ISSN 1644-0692
www.acta.media.pl

ACTA *Acta Sci. Pol. Hortorum Cultus, 15(5) 2016, 45-55*

ESTIMATION OF NUTRIENT STATUS IN PEAR USING LEAF MINERAL COMPOSITION AND DEVIATION FROM OPTIMUM PERCENTAGE INDEX

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Abstract. During 2012 and 2013 we investigated impact of quinces MA and BA.29 rootstocks on leaf macro- and micronutrients amount at 60 days after full bloom (DAFB) and deviation from optimum percentage (DOP and ΣDOP indexes) of three pear cultivars grown at Cacak region on heavy and acidic soil. Results showed that rootstocks significantly influenced leaf P, Ca and B levels, whereas impact on other leaf nutrients is minor. Quince MA increased leaf P and Ca contents, while BA.29 induced higher leaf B level. Stronger effect than rootstock on leaf nutrients had cultivar, although differences among them for leaf N, Mg and Fe were not significant. Leaf of 'Abbé Fetel' on BA.29 had the highest K, Ca, Cu and B amounts, whereas on MA this cultivar had the highest Mn concentration. Also, 'Abbé Fetel' alongside with 'Conference' on MA had the highest and similar leaf Ca, Cu and Zn amounts. 'Starking Delicious' on BA.29 had the highest leaf P content. The DOP index showed high deficiency of K and Mn on both rootstock and Ca on BA.29. Other leaf nutrients tended to have a DOP values close to the optimum level in general. According to ΣDOP index, BA.29 induced better balanced leaf nutritional values as compared to MA for all nutrients. Among cultivars, 'Abbé Fetel' on both rootstocks and 'Conference' on BA.29 showed the best balanced nutritional values, whereas 'Starking Delicious' exhibited a wider imbalance in nutritional values for all nutrients.

Key words: DOP and ΣDOP indexes, leaf macro- and micronutrients level, *Pyrus communis* L.

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INTRODUCTION

Soil tests have been used for many years to estimate the amounts of nutrients available to plants. Using a soil test to assess nutritional status is much better than relying on a visual diagnosis of plant symptoms, but the test must be done correctly to ensure valid results [Pritts 2008]. However, soil test has numerous disadvantages. For instance, laboratories worldwide use different methods to estimate available nutrients and interpretation of gained results is without consistent standards. Also, soil test have little meaning for the most macro- and micronutrients. Hence, soil test results give a good approximate estimate of the nutrient needs, but cannot be used to fine-tune a fertilizer program [Adriano 1986], and must be supplemented with plant tissue analysis.

Leaf mineral analysis is essential component to estimate proper nutritional status of plants. This practice is also fundamental to know the tendency of sufficiency, excess or deficiency in nutrients and nonessential elements for the plants, including fruit crops, which are grown in different agricultural systems. In general, the proven relationship between the quantity of a plant's nutrients and yield enables us to use leaf analysis to improve nutrition and yield, by means of appropriate growing techniques [Sanz et al. 1994, Gąstoł and Domagała-Świątkiewicz 2015]. Unfortunately, the efficiency of this method is interfered by peculiarities arising from numerous factors such as origin and plant development of fruit species, followed by weather, especially soil conditions. For instance, some nutrients become more available at a low pH, others at a high pH, and others between pH extremes [Pritts 2008, Milivojević et al. 2011].

Routine sampling time for leaf nutrient diagnosis for pear and other pome and stone fruit species is assessed at mid-summer, approximately at 120 DAFB [van den Ende and Leece 1975]. It could be adequately described as "late foliar analysis" or "postmortem" since it may give accurate information on nutritional disorders that it can only be correlated adequately in the next growing season [Abadia 1992]. In order to better knowledge about fruit trees nutrient status, some authors propose earlier leaf chemical analysis (60 DAFB) as a better prognosis tool for optimal, insufficient or excessive leaf macro- and micronutrients level [Betrán et al. 1997].

The deviation from optimum percentage (DOP) is an alternative method to the traditional diagnosis, which is capable of accurately defining the quantity and quality of each nutrient in plants [Montañes et al. 1991]. Besides, it provides the general nutritional status of all macro- and micronutrients through the sum of DOP indexes ($\Sigma\mathrm{DOP}_{\mathrm{macro}\text{-}}$ and $\Sigma\mathrm{DOP}_{\mathrm{micronutrients}}$).

