THE RELATION BETWEEN THE CONTENT OF MACROELEMENTS FROM SOIL AND PLANT, AT SOME PLUM VARIETIES

RELAȚIA DINTRE CONȚINUTUL ÎN MACROELEMENTE AL SOLULUI ŞI PLANTEI, LA UNELE SOIURI DE PRUN

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Abstract. *The minerals requirements of different species are related to the species biological feature and even depend on the every varieties characteristic feature. In this context, this article is focused on the determination of some correlation between soil and plant mineral content with a view to assure an equilibrate nutrients supply during the vegetation period. The soil supply with minerals was slightly different for the three analyzed plum cultivars (Rivers timpuriu, Stanley, Centenar), but generally, the soil had a good supply with nitrogen, phosphorus and potassium. The content of minerals on different organs had variable limits: 9.04 to 12.67% - leaves; 4.54 to 5.14% - fruits; 4.89 to 8.12% - shoots of 1 year old and 4.89 to 8.12% - shoots of 2 years old. The highest average content of minerals in the 4 organs analyzed was determined for the flowering phenophase (6.70%) and the average content of minerals for the organs analyzed in the three phenophases ranged between 6.02% (Centenar cv.) and 7.82% (Stanley cv.). For leaves, the lowest content of minerals was determined in August, during trees entrance in the dormancy period.*

Key words: plum, soil, nitrogen, phosphorus, potassium, organs, phenological phases

Rezumat. *Cerințele plantelor pentru elemente minerale se află în strânsă corelație cu particularitățile sale biologice, depinzând chiar de caracteristicile de soi sau cultivar. În acest context, acest articol este axat pe determinarea unor corelații între sol şi conținutul de minerale de plante cu scopul de a asigura o aprovizionare echilibrată cu nutrienți în timpul perioadei de vegetație. Conținutul solului în elemente minerale a fost uşor diferit pentru cele trei soiuri de prun analizate (Rivers timpuriu, Stanley, Centenar), dar, în general, s-a remarcat o bună aprovizionare a acestuia cu azot, fosfor şi potasiu. Conținutul de elemente minerale din diferite organe au variat în următoarele limite: 9,04 până la 12,67% în frunze; 4.54-5.14% în fructe; 4.89-8.12% în ramuri de 1 an şi între 4,89 până la 8,12% - în ramurile de 2 ani. Cel mai mare conținut mediu de minerale (6,70%), în cele 4 organe*

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analizate, a fost determinată în fenofaza de înflorire, iar conținutul mediu de minerale pentru organele analizate în cele trei fenofaze a variat între 6,02% (soiul Centenar) şi 7,82% (soiul Stanley). În frunze, s-a determinat cel mai mic conținut de elemente minerale în luna august, în momentul intrării pomilor în dormanță. Analiza corelațiilor dintre elemente minerale determinate în sol şi plante au arătat că, în general, acestea au fost negative (în timp ce conținutul de elemente din plantă creştea, conținutul de elemente din sol scădea).

Cuvinte cheie: prun, sol, azot, fosfor, potasiu, organe, fenofaze

INTRODUCTION

The fruits nutritional value is due by their biochemical composition. Diets high in fruits is widely recommended for their health-promoting properties (Slavin and Lloid, 2012; Simmonds and Preedy, 2016; Ivanović *et al.,* 2016). For a rationally nutrition, fruits are indispensable foods because they contain easily digestible sugars (sucrose, glucose, fructose), proteins, free organic acids, pectic substances, phenols and tanins, mineral substances, essential oils, vitamins and aminoacids (Delian *et al.,* 2011; Gregory, 1993; Treutter *et al.,* 2012; Heghedűş-Mîndru *et al.,* 2014). The quantity of *Prunus domestica* L. fruits useful substances and concentration of minerals varies in function of species, cultivar, pedo-climatic conditions, harvest date, agrotechnical factors, and also on rootstock (Hoza and Udrescu, 1997; Hoza and Asănică, 2003; Jaroszewska, 2011). In plums, the concentration of health-promoting compounds under the same cultivar and climate conditions is mainly due by the type of soil management (Lombardi-Boccia *et al.,* 2004).

