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NUTRIENT CONTENT IN THE LEAVES OF YOUNG PLUM TREES DEPENDING ON THE ROOTSTOCK AND NITROGEN FERTILIZATION

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Abstract

Objects of the present study were two plum cultivars – 'Jojo' and 'Topgigant Plus', grafted on the new clonal rootstock 'Docera 6'and the seedling rootstock P. cerasifera. The trees were planted in 2016 at the Fruit Growing Institute of Plovdiv, Bulgaria. Increasing amounts of ammonium nitrate (NH_4NO_3) - 260 kg ha^{-1}, 330 kg ha^{-1}, 400 kg ha^{-1} were applied twice during the vegetation periods in 2017 and 2018. The aim of the study was to investigate the dependence between the level of mineral nutrients content (N, P, K, Ca, Mg and Fe) in the leaves of the tested plum/rootstock combinations. The obtained results showed that the nutrient content in the leaves was affected by the rootstock but by the fertilizer rates. The values for the nitrogen content varied in range - 1.95%-2.49%. The content of K in the leaves was approximately twice higher for the trees grafted on 'Docera 6'. A reverse trend was observed for the elements Mg and Fe.

Key words*: Docera 6, nitrogen fertilization, nutrients, plum, rootstock.*

INTRODUCTION

Plum (*Prunus domestica* L.) is a traditional horticultural crop in Bulgaria. Due to its high productivity and very good adaptability to the agro-climatic conditions the plant is widely spread in the county (Vitanova et al., 2014).

In great importance for the practice are the vegetative and reproductive abilities of the grown cultivars. The vegetative and generative traits of the trees are being affected by the fertilization which is one of the main agro-technical factors directly affecting the nutritional status of the plants. On the other hand the absorption abilities of the plants depend on their root system, which for the fruit trees are formed by the rootstock. The rootstock on which the cultivar is grafted is indirectly influencing the vegetative and generative indicators of the fruit trees. Each type of rootstock forms root system reaching different depths of soil layers. The main mass of roots of the strong vigorous rootstocks is located in the layer up to 1 m. The low vigorous rootstocks differ with a shallower root system. According to Ikinci et al. (2014) the rootstocks can play an essential role to determining orchard performance of fruit trees. It is also one of the factors influencing the nutrition of the fruit trees and alters the concentration of the nutrients in the leaves (Stoilov, 1977). The timing, the manner of fertilizer introduction and the fertilizer rates must be in accordance with the biological requirements of the cultivated scion/rootstock combination and with the possibility of maximum absorption of the nutrients from them (Hristova et al., 2017). According to Apostolova et al. (2014), the optimal fertilizer rates required to produce a yield of 25 t / ha are N: 80-100 kg / ha, P_2O_5: 60-80 kg / ha and K_2O: 80-100 kg / ha of active substance. Nitrogen fertilizers are imported annually, several times during the vegetation, according to the phenological development of the trees – in early spring, after the flowering period and in the beginning of June, in the autumn (Stancheva et al., 2008). These fertilizer rates are established when the cultivars are grafted on the standard *Prunus cerasifera* rootstock. *Prunus cerasifera* is a seedling vigorous rootstock, forming strong and deep root system. 'Docera 6' is a newly bred in the Munich University rootstock. It is hypersensitive to the 'Sharka' disease which is the most damaging and limiting factor for plum production caused

by the *Plum pox virus* (PPV). The laboratory and field tests of 'Docera 6' determine the rootstock as an extremely promising to reduce the PPV (Milusheva and Bozhkova 2013). In nursery 'Docera 6' resembles to the semi-vigorous 'Saint Julien' (Bozhkova, 2009). The rootstock 'Docera 6' showed good compatibility with the grafted cultivars (Bozhkova and Nesheva, 2017). In the first two years of the tree field development, 'Docera 6' induces strong vegetative growth, similar to the seedling of *P. cerasifera* (Nesheva et al. 2019). Cultivars grafted on 'Dicera 6' have been studied only for their response to *Plum pox virus* infection (Polák and Komínek, 2013). There is no data about the behaviour of scion/hypersensitive rootstock combinations in an orchard and it should be studied.

The aim of the present study was to establish the N fertilizer rates suitable for trees grafted on 'Docera 6'. For this purpose the relationship between the level of mineral nutrition and the content of the main nutrients - N, P, K, Ca, Mg and Fe in the leaves of the plum trees were studied.