Pear (*Pyrus communis* L.) is one of the most important fruit species grown worldwide, including Serbia, in orchards with 2,000–5,000 trees ha^{-1} usually using quinces MA and BA.29 as rootstocks. Both these rootstocks require moderate fertile soils with adequate texture, optimal soil pH range between 5.6 and 6.5 without waterlogging and lime problems. However, a little is known about response of both MA and BA.29 rootstocks grafted with pear cultivars to typical heavy and acidic soil. Thus, the main goal of this work is determine behavior of these two rootstocks and three cultivars on limited soil conditions through leaf nutritional status at 60 DAFB and deviation from optimum percentage (DOP).

MATERIALS AND METHODS

Experimental layout and orchard management. This study was conducted in a private pear orchard in Prislonica village (43°53' N, 20°21' E, 305 m a.s.l.) near Cacak city, western Serbia. Three commercial pear cultivars ('Starking Delicious', 'Abbé Fetel' and 'Conference') grafted on quince MA and quince BA.29 rootstocks were used and compared in a trial from a fourth (2012) to fifth (2013) leaf after planting. Trees were spaced at 3.3 m × 1.2 m (2,525 trees ha^{-1}) with slender spindle as a training system. Standard cultural practices were used, except irrigation. Orchard was fertilized with 50 t ha^{-1} cattle manure before planting, i.e. in August 2008. After, starting from 2010, fertilization includes application of 350 kg ha^{-1} calcium ammonium nitrate (CAN) before onset of the growing cycle in each year. Treatments were distributed using the randomized complete block design with six trees for each rootstock-cultivar combination in four replicates ($n = 24$).

Soil characteristics and weather conditions. Soil analyses were done prior to the experiment. The orchard has a clay-loam soil texture with 1.62% organic matter and very low soil pH (4.71) in 0–30 cm soil depth. Soil contains 0.21% total N (N_{TOT}), 3.52 mg 100 g^{-1} P_2O_5, 10.75 mg 100 g^{-1} K_2O, 0.07% Ca, 1.04% Mg, 3.5% Fe, 1370 mg kg^{-1} Mn, 30 mg kg^{-1} Cu, 61 mg kg^{-1} Zn and 1.1 mg kg^{-1} B, all on dry matter basis. Hence, soil is rich source in N_{TOT}, Mn, Cu and Zn, moderate in organic matter, whereas other nutrients are in a low range [Adriano 1986].

Weather data for the long-term averages are characterized by the average annual temperature of 11.3°C and total annual rainfall of 690.2 mm. The average air temperature during vegetative cycle was 17.0°C. During experiment, frost was not registered. However, in the period April–October in both 2012 and 2013, mean monthly air temperatures were considerably higher than long-term average, while precipitation had lower values in general, especially in July and August (data not shown).

Analysis of leaf macro- and micronutrient composition. Leaf mineral analyses were carried out at four and five years after planting. Leaf samples, about 100 leaves, free of diseases and other damages, were collected from middle part of 1-year-old non--bearing shoots of the current year's growth (approximately 30–50 cm long) of each rootstock-cultivar combination at 60 DAFB.

Collected leaf samples were oven-dried at 65°C for 48 h, then ground to pass through a 30-mesh screen (0.595 mm openings). The ground material was analysed for macro- and micronutrients (N, P, K, Ca, Mg, Fe, Mn, Cu, Zn, B). Leaf N_{TOT} was measured by Kjeldahl method using Gerhardt Vapodest 50s equipment (Königswinter, Germany). For other elements, samples (1.0 g) were ashed in a muffle furnace at 550°C for 5 h, and the ash was then dissolved in 10 ml 2M HCl and made up to 100 ml with distilled water. Leaf P was analyzed spectrophotometrically by the phospho-vanadate colorimetric method using UV–visible spectrophotometer MA9523-SPEKOL 211 (Iskra, Horjul, Slovenia); leaf K was determined using a flame photometer Flapho 4 (Carl Zeiss, Jena, Germany). Atomic absorption spectrometry Pye Unicam SP 191 (Cambridge, UK) was used to determine leaf Fe, Mn, Cu and Zn; leaf B was quantified colorimetrically using kinalizarin on colorimeter MK 6/6 (Carl Zeiss, Jena, Germany). The all data are expressed as % and mg kg^{-1} on dry matter basis for each nutrient evaluated, respectively. All nutrients were performed by triplicate per each rootstock-cultivar combination in 2012 and 2013, and final values are mean ±SE for two years.