The mineral content of plum fruits varies between 0.40 % and 0.60 % fresh weight. In 100 g FW fruit it was determined: 221.00 mg potassium, 18.00 mg phosphorus (P), 14.00 mg calcium (Ca), 10.00 mg magnesium (Mg), 1.70 mg sodium (Na), 1.50 mg chlorine (Cl), 0.44 mg iron (Fe), 0.34 mg boron (B) and 0.09 mg cupper (Cu) (Souci *et al*., 1981). Research performed by Milošević and Milošević (2012) emphasized that the average content of ash in plum fruits reached 4.54%, N – 0.78%, P – 0.06%, K – 1.45%, Ca – 0.07%, Mg – 0.16%, Fe – 19.37 $\mu g\ g^{-1}$, manganese – 10.21 $\mu g\ g^{-1}$, Cu – 3.21 $\mu g\ g^{-1}$, zinc – 19.29 $\mu g\ g^{-1}$ and bor – 22.83 $\mu g\ g^{-1}$ of dry matter.

The minerals requirements of different species are related to the species biological feature and even depend on the every varieties characteristic feature. As for any living organism, also for plants it can be distinguish an age due to its vital cycle and an annual vegetation cycle characterized by different developmental stages. Minerals that are within the optimal limits of plants requirements have a favorable action on plants physiological processes, as well as on yield quality. If minerals content is out of optimal limits plants are stressed, physiological disorders may appear and yield can be negatively affected.

For plum and apricot trees, the uptake of soil minerals determined in leaves, cutting wood and leaves is about: 3.5 kg/t nitrogen, 1.05 kg/t phosphorous and 5.50 kg/t potassium (Trocmé and Gras, 1965).

Research carried out by Huget (1984) regarding the leaves mineral composition emphasized differences in relation to the leaf position on a branch and the variety. The existing a correlation between mineral content concentration in the analyzed organ and its supply status depends on plants species, age and physiological state (Davidescu and Davidescu, 1992). Also, a strong rootstock/cultivar/year interaction was found for most of the minerals in the case of plum fruits (Milošević and Milošević, 2012).

Sanchez-Alonzo and Lachica (1987) noticed that during the vegetation period the content of N, P and Zn decreases in the case of fruits plum of Golden Japan variety, while the content of Ca, Mg, S, Fe, Mn and Cu increases. Kenworthy (1969) recommended that leaves sample harvesting should be performed at 8-12 weeks after full blooming, to better express plants supply with mineral elements.

Carpena et al. (1968) found differences as regard as apricot leaves minerals composition, between those from the shoot base and shoot tips. As a consequence, Kenworth and Larsen (1982) recommended using for analysis the leaves situated at the middle position of an annual shoot, which have an intermediary minerals content, situated between those specific for basal and apical leaves position.

The purpose of this work was to verify the existence of some correlation between soil and plant mineral content with a view to assure an equilibrate nutrients supply during the vegetation period.

MATERIAL AND METHOD

The vegetal material and the experimentally conditions. The biological material was represented by three plums varieties: Rivers timpuriu, Centenar and Stanley, growth at the Didactical Experimental Field - Faculty of Horticulture Bucharest. The age plantation was 6 years old, the distances between trees were 5/3 m and the canopy form was vase shape. The normal orchard technology was applied, grassy field was maintained and dripping irrigation was used.

Soil analysis. Soil analysis was done on two depths (at a depth of 0-20 cM and 20-40 cM, respectively) according the ICPA methodology. At the soil level the followings parameters were determined:

Nitrate was quantified by using phenol-disulfonic acid method 30 g fresh soil sample mixed with 90 ml K_2SO_4 N/10 were shaken 5 minutes. After filtration, 10 mL extract was exposed to solvent evaporation using a rotary evaporator. Then, 1 mL phenol-disulfonic acid, 15 mL distilated water and NaOH 12 % were added. After the yellow color appeared, distillated water was added till 100 ml and in parallel with the etalon solutions the colorimetration was done.

