1}, manganu – 10,21 μg g^{-1}, miedzi – 3,21 μg g^{-1}, cynku – 19,29 μg g^{-1}, boru – 22,83 μg g^{-1} suchej masy. W przypadku większości składników mineralnych stwierdzono silną interakcję między podkładem, odmianą i rokiem badań. Zauważono istotne korelacje między popiołem a manganem oraz cynkiem, a także między manganem i cynkiem w śliwkach. Na podstawie analizy głównych komponentów doświadczenia stwierdzono, iż podkład z odmiany Stanley w większym stopniu pozwalał obu odmianom akumulować popiół i większość analizowanych składników mineralnych niż podkład Myrobalan.

Słowa kluczowe: odmiana, owoce, minerały, Myrobalan, *Prunus domestica* L., Stanley.

INTRODUCTION

Prunus domestica L. is one of the most important *Prunus* species, widely grown across the world. In Serbia, this crop, known as the Domestic or European plum, is a very old, traditional fruit tree, so plums are one the most popular fruits in local diet, playing an important role in the economy and social development of the country (Milošević, Milošević 2011). Plum trees are grown throughout Serbia, except cold mountainous area. The total area of plum orchards in Serbia reached over 130,000 ha in 2010 and the production output was 426,826 tons, which makes this country the fourth largest world producer after China, Romania and USA (FAO 2012). The most important plum tree growing area is Western Serbia. Cacak, a location in this region, is the most important plum production center. Plums are eaten fresh or dried. Other main processed products made from plums include *pekmez* (special old Serbian jam without sugar), *slatko* (old Serbian specialty for guests, with added sugar), jams, compotes, mousse, pulp, candied fruit, frozen fruit, jelly products and traditional Serbian plum brandy Rakija or Šljivovica (Milošević, Milošević 2011).

Generally, plum fruits are suitable for human nutrition (Jaroszewska 2011) owing to their high energy, nutritive, dietary and health values (Walkowiak-Tomczak 2008). The high dietary value of plums results from their considerable content of organic and inorganic phytochemical constituents, such as carbohydrates (mono- and disaccharides, pectin, dietary fiber) (Stecewicz-Sapuntzakis et al. 2001), antioxidant compounds, phenolic acids, flavonoids, vitamins, proteins, fat, etc. (Auger et al. 2004). Also, plums are raw material rich in ash and minerals (Nergiz, Yýldýz 1997) such as potassium, sodium, calcium and magnesium (Bhutani, Joshi 1995, Kunachowicz et al. 2005, Çalişr et al. 2005). Additionally, plums also contain microelements, especially boron and iron (Yagmur, Taskin 2011, Jaroszewska 2011).

Many authors reported that concentrations of minerals in plums depend on the cultivar, pedo-climatic conditions, harvest date (Nergiz, Yýldýz 1997), water and fertilization regimes (Jaroszewska 2011), and especially on rootstocks. Beside its effect on the vigor of a fruit tree, a rootstock can modify fruit quality (Rato et al. 2008, Daza et al. 2008). Myrobalan (*P. cerasifera* Ehrh.) seedlings are the most popular and traditional rootstock for European plum trees in Serbia (Milošević, Milošević 2011). However, this type of rootstock has some negative traits, such as inadequate compatibility with some cultivars, high vigor, only average winter-hardiness, etc. (Loreti et al. 1990). Thus, alternative rootstocks for intensively grown orchards are needed. Rootstocks of cv. Stanley seedlings have not been examined from that point of view until now. Thus, the objectives of our research were: a) to evaluate the influence of two rootstocks on the fruit quality of an individual plum cultivar with special reference to the macro- and microelements of the fruit; b) to estimate the most favorable rootstock for producing fruits from the cultivars Čačanska lepotica and Čačanska najbolja with the best mineral content.

MATERIAL AND METHODS

The present study was carried out in three successive years (2006, 2007, 2008) in a private orchard located at the village Viljusa (43°50' N, 20°24', 290 m above sea level) near Cacak, Western Serbia. Two cultivars (Čačanska lepotica and Čačanska najbolja) were grafted on two rootstocks (Myrobalan and Stanley seedlings). The orchard was established in 1992 at 6 m × 4 m planting distance. Trees were trained as Open vase, under non-irrigated, standard horticultural practice. A randomized complete blocks design was adopted in this trial, with five trees of each rootstock/cultivar/year combination in four replicates.