The deviation from optimum percentage (DOP index) of macro- and micronutrients were used to determine nutritional status of fruit trees: normal (DOP = 0), deficiency (DOP < 0) and excess (DOP > 0). It is and alternative tool to the traditional diagnosis, which is applicable of accurately defining the quantity and quality of each nutrient in plants [Montañes et al. 1991]. The DOP index was calculated from leaf chemical analysis at 60 DAFB by the following mathematical formula:

$$\mathrm{DOP} = \left(\frac{\mathrm{C_n}}{\mathrm{C_o}} - 1\right) \times 100$$

where: C_n = foliar content of the tested nutrient, and C_o = critical optimum micronutrient concentration which was estimated according to the guidelines of interpretation for pear nutrition [van den Ende and Leece 1975]. Also, DOP index provides the general nutritional status of nutrients through the ΣDOP index, which obtained by adding the absolute values of DOP of each element. The lower the ΣDOP, the greater is balances among nutrients [Montañes et al. 1991].

Data analysis. The differences between the experimental factors were verified using ANOVA. If the *F* test was significant, means were compared with the LSD test at $P \leq 0.05$. The analyses were performed using Excel software (Microsoft Corp., Redmond, WA, USA).

RESULTS AND DISCUSSION

Leaf macro- and micronutrients composition. The standard sampling time for pear foliar diagnosis is usually assessed at mid-summer, approximately at 120 DAFB [van den Ende and Leece 1975]. Commonly, this sampling is also called “late foliar diagnosis”. However, at this time, most of pear cultivars have been already harvested. Hence, leaf analysis at this time limited reaction in order to improve nutritional status of trees of above fruit species during growing cycle. On this line, the earlier leaf chemical analysis, approximately at 60 DAFB, also called “early foliar diagnosis” would mean that nutritional problems could be spotted at an earlier stage [Sanz et al. 1994].

Leaf nutrients content at 60 DAFB is presented in Table 1. As regards macronutrients, results showed that MA had better potential to improve leaf P and Ca as compared to BA.29, whereas leaf N, K and Mg contents was largely unaffected by rootstock. This result also suggests the possibility that BA.29 may be able to reduce the leaf P and Ca contents of pears grafted on it, and, as a consequence, may require more careful fertilizer management than MA rootstock in climatic and soil conditions like ours. Thus, Stassen and North [2005] reported that pear *cv*. ‘Forelle’ on the more vigorous BP1 shows higher requirements for leaf nutrients than the more dwarfing MA rootstock. Significant effect of rootstocks on leaf nutrient composition in pear *cv*. ‘Bartlett’ was previously reported [Woodbridge 1973].

Behavior of cultivars on different rootstocks in relates to leaf macronutrients content was not consistent. In the case of MA, differences among cultivars were found only in leaf Ca amount, whereas content of others elements are statistically similar. ‘Abbé Fetel’ and ‘Conference’ had higher and similar leaf Ca than ‘Starking Delicious’. On BA.29, ‘Abbé Fetel’ was the cultivar with higher leaf K and Ca levels as compared to other two cultivars. Contrary, leaf of ‘Starking Delicious’ had better potential to accumulate P as compared to ‘Abbé Fetel’ and ‘Conference’ cultivars. Similarly to our data, significant effect of rootstock and cultivar on leaf P, K and Ca was previously observed by Lewko et al. [2004], but influence of cultivar on leaf Mg was not found. However, these data were related to nursery trees of ‘Conference’ and ‘Erika’ grafted on seven vegetative and generative rootstocks, including MA. The leaf N and P contents in pears was lower, and leaf K, Ca and Mg were similar as compared to data obtained for macronutrients of the some pear cultivars published previously by Sanz et al. [1994]. Moreover, levels of leaf N and P in the present study were similar, and leaf K, Ca and Mg were higher than data obtained by Botelho et al. [2010]. However, all of the above authors sampled leaves at mid-summer, i.e. approximately at 120 DAFB. Basayigit and Senol [2009] sampled pear leaf from different orchards at the sampling date like ours. In their study, pear leaf contained much lower N, P, Ca and Mg contents, whereas leaf K content is 2.5-fold higher than our level.