MATERIALS AND METHODS

The trees were planted in 2016 at the Fruit Growing Institute of Plovdiv, Bulgaria.

To determine the main soil properties and main nutrient supply, soil samples taken from two depths were analysed. Soil pH, electrical conductivity, N, P and K contents were measured in a laboratory. The trail was designed to evaluate the responsiveness of the scion/rootstock combinations of 'Jojo' / 'Docera 6' and 'Jojo' /*P. cerasifera* as well as 'Topgigant Plus' / 'Docera 6' and 'Topgigant Plus' / *P. cerasifera* to zero nitrogen fertilization (Control) and increasing rates NH_4NO_3 applied at 260, 330 and 400 kg/ha. All fertilization rates were replicated 4 times. The rates were applied split on half two times during the vegetation. The first fertilization was done in spring – after the flowering period of the trees, and the second – in July.

To find the content of nutrient elements 15 fully developed leaves taken in August from the middle part of one-year-old shoots were analysed. The samples were taken from each replication of the variants separately. The samples were dried at 60 ºC, weighted and milled. They were mineralized with concentrated H_2SO_4 using H_2O_2 as a catalyst.

The total nitrogen content was determined according to Kjeldahl method by distillation in apparatus of Parnas-Wagner (Tomov et al., 2009). Phosphorus and Ferrum were determined colorimetrically (spectrophotometer Camspec M105) (Tomov et al., 2009), potassium - photometrically (flame photometer PFP-7) (Tomov et al., 2009) and Calcium, Magnesium - complexometrically. The results obtained are subjected to mathematical analysis using the method developed by David B. Duncan (Duncan, 1955; Harter, 1960). Software used in the study are "R-3.1.3" in combination with "RStudio-0.98" and installed package "agricolae 1.2-2" (Mendiburu, 2015).

RESULTS AND DISCUSSIONS

Determination of the main characteristics and the overall nutrient supply of the soil are of crucial importance in the fruit trees cultivation. Mineral nutrients are essential for plant growth and development (Schumann et al., 2010).

The main characteristics and total nutrient content of the soil in the trial orchard are presented in Table 1. The results showed that soil pH ranged from 7.15 to 7.36 indicating that the soil of the experimental plum orchard was slightly alkaline. Electrical conductivity ranged from 260 to 267 µS/cm. Nitrogen content in ammonia and nitrate form in both soil profiles ranges from 13.8-21.98, which shows that the soil is with low available N. The phosphorus and potassium content in both soil profiles are high. Because of the complex nature of soil, soil tests are not widely used to diagnose nutrient status in stone fruit trees. However, plant tissue analyses are considered the best indicator of plant nutrients status.

The optimal content of nutrients in the leaves of the plums varied between 2,2-3,2% of N, 0,18-0,35% of P, 1,6-2,5% of K and 0,30-0,60% of Mg (Apostolova et al., 2014).

Relying on plant analyses results, values of nitrogen content in the leaves of 'Jojo' / 'Docera 6' trees varied in range of 1.97% - 2.02% and non-significant differences were

Table 1. Soil characteristics of the experimental orchard

Soil layer	pH	EC (µS/cm)	NH_4^+ (mg/kg)	NO_3^- (mg/kg)	P_2O_5 (mg/100g)	K_2O (mg/100g)
0 – 30 cm	7.15	260	21.98	13.34	110	65
30 – 60 cm	7.36	267	17.27	13.08	114	70

observed between all fertilized treatments (Table 2). In the leaves of the trees 'Jojo' / 'Docera 6' fertilized with the highest N rate the lowest P% content was observed. Regarding the K% content, again the trees fertilized with 400 kg/ha had the lowest K in their leaves but only in 2017. In 2018 there were non-significant differences between the variants. For the scion/rootstock combination 'Jojo' / *P.cerasifera* the nitrogen content varied from 1.97% to 2.04%. When compared, the variants fertilized with the examined rates, a significant difference was found between the non-fertilized control and the variant with the highest fertilizer rate (400kg/ha) only in 2017. In this year the non-fertilized control had the lowest N content.

In 2018, the trees fertilized with the highest rate had the lowest N% content in their leaves but the differences with the other variants were not statistically proved. Higher P and K content were observed for the leaves of the non-fertilized control of this scion/rootstock combination.