Table 1

Soil chemical properties at different soil depths

Soil pH, organic matter, and macronutrient	Units or content	Micronutrient and EC*	Content
Soil pH	4.31	Fe (mg kg^{-1})	78.0
Organic matter (%)	1.29	Mn (mg kg^{-1})	7.8
Total nitrogen (%)	0.14	Cu (mg kg^{-1})	1.6
P_2O_5 (mg kg^{-1})	34.1	Zn (mg kg^{-1})	0.52
K_2O (mg kg^{-1})	270.1	B (mg kg^{-1})	2.3
CaO (%)	0.73	Na_2O (%)	0.68
MgO (%)	2.34	EC (dS m^{-1})	0.74

*EC: Electrical conductivity

Orchard soil was Cambisol (Serbian Soil Taxonomy). The average soil chemical composition from the 0-20 cm soil depth is presented in Table 1. The data showed that the soil was highly acid, low in organic matter and in total nitrogen. The content of available P_2O_5 and K_2O was low and moderate, respectively. The content of CaO, MgO and Na_2O was low, and did not reach the standard levels for Cambisol soil of a sandy-loam texture in Serbia (Protic et al. 2003). Electrical conductivity (EC) of the soil samples was 0.74 dS m^{-1}. The soil showed broad variation in the content of available micronutrients, ranging from very high for Fe, high for Cu and B, low for Mn to very low for Zn (Ankerman, Large 1977).

The climate is maritime temperate, with moderate to strong winters and hot and semi to dry summers, characterized by the average annual temperature of 11.3°C and total annual rainfall of 690.2 mm.

Fruit samples for analysis were collected at commercial maturity, carefully rinsed with deionized water and, after recording their surface area, oven dried, weighed, ground to pass a 0.5 mm mesh and analyzed for macronutrient content according to the guidelines of the Association of Official Analytical Chemists (AOAC 1995). Nitrogen was determined by Kjeldahl analysis; phosphorus was analyzed spectrophotometrically by the phospho-vanadate colorimetric method (Hewlett Packard 8452A, Ontario, Canada); K was determined by flame photometry (Corning 405, Halstead, UK), and Ca, Mg, Fe, Mn, Cu and Zn by atomic absorption spectroscopy (Pye Unicam SP 191, Cambridge, UK); B was determined colorimetrically using quinalizarin, in a colorimeter Zeiss MK 6/6 (Carl Zeiss, Jena, Germany). The data are given as % and µg g^{-1} of dry matter for each macro- and microelement studied, respectively. The ash content was estimated after burning at 550°C and expressed as %. The values are presented as means ± standard error (SE) of triplicate analyses for each treatment per year.

A 2´2´3 factorial design was employed. The data from determinations of the minerals were analyzed by analysis of variance (ANOVA), using an MSTAT-C statistical package (Michigan State University, East Lansing, MI, USA), and mean values were grouped using an LSD test at $p \leq 0.05$ as a *post-hoc* analysis. Relationships between the minerals were evaluated by Pearson's product-moment correlation at $p \leq 0.05$. A principal component analysis (PCA) was performed to determine the relationships among rootstock/cultivar combinations and among variables using the PRINCOMP procedure of the SAS statistical package (SAS Institute Inc., North Carolina, USA).

RESULTS AND DISCUSSION

Ash and content of macroelements

Amounts of ash, P and K in plums varied significantly between the rootstocks, cultivars and years, whereas Ca and Mg significantly differed only

Table 2

Fruit ash and macroelements in Čačanska lepotica and Čačanska najbolja on different rootstocks