According to data in Table 1, cultivars grafted on BA.29 tended to have a higher leaf B level as compared to MA rootstock. In the case of leaf Fe, Mn, Cu and Zn levels, differences between rootstocks were not significant. These results were not in agreement with data of Stassen and North [2005] who reported that leaf micronutrients content is significantly influenced by rootstock. Probably, origin of rootstocks, cultivar, environment and cultural practice produced this discrepancy. Leaf Fe on both MA and BA.29, leaf B on MA and leaf Mn on BA.29 was not affected by cultivars. Generally, ‘Abbé Fetel’ and ‘Conference’ showed statistically similar and higher Cu and Zn in leaf on both rootstocks compared to ‘Starking Delicious’. It seems that ‘Starking Delicious’ had lower capacity to accumulate micronutrients, except leaf Fe on both rootstocks and leaf B on MA. Large variability among pear cultivars regarding leaf micronutrients amount were previously reported [Botelho et al. 2010]. In addition, our values for some leaf macronutrients were higher or lower when compared to the results of Botelho et al. [2010] and Basayigit and Senol [2009] and, indicating that, besides rootstock and cultivars, other factors like geographical region, pedo-climatic conditions and cultural practice (pruning, irrigation, fertilization) play an important role in accumulation capacity of these nutrients in pear leaf [Singh et al. 2005, Stassen and North 2005].

Deviation from optimum percentage (DOP index). The positive DOP_N and DOP_P on both MA and BA.29 rootstocks in the most cases indicated the tendency of N and P excesses in pear trees (tab. 2) as compared with reference values proposed by van den Ende and Leece [1975] for this fruit species. Slightly higher excessive leaf N was found by BA.29 when compared with MA rootstock. Leaf P was found to be also excessive on MA, but on BA.29 varied from close to optimum to excessive. The excessive leaf N content (DOP > 0) was found in cultivars on both rootstocks was attributed to an excessive N fertilization with CAN and cattle manure and relatively high level of N_{TOT} in soil. However, the excessive leaf P in some cases (see ‘Starking Delicious’ on both rootstocks and ‘Conference’ on MA in tab. 2) was unexpected because soil had low available P_2O_5 content. This tendency for both above nutrients has also been found in our previous study, especially for leaf P [Milošević et al. 2013], although worldwide pear trees respond to N, but rarely to other nutrients [van den Ende and Leece 1975].

The negative DOP_K on both rootstocks and DOP_{Ca} on BA.29 indicated the tendency of their deficiency in pear leaves. In contrast, DOP values for Mg on both rootstocks were in the optimal level (DOP = 0). Different response of two quince rootstocks to uptake capacity of some macronutrients is evident, and can be linked with xylem sap in graft union that shows very convoluted vessels that act as filters so influencing the balance of different solutes reaching its scion [Jones 1971]. On the other hand, the scion also has an effect on the nutrient content of the rootstock. Naumann [1959] studied the nutrients content of both rootstock and scion pear leaves, and found an interaction. A rootstock high in P produced a low P reading in the scion, and a low K rootstock resulted in a high K reading in the scion. Neither the significance nor cause of the rootstock-scion interaction has been explained. In addition, scion leaf values do not necessarily follow those of the rootstock [Naumann 1959]. In orchards, the excessive P amount is not common but was attributed to an excessive P fertilisation in the growing conditions [Jiménez et al. 2007]. Probably, high rate of cattle manure application (50 t ha^{-1}) in our trial improved soil physical, chemical and biological traits, and through this way promoted P uptake. On the other hand, for chemical analysis we collected leaves from middle part of 1-year-old non-bearing shoots of the current year’s growth which had higher P amount than leaves on the top part of shoots, i.e. younger leaves [Johnson and Uriu 1989]. The tendency of leaf K and Ca deficiency levels may be explained by their low soil contents and acidic soil [van den Ende and Leece 1975]. Additionally, several authors reported that decreased leaf K associated with heavier cropping rootstocks for some fruit species such as prune [Weinbaum et al. 1994] and cherry [Jiménez et al. 2007].

ΣDOP index for macronutrients significantly varied between rootstocks and among cultivars on the same rootstock (fig. 1a). Quince MA induced a wider imbalance in nutritional values as compared to quince BA.29. This confirms the better adaptation of quince BA.29 rootstock which originated from calcareous region of France to heavy and acidic soil than MA [Wertheim 1989]. ‘Abbé Fetel’ pear on both rootstocks showed better balanced nutritional values as compared to ‘Conference’ and ‘Starking Delicious’.