Regarding the Ca in the leaves of the trees 'Jojo' / 'Docera 6', in the two experimental years, the highest content was observed for the non-fertilized controls and the differences with some of the fertilized variants were significant (Table 3). The Mg and Fe values for the trees grafted on 'Docera 6' did not vary depending on the N rate. A reversed tendency was observed for Ca in the leaves of the trees 'Jojo' /*P. cerasifera*. The controls had the lowest Ca. For this rootstock the Mg and Fe content did not vary between the fertilized variants, also.

For comparison of the two different rootstocks the non-fertilized controls were used. It is noticeable that the K content in the leaves of the controls grafted on 'Docera 6' is higher than those grafted on *P. cerasifera*. In regard to N and P content in the leaves there was no difference between the non-fertilized trees grafted on 'Docera 6' and *P.cerasifera*. The increase of N rates did not show a clear influence to the Ca and Mg content in the plum's leaves. 'Jojo' exhibited no difference in foliar Ca, Mg content based on rootstock, also. The concentrations of Fe were lower when the cultivar was grafted on 'Docera 6'. When grafted on *P. cerasifera* the Fe content in the leaves is was twice higher in 2017.

Table 2. Content of N, P and K in the leaves of the scion/rootstock combinations Jojo / Docera 6 and Jojo /*P. domestica*

Variants	N%			P%			K%		
'Jojo' / 'Docera 6'	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**
Control	1.93 a	2.00 a	1.97	0.36 a	0.37 a	0.37	3.42 a	3.03 a	3.23
260 kg/ha	2.01 a	2.03 a	2.02	0.32 a	0.34 ab	0.33	3.16 ab	2.91 a	3.03
330 kg/ha	1.94 a	2.19 a	2.06	0.33 a	0.34 ab	0.33	2.96 ab	3.25 a	3.10
400 kg/ha	2.00 a	2.04 a	2.02	0.27b	0.29 b	0.28	2.71 b	3.06 a	2.88
Variants	**N%**			**P%**			**K%**		
'Jojo' / *P. cerasifera*	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**
Control	1.89 b	2.04 a	1.97	0.31 a	0.40 a	0.36	2.92 a	2.60 a	2.76
260 kg/ha	2.08 ab	2.09 a	2.08	0.26 a	0.36 ab	0.31	2.66 a	2.18 ab	2.42
330 kg/ha	2.03 ab	2.09 a	2.06	0.22 a	0.32 b	0.27	2.74 a	1.39 c	2.07
400 kg/ha	2.13 a	1.95 a	2.04	0.27 a	0.24 c	0.26	2.77 a	1.93 bc	2.35

Table 3. Content of Ca, Mg and Fe in the leaves of the scion/rootstock combinations Jojo/Docera 6 and Jojo/*P. cerasifera*

Variants	Ca%			Mg%			Fe mg/kg		
'Jojo' / 'Docera 6'	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**
Control	2.35 a	2.40 a	2.38	0.51 a	0.50 a	0.50	49.65 a	114.54 b	82.10
260 kg/ha	2.17 ab	1.92 b	2.05	0.55 a	0.58 a	0.57	56.71 a	105.60 b	81.16
330 kg/ha	1.89 b	2.04 b	1.97	0.44 a	0.51 a	0.47	48.89 a	105.89 b	77.39
400 kg/ha	1.90 b	2.58 a	2.24	0.60 a	0.61 a	0.60	71.96 a	169.62 a	120.79
Variants	**Ca%**			**Mg%**			**Fe mg/kg**		
'Jojo' / *P. cerasifera*	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**
Control	2.18 b	2.33 b	2.26	0.58 a	0.60 b	0.59	150.55 a	173.99 a	162.27
260 kg/ha	2.41 a	2.52 ab	2.47	0.65 a	0.74 b	0.70	173.07 a	173.71 a	173.39
330 kg/ha	2.22 b	2.54 ab	2.38	0.60 a	1.20 ab	0.90	174.85 a	162.24 a	168.55
400 kg/ha	2.46 a	2.85 a	2.66	0.55 a	0.77 b	0.66	163.54 a	161.20 a	162.37