Parameter	Ash (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Rootstock (A)						
Myrobalan	4.435±0.336[b]	0.780±0.021[a]	0.052±0.005[b]	1.595±0.035[a]	0.072±0.002[a]	0.166±0.006[a]
Stanley	4.640±0.261[a]	0.790±0.010[a]	0.066±0.004[a]	1.375±0.005[b]	0.076±0.005[a]	0.150±0.028[a]
Cultivar (B)						
Čačanska lepotica	4.838±0.291[a]	0.798±0.031[a]	0.054±0.007[b]	1.505±0.133[a]	0.078±0.005[a]	0.169±0.015[a]
Čačanska najbolja	4.240±0.207[b]	0.772±0.026[a]	0.063±0.004[a]	1.463±0.060[b]	0.070±0.010[a]	0.148±0.012*a*
Year (C)						
2006	5.077±0.359[a]	0.830±0.018[a]	0.060±0.007[b]	1.382±0.101[c]	0.060±0.005[b]	0.157±0.019[b]
2007	4.347±0.134[b]	0.710±0.011[a]	0.064±0.008[a]	1.588±0.105[a]	0.068±0.009[b]	0.155±0.021[b]
2008	4.192±0.335[c]	0.815±0.028[a]	0.052±0.006[c]	1.482±0.159[b]	0.094±0.005[a]	0.162±0.014[a]
Average	4.539±1.028	0.785±0.013	0.059±0.007	1.484±0.211	0.074±0.004	0.158±0.008
ANOVA (significance)						
A × B	ns	ns	*	*	ns	ns
A × C	ns	ns	*	*	ns	ns
B × C	ns	ns	*	*	ns	ns

Different letter in columns indicate significantly different values at $p \leq 0.05$ by LSD test. The asterisk in column indicates a significant difference between means at $p \leq 0.05$ by LSD test. ns: non-significant differences.

among years (Table 2). Also, strong rootstock/cultivar/year interaction was observed for the ash, P and K content in plums. On the other hand, there were no significant differences among rootstocks, cultivars and years in the N and Mg content. The highest ash and P content were found in plums of the cultivars grafted on Stanley rootstock, whereas the K content was the highest in the cultivars grafted on Myrobalan. Fruits of Čačanska lepotica were richer in ash and K, whereas plums of Čačanska najbolja had a higher P content. Regarding the years, significantly higher ash content was determined in the first season; in the second year, the P and K content was the highest, while in the third season, the Ca and Mg content was higher. The total quantities of the macroelements accumulated in fully ripe plums followed a decreasing order: K > N > Mg > Ca > P.

Wide variations in the mineral composition of plums have been previously reported in the literature, for example NERGIZ, YÝLDÝZ (1997) claimed that the ash content was significantly affected by cultivars and geographical regions, and varied between 3.7 and 9.0 g kg^{-1}. ÇALIŞIR et al. (2005) reported that wild plum contained close to 3% ash. Our arrangement of the microelements in plums in the decreasing concentration order was in agreement with BHUTANI, JOSHI (1995), KUNACHOWICZ et al. (2005) and ÇALIŞIR et al. (2005), who all reported that K was a dominant mineral, followed by Ca and Mg. JAROSZEWSKA (2011) reported that under different water and fertilization regimes, macronutrient amounts in plums of Čacanska rana followed a decreasing order: K > N > P > Ca > Mg. Differences between the present results for some macroelements and those obtained by JAROSZEWSKA (2011) are probably due to diferent cultivars and environmental conditions. Namely, in our unpulished work, fruit of Čačanska rana had a higher water content when compared with Čačanska lepotica and Čačanska najbolja. This was connected with the solubility of minerals in water, due to which some amounts of the minerals were transferred to water (CLYDESDALE et al. 1991). On the other hand, RATO et al. (2008) reported that the content of some phytochemicals may be affected by a soil type and plum rootstock. In addition, plums of both cultivars on both rootstocks contained considerable amounts of Ca and Mg, which is in agreement with some previous studies carried out on plum (WALKOWIAK-TOMCZAK 2008, JAROSZEWSKA 2011). Finally, significant interactions between rootstocks, cultivars and years verified for some macroelements suggested that their content under the same conditions does not depend on a particular parameter alone (rootstock, cultivar or year) but on their combination, as observed previously (NERGIZ, YÝLDÝZ 1997).

Concentrations of microelements

Concentrations of microelements in two plum cultivars are shown in Table 3. Regarding rootstocks, Myrobalan induced a higher Fe concentration in plums, while plums growing from the Stanley rootstock had more B. Differences between the rootstocks in Mn, Cu and Zn concentrations were not significant. In this context, THORP et al. (2007) reported that rootstocks led to differences in the vigor of trees and had an important role in determining nutrient concentrations in fruits and leaves. According to the above authors, some rootstocks were evidently able to absorb nutrients from soil better than others, irrespective of their effect on the tree vigour. A similrar observation was previously reported by DAZA et al. (2008).