Data in Table 2 revealed deficiency of leaf Mn amounts, whereas leaf Cu, Zn and B greatly varied from very high deficiency to close to optimum level. Additionally, cultivars grafted on both rootstocks tended to be closer to the optimum leaf Fe concentration. The DOP values of Cu, Zn and B for ‘Starking Delicious’ on MA, and DOP of Cu and Zn for this cultivar on BA.29 were in a deficiency range, whereas DOP values of these nutrients for ‘Abbé Fetel’ and ‘Conference’ on both rootstocks were close to zero. Although soil in this trial contained high Zn and Cu levels, their deficiency might be due to the antagonistic effect on P excessive [Tisdale and Nelson 1966]. Namely, excess of P can inhibit the uptake of Zn and its transport within the plant, prolonged excess can cause Cu, Mn and Fe deficiencies [Hansen et al. 2006]. The negative DOP_{Mn} tended to very high Mn deficiency in pear leaves, although its soil amount is high [Adriano 1986].

The Mn is les mobile in plant tissues [Mengel et al. 2001] and this occurrence can be associated with its lack of solubility or losses in Vertisol with low soil pH, as previously reported by Milivojević et al. [2011].

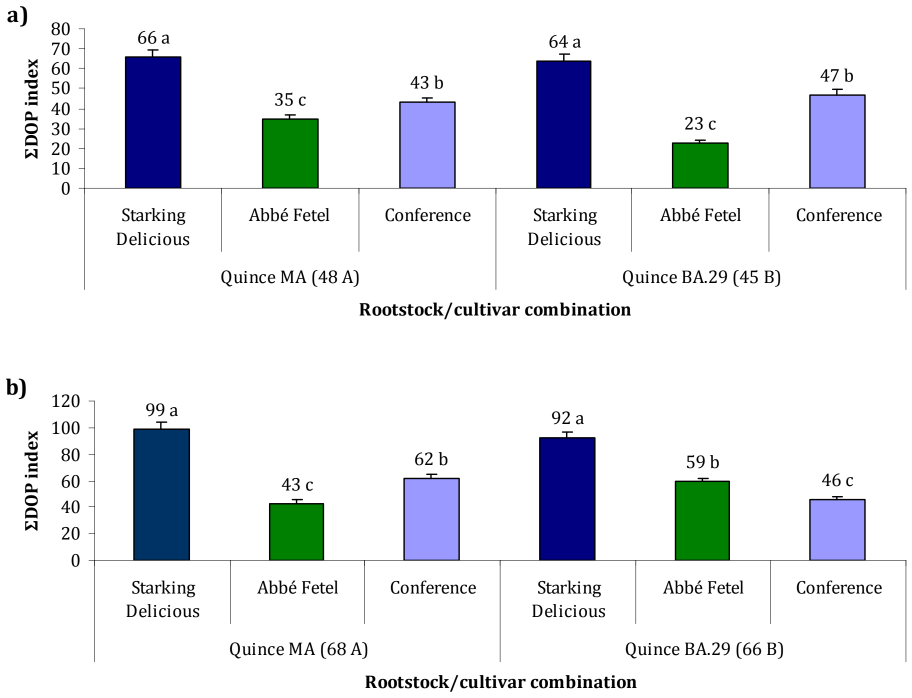

Fig. 1. The ΣDOP index determined from leaf macronutrinets (*a*) and micronutrients (*b*) level at 60 DAFB of three pear cultivars grafted on two rootstocks. Values are the mean for 2012 and 2013. The different small letters at the top of columns indicate significant differences among ΣDOP indexes within each cultivar at $P \leq 0.05$ by LSD test. The different capital letter in brackets in base of figures indicate significant differences between ΣDOP indexes for leaf macro- and micronutrients content within each rootstock at $P \leq 0.05$ by LSD test, respectively

The B nutrient is very important in fruit production because it plays a major role in the reproductive development. In the present work, pears on both rootstocks tended to have a DOP values close to the normal level (DOP = 0) except ‘Starking Delicious’ on MA which had negative value (DOP < 0). This situation can be explained with fact that scions may differ in nutrient content due to differential nutrient absorption and/or translocation [Milošević et al. 2013]. In addition, Milošević et al. [2015] reported that in heavy and acidic soils neither liming nor addition of extra B seemed to have any negative effects on any of the studied pear agronomic characteristics. Similar data noted Paparnakis et al. [2013] for apple trees.