Ammonia nitrogen was quantified by using Nessler's reagent. From the previous extract 20 mL were collected. There were added 1 ml Seignette salt (50%) and 1ml Nessler's reagent. After 30 minutes the sample was supposed to in parallel colorimetration with etalon solutions.

Total phosphorus was determined by a method agreed by ICPA. In a Kjeldahl recipient, 1 g soil and 10 mL concentrated H_2SO_4 were boiled till complete mineralization (white color). There was made 100 mL by repeated washing, 20 mL poured in 100 mL flask and were added: 6 mL potassium ferrocyanide 10%; 3.5 mL H_2SO_4 2N and ammonia 10%, till red color apparition. It was brought to volume and filtered. 50 mL of the extract solution was taken, which was poured in a flask of 50mL and 15 mL ammonium was nitro-vanadate added. The extinction of the solution determined at a wavelength of 445 nm in parallel with the standard solutions.

Mobile phosphorus was quantified spectrophotometricaly. In a 500 mL flask, 5 g soil and 20 mL acetate ammonium lactate were stirred for 90 minutes. After filtration, it passed into a vessel 25 mL of extract, 2 mL molybdate reagent and 1 mL of stannous chloride reagent. Extinction color of blue molybdenum was colorimetric read in parallel with that of standard solutions.

Mobile potassium was determined by flam photometry. 5 g soil was passed into a 500 mL flask, together with 20 mL ammonium acetate–lactate 1 N. The mixture was stirred for one hour, and then filtered. Mobile potassium content was determined by flame photometry, using for this purpose a scale of standards with different concentrations of potassium.

Determination of total soluble salts was carried out by conductometric method, using the aqueous extracts obtained from 1 g soil and 2.5 mL of distilled water.

Soil solution pH was determined potentiometrically by means of a pH meter. In a 50mL Berzelius glass, 8 g of ground soil and 20 mL of distilled water were added and stirred. The pH meter electrode was introduced in the mixture and the pH value was read.

Plant analysis. The content of minerals in plant was determined in the branch year II, the branch year I, leaves and fruits, at three times (phenological phases). The samples were calcinated at 570 ˚C in order to obtain the total minerals (%), then solubilized in HNO3 and analyzed by an IRIS INTREPID ICP-OES multielement method.

RESULTS AND DISCUSSIONS

The content of macroelements in soil

The analyzes carried out at soil level showed a pH reaction close to neutral, with small deviations from the soil level depth and variety, with a trend of a slight decrease from the soil surface to depth (tab. 1) and falls within the tolerance limits of plum (6.5 to 7.8). Mineral salts content varied from 0.012 to 0.024%, with a slight downward trend on vertical direction, but it does not reveal salinization problems at the soil level.

Mineral nitrogen, determined as the sum of ammonia and nitric forms shows a very good state of supply, limits being between 15.75 ppm and 48.5 ppm, higher values were registered in all varieties at a depth of 20-40 cm. Soluble phosphorus determined in aqueous extracts was low, the determined values ranging from 7.80 ppm and undetectable. Potentially digestible phosphorus reserve, extracted into ammonium acetate–lactate varied between 79.6 and 244ppm. The obtained results indicate a very high degree of digestible phosphorus supply, taking into consideration that the optimal plum values are between 70-100ppm (after Davidescu and Davidescu, 1992).

Soil supply degree with soluble potassium (potentially asimilable) extractable in ammonium acetate–lactate varied between 340 and 560 ppm, showing a very good degree of supply.

At the plant level three determination were done at three distinct phases: March (bud swelling), May (blooming) and August (early buds differentiation), and the results were different depending on the time of the determination, the organ analyzed and variety (tab. 2).