In respect of the cultivars, Čačanska lepotica had significantly higher amounts of Mn, Cu and Zn; plums of Čačanska najbolja had a higher Fe concentration, whereas no differences between the cultivars in the B content were observed. The Fe, Cu, Zn and Mn concentrations in fresh plums of *P. domestica* determined in the present study were much higher than found by YAGMUR, TASKIN (2011). L. NERGIZ, YÝLDÝZ (1997) also reported much less Fe in plums than observed in our study, whereas JAROSZEWSKA (2011) observed more Fe and less Zn in fruits of Čačanska rana than in our study. This may be due to differences in the tested cultivars. In general, our findings were similar to the data obtained by KATÝYAR et al. (1990), who reported

Table 3

Concentration of microelements in fruits of Čačanska lepotica and Čačanska najbolja on different rootstocks

Parameter	Fe (μg g^{-1})	Mn (μg g^{-1})	Cu (μg g^{-1})	Zn (μg g^{-1})	B (μg g^{-1})
Rootstock (A)					
Myrobalan	20.50±0.832^{a}	9.800±2.638^{a}	3.300±0.431^{a}	18.92±2.091^{a}	21.56±0.567^{b}
Stanley	18.25±1.083^{b}	10.62±1.956^{a}	3.135±0.065^{a}	19.66±0.837^{a}	24.10±0.501^{a}
Cultivar (B)					
Čačanska lepotica	19.25±2.077^{a}	12.50±0.682^{a}	3.467±0.641^{a}	20.25±1.189^{a}	22.87±2.530^{a}
Čačanska najbolja	19.50±1.204^{a}	7.917±0.471^{b}	2.967±0.253^{b}	17.83±2.355^{b}	22.80±1.987^{a}
Year (C)					
2006	18.00±2.380^{b}	10.65±1.746^{a}	2.750±0.126^{c}	22.87±2.276^{a}	29.20±1.829^{a}
2007	21.62±0.746^{a}	10.30±1.692^{a}	3.125±0.382^{b}	19.00±2.406^{b}	18.20±0.804^{c}
2008	18.50±2.372^{b}	9.675±0.945^{a}	3.775±0.953^{a}	15.87±1.419^{c}	21.10±0.451^{b}
Average	19.37±1.128	10.21±0.411	3.215±0.085	19.29±0.371	22.83±1.274
ANOVA (significance)					
A × B	ns	ns	*	*	*
A × C	ns	ns	*	ns	*
B × C	*	*	*	ns	*

Different letter in columns indicate significantly different values at $p \leq 0.05$ by LSD test.
The asterisk in column indicates a significant difference between means at $p \leq 0.05$ by LSD test.
ns – non-significant differences

that plums of *P. domestica* L. contained 4-360 mg kg^{-1} Fe. The total amounts of microelements in plums followed a decreasing order: B > Fe > Zn > Mn > Cu (Table 3). These results are in good agreement with the orders reported by STACEWICZ-SAPUNTZAKIS et al. (2001) and WALKOWIAK-TOMCZAK (2008), who all emphasized that plums are an important source of B. In contrast, ÇALIŞIR et al. (2005) reported that wild plums conatined more Fe than B, and their decreasing order for five microelements was: Fe > B > Cu > Mn > Zn.

Year-by-year variations in levels of the microelements were observed; Zn and B concentrations were higher in 2006, Fe – in 2007, and Cu – in 2008. Differences between the years in Mn concentrations were not observed. Annual variations in the content of Fe, Cu, Zn and B could be due to the environmental conditions as well as the nutritional status of the plantation (NERGIZ, YÝLDÝZ 1997, STACEWICZ-SAPUNTZAKIS et al. 2001).

Finally, strong interactions between the cultivar and year with respect to Fe, and among the rootstock, cultivar and year in the case of the other microelements indicated a very complex nature of the accumulation of microelements in fruits of plum trees and the importance of a good choice of rootstocks to maximize the potential performance of a cultivar grown in an orchard for several years, both observations claimed previously by THORP et al. (2007).