Analysis of ΣDOP values for leaf micronutrients significantly highlighted the better balanced nutritional values with BA.29 rootstock as compared to MA (fig. 1b). Comparing cultivars, 'Abbé Fetel' showed more balanced nutritional values than 'Starking Delicious' and 'Conference', respectively.

Table 1. Influence of rootstock and cultivar on leaf macro- and micronutrients content in pear trees. Data are the mean ±SE for 2012 and 2013

Rootstock	Cultivar	N	P	K	Ca	Mg
Quince MA	Starking Delicious	2.82 ±0.01 a	0.22 ±0.00 a	0.89 ±0.01 a	1.03 ±0.00 b	0.32 ±0.00 a
	Abbé Fetel	2.68 ±0.03 a	0.20 ±0.01 a	0.78 ±0.04 a	1.56 ±0.01 a	0.41 ±0.02 a
	Conference	2.80 ±0.03 a	0.21 ±0.00 a	0.79 ±0.01 a	1.49 ±0.01 a	0.37 ±0.01 a
Average		2.76 ±0.02 A	0.21 ±0.00 A	0.82 ±0.02 A	1.36 ±0.01 A	0.37 ±0.01 A
Quince BA.29	Starking Delicious	2.88 ±0.08 a	0.21 ±0.00 a	0.86 ±0.01 b	1.06 ±0.00 c	0.31 ±0.00 a
	Abbé Fetel	2.81 ±0.03 a	0.17 ±0.00 b	1.03 ±0.01 a	1.33 ±0.01 a	0.34 ±0.01 a
	Conference	2.92 ±0.02 a	0.18 ±0.00 b	0.90 ±0.00 b	1.21 ±0.01 b	0.33 ±0.00 a
Average		2.87 ±0.04 A	0.19 ±0.00 B	0.93 ±0.01 A	1.20 ±0.01 B	0.33 ±0.00 A
Rootstock	Cultivar	Fe	Mn	Cu	Zn	B
Quince MA	Starking Delicious	84.00 ±3.61 a	21.84 ±0.43 b	8.05 ±0.26 b	17.33 ±0.18 b	17.89 ±0.62 a
	Abbé Fetel	109.81 ±1.21 a	33.97 ±0.46 a	17.53 ±0.72 a	36.44 ±1.00 a	21.11 ±0.43 a
	Conference	101.62 ±0.92 a	22.97 ±0.63 b	15.00 ±0.47 a	34.61 ±0.60 a	20.02 ±0.50 a
Average		98.48 ±1.91 A	26.26 ±0.51 A	13.53 ±0.48 A	29.46 ±0.59 A	19.67 ±0.52 B
Quince BA.29	Starking Delicious	95.06 ±0.75 a	19.63 ±0.40 a	7.20 ±0.13 c	19.07 ±0.26 b	21.41 ±0.55 c
	Abbé Fetel	106.24 ±1.90 a	24.87 ±1.19 a	15.06 ±0.14 a	33.06 ±0.26 a	25.16 ±0.37 a
	Conference	114.19 ±1.55 a	27.34 ±1.00 a	9.94 ±0.11 b	31.25 ±0.60 a	22.45 ±0.45 b
Average		105.16 ±1.40 A	23.95 ±0.86 A	10.73 ±0.21 A	27.79 ±0.37 A	23.00 ±0.46 A

The different small letter(s) in column indicate significant differences among means within each cultivar, whereas different capital letter in column indicates significant differences within each rootstock at $P \leq 0.05$ by LSD test, respectively

Table 2. The DOP index determined from leaf macro- and micronutrients content at 60 DAFB of three pear cultivars when grafted on two rootstocks. Values are the mean for 2012 and 2013

Rootstock	Cultivar	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
Quince MA	Starking Delicious	+4	+10	-26	-26	0	0	-64	-11	-13	-11
	Abbé Fetel	0	0	-35	0	0	0	-43	0	0	0
	Conference	+4	+5	-34	0	0	0	-62	0	0	0
Quince BA.29	Starking Delicious	+7	+5	-28	-24	0	0	-67	-20	-5	0
	Abbé Fetel	+4	0	-14	-5	0	0	-59	0	0	0
	Conference	+8	0	-25	-14	0	0	-46	0	0	0