Table 1

Soil pH and its supply with minerals

No.	Cultivar	pH	Total soluble salts (%)	N mineral ppm	PO_4^{3-} ppm	K ppm	P_{AL} ppm	K_{AL} ppm
1.	Rivers timpuriu (0-20 cM)	7.32	0.02464	28.75	1.00	55.0	175.6	560
2.	Rivers timpuriu (20-40 cM)	7.13	0.01984	30.75	3.70	40.0	244.4	460
3.	Stanley (0-20 cM)	7.14	0.01888	18.75	5.60	50.0	139.2	520
4.	Stanley (20-40 cM)	6.70	0.01248	48.50	Bdl	45.0	84.4	400
5.	Centenar (0-20 cM)	7.11	0.01856	41.00	7.80	46.0	125.6	420
6.	Centenar (20-40 cM)	6.87	0.01312	15.75	1.20	41.0	79.6	340

Bdl – below detection limit; ppm (mg element/kg soil)

Table 2

Minerals from some plum tree organs

Variety	Organ	Total Mineral Content (%)		
		03.08.2011	21.03.2012	10.05.2012
Rivers timpuriu	Branch year II	0.49	0.49	2.11
	Branch year I	1.26	1.26	6.23
	Leaves	5.62	5.62	12.03
	Fruits	nd	nd	4.67
Stanley	Branch year II	1.76	1.76	5.33
	Branch year I	2.03	2.03	8.12
	Leaves	5.62	5.62	12.67
	Fruits	0.47	nd	5.14
Centenar	Branch year II	2.17	2.17	5.60
	Branch year I	3.81	3.81	4.89
	Leaves	6.48	6.48	9.04
	Fruits	0.71	nd	4.54

The highest mean of minerals, of the 4 organs analyzed was determined in the flowering phenophase (10.05), when he had a content equal: 6.70%. For the leaves, the lowest mineral content was determined in August, during the entry of trees in the dormancy state. In this preparatory period for the winter, some of the minerals with greater mobility are translocated from leaves, to perennials organs to ensure high resistance to frost and ensure an important infusion of minerals in spring when restarting the vegetative growth. In this phenological phase, the average content of minerals in leaves of three varieties of plum was 5.91%.

The average content of minerals from organs analyzed in the three phenophases ranged between 6.02% (Centenar) and 7.82% (Stanley).

There were large differences in the content of minerals in the different plum tree organs. Thus, on 10.05., the highest minerals content was determined in leaves. It ranged between 9.04 and 12.67%, followed by fruits, whose content varied between 4.54 and 5 14%. The content of minerals branches of plum tree plants (1 year old) ranged between 4.89 and 8.12%, and the lowest content was noticed for branches of two years old (between 4.89 and 8.12%). As earlier Milošević *et al.* (2013) noticed, for leaves, principal nutrient accumulation was non-uniform, being cultivar-dependent, and resulted in nutrient deviation from optimum values.

From the obtained analytical data, it can be concluded that the degree of plant nutrition should be appreciated by foliar diagnosis done in May, when plants are the largest mineral requirements for supporting the growth and flowering, but little information is available on the planting density influence on plum scion leaf nutrient content (Milošević *et al*., 2012). As already have been demonstrated by many researchers, during the vegetation phenophases translocation and accumulation processes of different substances in fruits and woody biomass take place (Jivan ans Sala, 2014).

Correlating the amount of minerals determined in plant with soil macroelements content, some correlations have emerged, showing that consumption of minerals from soil, their content decreases as well as the total reserve. Thus, correlation between the minerals in the plant and soil nitrogen content had a low correlation coefficient, r^2 = 0.11. This negative correlation confirms that during the growing season soil nitrogen content decreases, as it accumulates in the plant (fig. 1).

The phosphorus content decreases further due to the accumulation in the plant. Thus, if in March the correlation between minerals content in plant and soil potassium was balanced, the correlation coefficient being r^2 = 0.02 (fig. 2), with the plant increase the soil phosphorus reserve was significantly reduced, the correlation coefficient value reached r^2 = 0.35 (fig. 3), the correlation being negative. This shows that as the plants grow, they consume minerals from soil, at a rate greater than the capacity of soil to assure available phosphorus to plants, through natural sources mobilization.

The potassium content decreases during the summer, both the available and that in reserve. Values of correlation coefficients between minerals in plant and this element were r^2 = 0.29 (fig. 4), as against the assimilable potassium, and r^2 = 0.79 (fig. 5) as against to reserves in the soil. This shows that during the buds differentiation it can be some problems with potassium assuring, and this deficit negatively affects the process.