Relationship among fruit minerals and principal component analysis

The data given in Table 4 showed some significant relations between the set of variables evaluated. The Mn and Zn amounts significantly correlated with the ash content. These relationships indicated that a higher ash

Table 4

Correlation matrix between the analyzed variables

Varia-bles	Ash	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
Ash	1										
N	0.897	1									
P	-0.435	-0.171	1								
K	-0.133	-0.280	-0.815	1							
Ca	0.660	0.420	0.000	-0.537	1						
Mg	0.318	-0.133	-0.621	0.316	0.570	1					
Fe	-0.249	-0.117	-0.477	0.812	-0.860	-0.292	1				
Mn	0.988*	0.863	-0.565	0.022	0.580	0.366	-0.121	1			
Cu	0.714	0.718	-0.733	0.467	-0.032	0.072	0.501	0.795	1		
Zn	0.960*	0.948	-0.470	-0.015	0.428	0.121	-0.003	0.967*	0.856	1	
B	0.366	0.652	0.635	-0.843	0.322	-0.588	-0.452	0.240	0.001	0.381	1

Asterisk indicated that correlation coefficient is significant at $p \leq 0.05$.

content contained more Mn and Zn. Additionally, Zn and Mn significantly correlated with each other. Correlations between the other variables were not significant. JAROSZEWSKA (2011) noticed a strong relationship between sugars and K or Ca, which proves that the content of macro- and microelement in plums is a complex phenomenon, determined by numerous characteristics, e.g. the soil type and texture, content of soil nutrients and their ratio, amounts of rainfall, field water capacity, air temperature and horticultural practice (BERNSTEIN et al. 1956).

More than 80% of the variability obtained in this study was explained by the first two variables (Table 5). PC1 and PC2 accounted for 47.01% and 33.93% of the variability, respectively. Figure 1 represents PC1 and PC2 plotted on a two-dimensional plane. Table 6 shows correlations between the original variables and the first two principal components: PC1 represents

Table 5

Eigenvalues and proportion of total variability among rootstock/cultivar combinations as explained by the three principal components (PC)

PC	Eigenvalues	Percent of variance	Cumulative (%)
1	5.171	47.011	47.011
2	3.732	33.926	80.937
3	2.097	19.063	100.000

Table 6

Component loadings for macro- and microelements in plums for four rootstock/cultivar combinations based on three principal components

Variable	Component loadings		
	PC1, λ = 47.01	PC2, λ = 33.93	PC3, λ = 19.06
Ash (%)	0.995	-0.074	0.061
N (%)	0.908	-0.217	-0.359
P (%)	-0.485	-0.842	-0.238
K (%)	-0.061	0.998	0.020
Ca (%)	0.587	-0.515	0.625
Mg (%)	0.287	0.316	0.904
Fe (μg g^{-1})	-0.155	0.815	-0.559
Mn (μg g^{-1})	0.995	0.082	0.060
Cu (μg g^{-1})	0.777	0.522	-0.351
Zn (μg g^{-1})	0.980	0.049	-0.194
B (μg g^{-1})	0.336	-0.815	-0.472

the amounts of ash, N, Ca, Mn, Cu and Zn; PC2 represents the amounts of P, K, Mg, Fe and B. The positive PC1 values indicate that Čačanska lepotica on Stanley gives a higher amount of ash, N, Ca, Mn, Cu and Zn, as shown in Figure 1. The positive values for PC2 show that Čačanska lepotica on Myrobalan had a higher amount of K, Mg and Fe, while the negative PC2 values indicate a higher content of P and B in Čačanska najbolja on Stanley. In general, higher positive values for PC1 and PC2 indicate that Čačanska lepotica on both rootstocks had a higher content of ash, N, K, Ca, Mg, Fe, Mn, Cu and Zn, while Čačanska najbolja on Stanley rootstocks had a higher P and B content.