Leaf composition standards for pear based on mid-shoot leaves sampled at 60 DAFB [van den Ende and Leece 1975]. Sign (-) indicates lower content than optimum, while sign (+) indicates higher content than optimum

On the basis our results, it seems that fertilization with cattle manure prior to trial establishment and with CAN (350 kg ha^{-1}) during experimental period were inadequate to prevent the development of some nutrient deficiency in pears such as K, Mn, partially Ca, Cu and Zn and requires a new fertilization strategy, more aggressive other management practice, including irrigation, liming and usage of other nutrients for fertilization. From this point, leaf analysis at 60 DAFB could be a better solution for reaction in order to predicting nutrient deficiency or excess as compared to leaf analysis at mid-summer. However, because differences between rootstocks and among cultivars for more DOP values were not significant (tab. 1), leaf nutrient analysis should be investigated in the future in order to obtaining a more realistic picture of the mineral status of pear trees grown on heavy and acidic soil.

CONCLUSIONS

1. In heavy and acidic soil, MA and BA.29 rootstocks tended to similar effect on leaf N, Ca, Mg, Fe, Mn, Cu and Zn levels at 60 days after full bloom.
2. Both MA and BA.29 rootstocks may reduce some macro- and micronutrients uptake in all cultivars, except N and P, which is manifested in deficiency range of leaf levels.
3. The MA rootstock showed the widest imbalance for macro- and micronutrient values as compared with BA.29.
4. 'Abbé Fetel' showed the best balanced nutritional values, whereas 'Starking Delicious' demonstrated a wider imbalance in nutritional values for all nutrients.

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OCENA STANU ODŻYWIENIA GRUSZKI PRZY UŻYCIU SKŁADU MINERALNEGO LIŚCIA ORAZ ODCHYLENIA OD WSKAŹNIKA PROCENTOWEGO

Streszczenie. W latach 2012 i 2013 badano wpływ podkładek pigwy MA i BA.29 na ilość makro- i mikroelementów 60 dni po pełnym kwitnieniu (DAFB) oraz odchylenie od optymalnego wskaźnika procentowego (DOP i ΣDOP) trzech odmian gruszy w rejonie Cacak na ciężkiej kwaśnej glebie. Na podstawie wyników wnioskuje się, że zastosowane podkładek istotnie wpłynęło na poziom P, Ca i B natomiast ich wpływ na inne składniki liści był niewielki. Zastosowanie podkładki pigwy MA zwiększyło zawartość P i Ca, natomiast podkładki BA.29 powodowało wyższy poziom B. Odmiana miała większy wpływ na składniki liścia, chociaż różnice dotyczące N, Mg i Fe nie były istotne. Liść ‘Abbé Fetel’ na podkładce BA.29 miał największą zawartość K, Ca, Cu i B, a na MA odmiana ta wykazywała największą zawartość Mn. ‘Abbé Fetel’ i ‘Conference’ na podkładce MA miały największą i podobną zawartość Ca, Cu i Zn w liściu. ‘Starking Delicious’ na podkładce BA.29 miał największą zawartość P w liściu. Wskaźnik DOP ujawniał wysoki niedobór K i Mn na obu podkładkach, a w przypadku do K – na BA.29. Inne składniki liścia miały wartości DOP zbliżone to poziomu optymalnego. Według indeksu ΣDOP, zastosowanie podkładki BA.29 sprawiało, że wartości odżywcze liścia były bardziej zrównoważone w porównaniu z podkładką MA w odniesieniu do wszystkich elementów. ‘Abbé Fetel’ na obydwu podkładkach, a ‘Conference’ na BA.29, wykazywały najlepiej zbalansowane wartości odżywcze, natomiast ‘Starking Delicious’ wykazywał większy brak równowagi w wartościach odżywczych dla wszystkich elementów.

Słowa kluczowe: wskaźniki DOP i ΣDOP, poziom makro- i mikroelementów w liściu, *Pyrus communis* L.

Accepted for print: 11.05.2016

For citation: Milošević, T., Milošević. N. (2016). Estimation of nutrient status in pear using leaf mineral composition and deviation from optimum percentage index. Acta Sci. Pol. Hortorum Cultus, 15(5), 45–55.