When the cultivar 'Topgigant Plus' was grafted on 'Docera 6', the non-fertilized controls had the highest P and K content, as 'Jojo' / 'Docera 6' (Table 4). The N content for the non-fertilized controls was the lowest, but in 2018 the differences with the other fertilized variants were statistically non-significant. For the trees 'Topgigant Plus' /*P. cerasifera* the data for the nutrient content in their leaves was diverse. In 2017 the controls had the lowest content of N, P, K but in 2018 – the highest. When compared the two different rootstocks, there were no differences between the main nutrient content. For this cultivar the Ca, Mg and Fe concentrations did not vary in dependence of the N fertilizer rate (Table 5). Significant differences were observed for the Fe concentrations of the trees grafted on the different rootstocks. When grafted on *P. cerasifera* the leaves of 'Topgigant Plus' had higher Fe content. In 2017 the values were more than 3 folds higher compared to the trees grafted on 'Docera 6'.

Table 4. Content of N, P and K in the leaves of the scion/rootstock combinations Topgigant plus/Docera 6 and Topgigant plus/*P. cerasifera*

Variants	N%			P%			K%		
'Topgigant Plus' / 'Docera 6'	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**
Control	1.95 b	2.31 a	2.13	0.40 a	0.44 a	0.42	3.54 a	3.69 a	3.61
260 kg/ha	2.11 a	2.33 a	2.22	0.33 b	0.35 b	0.34	2.92 b	3.43 ab	3.18
330 kg/ha	2.10 a	2.48 a	2.29	0.36 ab	0.34 b	0.35	2.90 b	3.47 ab	3.18
400 kg/ha	2.11 a	2.43 a	2.27	0.24 ab	0.30 b	0.27	3.02 ab	2.94 b	2.98
Variants	**N%**			**P%**			**K%**		
'Topgigant Plus' / *P. cerasifera*	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**	**2017**	**2018**	**Average**
Control	1.93 b	2.44 a	2.19	0.29 ab	0.38 a	0.33	2.64 b	3.69 a	3.17
260 kg/ha	2.17 a	2.32 a	2.25	0.34 a	0.37 a	0.35	2.68 b	3.43 ab	3.06
330 kg/ha	2.23 a	2.30 a	2.27	0.20 c	0.31 b	0.26	2.80 a	3.47 ab	3.14
400 kg/ha	2.19 a	2.49 a	2.34	0.23 bc	0.30 b	0.27	2.85 a	2.94 b	2.90

Table 5. Content of Ca, Mg and Fe in the leaves of the scion/rootstock combinations Topgigant plus/Docera 6 and Topgigant plus/P. domestica

Variants	Ca%			Mg%			Fe mg/kg		
'Topgigant Plus' / 'Docera 6'	2017	2018	Average	2017	2018	Average	2017	2018	Average
Control	2.73 a	2.42 ab	2.57	0.69 a	0.57 a	0.63	63.32 a	129.79 a	96.56
260 kg/ha	2.65 a	2.18 b	2.42	0.53 a	0.65 a	0.59	50.09 a	130.22 a	90.16
330 kg/ha	2.77 a	2.70 a	2.74	0.68 a	0.63 a	0.65	31.26 a	107.36 a	69.31
400 kg/ha	2.89 a	2.41 ab	2.65	0.66 a	0.64 a	0.65	30.67 a	110.24 a	70.46
Variants	**Ca%**			**Mg%**			**Fe mg/kg**		
'Topgigant Plus' / *P. cerasifera*	2017	2018	Average	2017	2018	Average	2017	2018	Average
Control	2.91a	2.63 a	2.77	0.75 a	1.40 a	1.08	170.87 a	173.85 ab	172.36
260 kg/ha	2.80 a	2.06 b	2.43	0.70 a	1.03 b	0.87	162.09 a	170.65 ab	166.37
330 kg/ha	2.99 a	2.13 b	2.56	0.68 a	1.17 ab	0.92	138.27 a	152.72 b	145.50
400 kg/ha	3.42 b	2.22 ab	2.82	0.55 a	1.06 b	0.80	140.22 a	182.98 ab	161.60

CONCLUSIONS

The fertilization rate did not significantly affect the nitrogen content in the leaves of the plum trees in all scion/rootstock combinations.

There were no substantial differences between the main nutrients N, P, K content in the leaves of the trees grafted on the different rootstocks. This indicates that at this stage of the trees development there is no difference in the absorption ability of the rootstocks. This is in full correspondence with the results obtained from previous study in which the tested clonal rootstock resembles the seedling *P. cerasifera* in growth strength in the first two years of the trees development. This also, shows us that the standard recommended N rates, established for cultivars grafted on *P.cerasifera*, are appropriate to be used for cultivars grafted on 'Docera 6' rootstock.