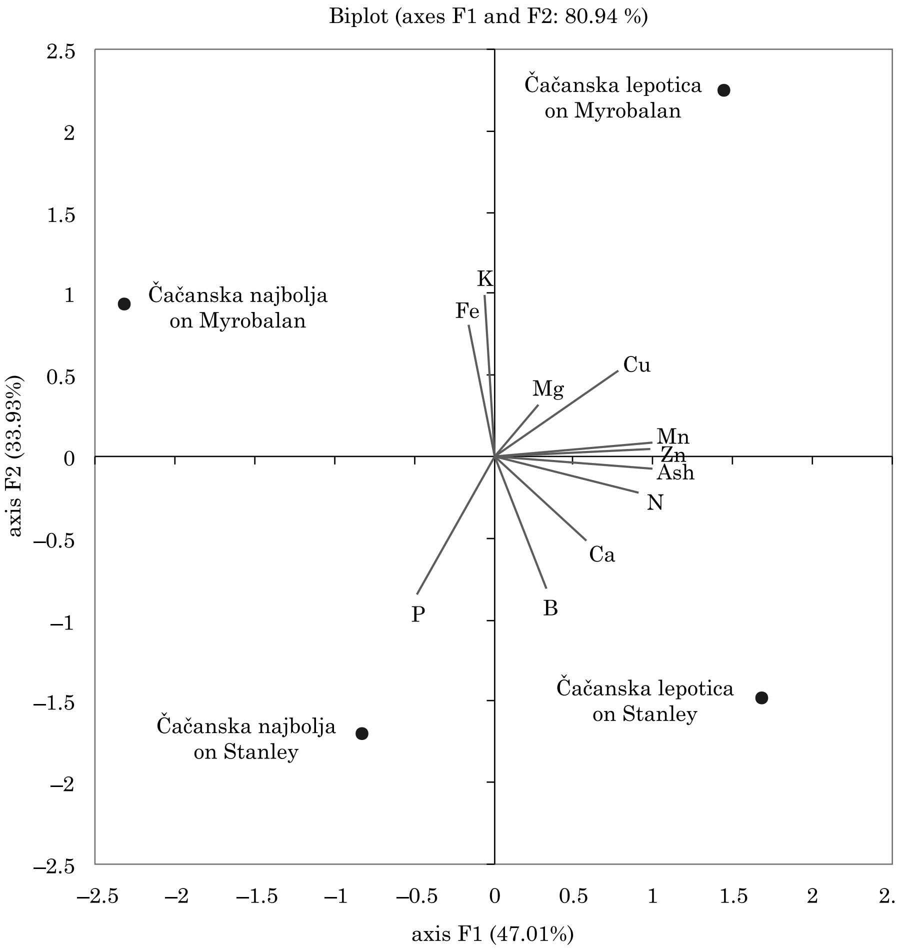

Fig. 1. Biplot based on principal component analysis (PCA) for ash, macro- (N, P, K, Ca and Mg) and microelement (Fe, Mn, Cu, Zn and B) contents in four plum cultivar/rootstock combinations

CONCLUSIONS

1. The results showed that rootstocks, cultivars, years and their mutual interaction induced a wide variation in amounts of macro- and microelements, except nitrogen, in fruit of plum trees. Stanley seedlings as a rootstock resulted in a higher content of ash, phosphorus and boron, while Myrobalan rootstock stimulated higher levels of potassium and iron in plums; fruits of Čačanska lepotica had more ash, potassium, manganese, copper

and zinc, and Čačanska najbolja fruits had more phosphorus and iron; more ash, zinc and boron was found in the 1st season; more phosphorus and potassium in the 2nd year and more calcium, magnesium and copper in the 3rd season.

2. Strong positive relationships were observed between ash and manganese or zinc, and between zinc and manganese.

3. The Principal component analysis suggested that Stanley rootstock may be better at achieving higher amounts of minerals in fruits than Mirobalan for Čačanska lepotica and Čačanska najbolja grown on Cambisol with low soil pH and deficiency of most soil nutrients.

REFERENCES

ANKERMAN D., LARGE R. 1977. *Minor elements*. In: (Ed.). *Soil and plant analysis*. Ankerman D. Soil Science Society of America, Inc., Madison, Wisconsin, USA, 34-45.

AOAC. 1995. *Official Methods of Analysis*. In: 16th Ed. Washington DC, 67-75.

AUGER C., AL-AWWADI N., BORNET A., ROUANET J.M., GASC F., CROS G., TEISSEDRE P.L. 2004. *Catechins and procyanidins in Mediterranean diets*. Food Res. Int., 37(3): 233-245.

BERNSTEIN L., BROWN J. W., HAYWARD H.E. 1956. *The influence of rootstock on growth and salt accumulation in stone-fruit trees and almonds.* Proc. Am. Soc. Hort. Sci., 68: 86-95.