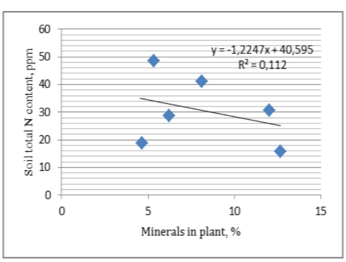

Fig. 1 The correlation between minerals in plant and soil nitrogen content

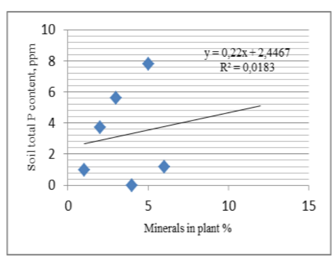

Fig. 2 The correlation between minerals in plant and soil phosphorus content

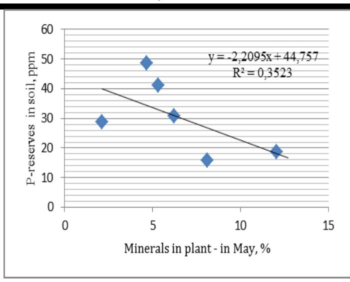

Fig. 3 The correlation between minerals in plant and soil phosphorus reserves

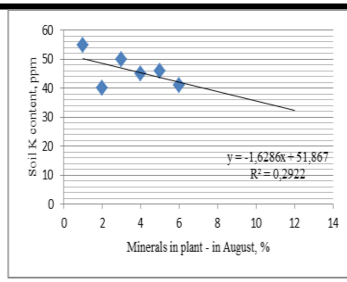

Fig. 4 The correlation between minerals in plant and soil potassium content

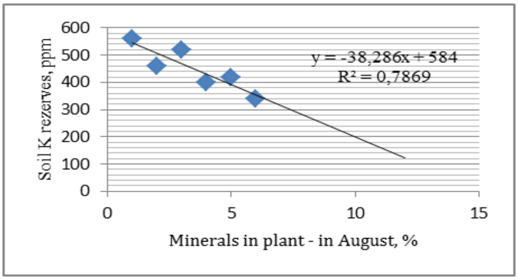

Fig. 5 The correlation between minerals in plant and soil phosphorus reserves

Potassium is known as the most common macroelement, not only in fresh fruits, but also in dried ones (Ivanović *et al.*, 2016). According Lombardi-Boccia *et al.* (2004), the concentration of health-promoting compounds in plums, under the same cultivar and climate conditions is mainly due by the type of soil management.

CONCLUSIONS

1. The soil supply with minerals was slightly different for the three analyzed plum cultivars, but generally, the soil had a good supply with nitrogen, phosphorus and potassium

2. The highest average content of minerals in the 4 organs analyzed was determined in the flowering phenophase: 6.70%.

3. For leaves, the lowest mineral content was determined in August, during trees entrance in the dormancy period.

4. The average content of minerals for the organs analyzed in the three phenophases ranged between 6.02% (Centenar cv.) and 7.82% (Stanley cv.).

5. The content of mineral substances on different organs had variable limits: 9.04 to 12.67% - leaves; 4.54 to 5.14% - fruits; 4.89 to 8.12% - shoots of 1 year old and 4.89 to 8.12% - shoots of 2 years old.

6. The correlations between the soil and plant minerals generally showed that there were negative correlations (as plants mineral content increases, the soil mineral content decreases).

Given the current discussions about the translocation of mineral elements from the soil to the plum tree for these cultivated varieties, the results deserve to be subject to future investigations.