In the first two years of the trees development the iron content in the leaves of the cultivars grafted on 'Docera 6' was lower than the once grafted on the seedling rootstock.

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REFERENCES

Apostolova, M., Bistrichanov, S., Vuleva, N., Yordanov, A., Yordanov, Ya., Kostadinova, S., Kutev, V., Manolov, I., Mitova, I., Mihalev, D., Popov, K., Stalev, B., Stamenov, Yo., Shaban, N. (2014). Good Practices for Sustainable management of the Nutrition of the Crops. Best Management Practices for Sustainable Crop Nutrition in Bulgaria. (In Bulgarian). Retrieved from: http://research.ipni.net/page/RRCA-2323

Bozhkova, V. (2009). Growth habit of new plum and peach vegetative rootstocks in plant nursery. Materials of the Third International Symposium *"Ecological approaches towards the production of safety food"*, 113-116. (In Bulgarian)

Bozhkova, V., Nesheva, M. (2017). Investigation of the rootstocks 'Docera 6', 'Garnem' and 'Greenpac' in nursery. *Journal of Mountain Agriculture on the Balkans*, 20(1), 328-335.

Duncan, D. B. (1955). Multiple Range and Multiple F Tests. *Biometrics,* 11 (1), 1-42.

Harter, H. L. (1960). Critical Values for Duncan's New Multiple Range Test. *Biometrics,* 16 (4), 671-685.

Hristova, D., Markov, E., Georgiev, D., Valeva, S. (2017). Assessment of the main agrochemical status of soil in 'Tegera' plum cultivar after organic stockpile fertilization in trenches. *Journal of Mountain Agriculture on the Balkans*, 20 (2), 317-325.

Ikinci, A., Bolat, I., Ercisli, S., Kodad, O. (2014). Influence of rootstocks on growth, yield, fruit quality and leaf mineral element contents of pear cv. 'Santa

Maria' in semi-arid conditions. *Biological research*, 47(1), 71.

Mendiburu, F. (2015). Statistical Procedures for Agricultural Research. Retrieved from : http://cran.r-project.org/web/packages/agricolae

Milusheva, S., & Bozhkova, V. (2013). Reaction of six Prunus rootstocks to Plum pox virus in Plovdiv, Bulgaria. In *II International Symposium on Plum Pox Virus*, 1063, 111-116.

Nesheva, M., Malchev, S., Bozhkova, V., Akova, V., Nikolova, V., Todorova, L., Neshev, N. (2019). Growth characteristics of young plum trees grafted on 'Docera 6'rootstock. *sa54*, 553.

Polák, J., Komínek, P. (2013). Response of plum cultivars grafted on hypersensitive rootstocks under field natural infection with Plum pox virus. In *II International Symposium on Plum Pox Virus,* 1063, 99-104.

Schumann, A., Spann, T., Mann, T., Obreza, T., Zekri, M. (2010). Effects of mineral nutrition on health and performance of citrus trees. Citrus Industry - extension-publications. Retrieved from https://crec.ifas.ufl.edu/media/crecifasufledu/extension/extension-publications/2010/2010-July-mineral-nutrition.pdf

Stancheva, Jo., Borovinova, M., Andreev, R., Kalinova, Sht., Balevski, N., Simova, S., Velcheva, N., Staneva, E., Draganova, S., Arnaudov, V, Kolev, K., Stoev A., Rankova, Z, Georgieva, M. (2008). Guide to Integrated Pest Management in Fruit Crops. Ministry of Agriculture and Food; National Plant Protection Office, 64-65. (In Bulgarian).

Stoilov, G. (1977). *Mineral Nutrition of Fruit Plants and Methods for Controll*. Plovdiv, BG: Ed. "Hr. G. Danov ". (In Bulgarian).

Tomov, T., Rachovski, G., Kostadinova, S., Manolov, I. (2009). *Handbook of Agrochemistry*. Academic publisher of Agricultural University Plovdiv, 109. (In Bulgarian).

Vitanova, I., Ivanova, D., Stefanova, B., Dimkova, S. (2014). Perspectives for development of the biologic plum production in Bulgaria. *New knowledge Journal of science*, 3(1).