BHUTANI V.P., JOSHI V.K. 1995. *Plum*. In: Salunkhe D.K. Kadam S.S. (Ed.). *Fruit science and technology, production, composition, storage and processing*. Marcel Dekker, Inc., New York, 203-241.

ÇALIŞIR S., HACÝSEFEROÐULLARÝ H., ÖZCAN M., ARSLAN D. 2005. *Some nutritional and technological properties of wild plum (Prunus spp.) fruits in Turkey*. J. Food Eng., 66(2): 233-237.

CLYDESDALE F.M., HO L.T., LEE C.Y., MONDY N.I., SHEWFWLT R.L. 1991. *The effects of postharvest treatment and chemical interactions on the bioavailibility of ascorbic acid, thiamin, vitamin A, carotenoids and minerals*. Crit. Rev. Food Sci. Nutr., 30(6): 599-638.

DAZA A., GARCIA-GALAVIS P.A., GRANDE M.J., SANTAMARIA C. 2008. *Fruit quality parameters of 'Pioneer' Japanese plums produced on eight different rootstocks*. Sci. Hort., 118(3): 206-211.

FAO Statistics Division, February 16, 2012. Available from http://faostat.fao.org.

GEORGE F.M.B. 2006. *Vitamins in foods: analysis, bioavailability and stability*. CRC Press, United States.

JAROSZEWSKA A. 2011. *Quality of fruit cherry, peach and plum cultivated under different water and fertilization regimes*. J. Elementol., 16(1): 51-58.

KATÝYAR S.K., SHARMA K., KUMAR N., BHATIA A.K. 1990. *Composition of some unconventional Himalayan wild fruits*. J. Food Sci. Technol., 27(5): 309-310.

KUNACHOWICZ H., NADOLNA I., PRZYGODA B., IWANOW K. 2005. *Food composition tables*. PZWL, Warsaw. (in Polish)

LORETI F., GUERRIERO, R., MASSAI R. 1990. *A new and promising plum rootstock selection: "Mr.S.2/5"*. Acta Hort., 283: 261-266.

MILOŠEVIĆ T., MILOŠEVIĆ N. 2011. *Growth, fruit size, yield performance and micronutrient status of plum trees (Prunus domestica* L.*)*. Plant Soil Environ., 57(12): 559-564.

NERGIZ C., YÝLDÝZ H. 1997. *Research on chemical composition of some varieties of European plums (Prunus domestica) adapted to the Aegean district of Turkey*. J. Agr. Food Chem., 45(8): 2820-2823.

PROTIC N., MARTINOVIC L., MILICIC B., STEVANOVIC D., MOJASEVIC, M. 2003. *The status of soil surveys in Serbia and Montenegro*. In: *Soil resources of Europe*. JONES R., HOUŠKOVA B., BULLOCK P., MONTANARELLA L. (Ed.). The European Soil Bureau, Luxemburg: Ispra, 297-315.

RATO E.A., AGULHEIRO C.A., BARROSO M.J., RIQUELME, F. 2008. *Soil and rootstock influence on fruit quality of plums (Prunus domestica* L.*)*. Sci. Hort., 118(3): 218-222.

STACEWICZ-SAPUNTZAKIS M., BOWEN P.E., HUSSAIN E.A., DAMAYANTI-WOOD B.I., FARNSWORTH N.R. 2001. *Chemical composition and potential health effects of prunes: a functional food?* Crit. Rev. Food Sci. Nutr., 41(4), 251-286.

THORP T.G., BOYD L.M., BARNET A.M., LOWE R.G., HOFSTEE B.J., BLATTMANN P.J., CLEARWATER M.J. 2007. *Effect of inter-specific rootstocks on inorganic nutrient concentrations and fruit quality of 'Hort16A' kiwifruit* (*Actinidia chinensis* Planch. var. *chinensis*). J. Hortic. Sci. Biotech., 82(6): 829-838.

WALKOWIAK-TOMCZAK D. 2008. *Characteristics of plums as a raw material with valuable nutritive and dietary properties – a review*. Pol. J. Food Nutr. Sci., 58(4): 401-405.

YAGMUR C., TASKIN M. 2011. *Study on changes in mineral content of plum (Prunus domestica) and strawberry (Fragaria × ananassa) during canning*. Ind. J. Agr. Sci., 81(8): 723-728.