REFERENCES

1. **Carpena O., Monillor E., Hellen E., 1968 -** *Tecnica de muestreno folia ren albaricoquero y melocotonero.* Col. Europ. Contr. Fertil., Sevilia.
2. **Davidescu D., Davidescu V., 1992** - *Agrochimia horticolă*. Edit. Academiei Române, Bucureşti
3. **Delian E., Petre V., Burzo, I., Bădulescu L., Hoza D., 2011 -** *Total phenols and nutrients composition aspects of some apple cultivars and new studied breeding creations lines grown in Voineşti area- Romania.* Romanian Biotech. Letters, Vol.16, No.6: 6722-6729.
4. **Delian E., Bădulescu L., Bădescu C., Burzo I., Dobrescu A. 2011**- *Influence of substrata composition on leaves elemental concentration and plant growth of highbush blueberry.* Journal of Environmental Protection and Ecology, Vol.12, Issue 2: 509-518.
5. **Gregory, J. F. 1993 -** *Ascorbic acid bioavailability in foods and supplements.* Nutrition Review 51: 301–303.
6. **Heghedűş-Mîndru R.C., Heghedűş-Mîndru G., Negrea P., Şumălan R., Negrea A., Ştef D., 2014 -** *The monitoring of mineral elements content in fruit purchased in supermarkets and food markets in Timisoara, Romania.* Annals of Agricultural and Environmental Medicine, Vol 21, No 1, 98–105.
7. **Hoza D., Udrescu S. 1997 -** *Vigoarea de creştere a unor soiuri de prun pe un sol podzolic în bazinul Sâmbureşti-Olt.* Lucrări ştiințifice, UASMV Iaşi, seria A, vol. 40, 1997, pag. 63-66.
8. **Hoza D., Asănică A. 2003 -** *The behavior of plum management as vessel bush.* Analele Universității din Craiova, vol VIII (XLIV), 369-372.
9. **Huget C., 1984 -** *Abricotier, Prunier.* În Analise Vegetale dans le Control de l'Alimentation des Plantes. Martin-Prevel P, Gagnard J., Gautier P., Ed. Lavoisier, Paris.
10. **Jaroszweska A. 2011** - *Quality of fruit cherry, peach and plum cultivated under different water and fertilization regimes.* J. Elementol., 16(1): 51-58.
11. **Jivan S., Sala, F. 2014 -** *Relationship between tree nutritional status and apple quality.* Hort. Sci., Vol. 41, No. 1: 1–9.
12. **Ivanović M., Tošić S., Mitić S., Petrović M., Aksić J., 2016 -** *Mineral profile of some dried fruits.* Zbornik radova, Vol. 21 (23).
13. **Lombardi-Boccia G., Lucarini M., Lanzi S., Aguzzi A., Cappelloni M. 2004 -** *Nutrients and Antioxidant Molecules in Yellow Plums (Prunus domestica L.) from Conventional and Organic Productions: A Comparative Study.* J. Agric. Food Chem., 52 (1), pp 90–94.
14. **Milošević, T., Milošević, N. 2012 -** *Factors influencing mineral composition of plums fruits*. J. Elem. s. 453–464.
15. **Milošević T., Milošević N., Glišić I. 2012 -** *Vegetative growth, fruit weight, yield and leaf mineral content of plum growth on acidic soil.* Journal of Plant Nutrition, 35:770–783.
16. **Milošević T., Milošević N., Glišić I. 2013 -** *Agronomic properties and nutritional status of plum trees (Prunus domestica L.) influenced by different cultivars.* J. Soil Sci. Plant Nutr. vol.13 no.3 Temuco set.
17. **Sanchez-Alonzo F., Lachica M., 1987 -** *Seasonal trends in elemental content of plum leaves.* Communication in Soil Science and Plant Analysis, vol. 18, (1), 31 – 43.
18. **Simmonds M., Preedy V., 2016 -** *Nutritional composition of fruit cultivars.* Elsevier
19. **Souci Fachmann, Kraut, 1981 -** *La composition des aliments,* Stuttgart.
20. **Slavin J.L., Lloyd, 2012 -** *Health Benefits of Fruits and Vegetables.* Adv. Nutr.Vol. 3: 506-516.
21. **Trocme Gras, 1965 -** *Sol et fertilization en l'arboriculture, Paris*.
22. **Treutter D., Mohamed D., Farag M.A., Arguera Baires G.D., Rühmann S., Neumüller M. 2012 -** *Diversity of Phenolic Profiles in the Fruit Skin of Prunus domestica Plums and Related Species.* J. Agric. Food Chem., 60 (48), pp 12011–12019.