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Influence of foliar micronutrients fertilization on nutritional status of apple trees

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Abstract: The effect of leaf-applied fertilizers on nutritional status and yields of apple cv. Rubinola grown on two soil types (Luvisol, Cambisol) differing in yield levels was studied in a three-year experiment at the orchard in Vanovice, Czech Republic. Two fertilizers, A (containing N, Mg, Ca, B and Zn) and B (N, B, Zn, Mn and Fe) were applied after blooming, leaves and fruit were analyzed. Zn and B concentrations increased significantly in leaves and fruit in both soils after the application of solution A compared to the control. Foliar fertilizer B increased the concentration of Zn and Mn significantly both in leaves and fruit compared to the control. The content of Mn in dry leaf matter increased almost 4 times (from the control level about 30 mg/kg), of B up to 1.5 times (from 28 mg/kg) and the content of Zn even more than 10 times (from 15 mg/kg). The application of foliar fertilizers was more efficient in the Cambisol orchard section with worse soil conditions; however, the enhanced nutritional status did not significantly increase fruit yields in either of the experimental soil types.

Keywords: *Malus domestica* (Borkh.); nutrient deficiency; foliar analysis; foliar nutrition; multicriterial evaluation

Apple trees (*Malus domestica*) are the most frequently planted fruit crops in the Czech Republic. The apple tree is a perennial crop and it has specific nutrient requirements for growth and fruit development. Balanced nutrition is one of the main prerequisites for healthy growth, high yield and quality of fruit. Horticultural crops suffer widely from zinc deficiency, followed by boron, manganese, copper, iron (mostly induced) and molybdenum deficiencies (Suman et al. 2017). Trace elements are often poorly available to plants by the root system, although their soil content may be sufficient. Soil micronutrient availability to plants is determined by micronutrient contents of soil components such as minerals and organic matter and by the influence of different edaphic and biological factors such as pH, redox potential, interaction with coexisting ions, organic matter dynamics and soil microorganisms (Masunaga and Fong 2018). Foliar application is often used to correct micronutrient deficiency (Weinbaum 1988, Wojcik 2004). Foliar fertilization has several main advantages. It can be applied throughout the growing season, which enables spraying with small quantity and composition of the nutrient solution, appropriate to the specific requirements in different phases of the crop development (Haitova 2013). Foliar fertilization also allows for multiple application timing post planting. Moreover, the application on leaves reduces concerns for nutrient loss, tie up or fixation as compared to soil application (Suman et al. 2017). The foliar spray of micronutrients is the common practice to overcome the micronutrients deficiencies to improve the fruit quality (Annes et al. 2011). Fertilization with B and Zn improved fruit quality at harvest (Davarpanah et al. 2016). However, Wojcik (2007) referred that tree vigour, fruit set, yield and fruit quality at harvest (meaning fruit weight, firmness, colour, russeting, soluble solids concentration and acidity) were not influenced by zinc fertilization.

The foliar application can be more effective when sink demand exists. Saa et al. (2018) experimented with enriched ^{68}Zn:^{67}Zn, which showed that remo-

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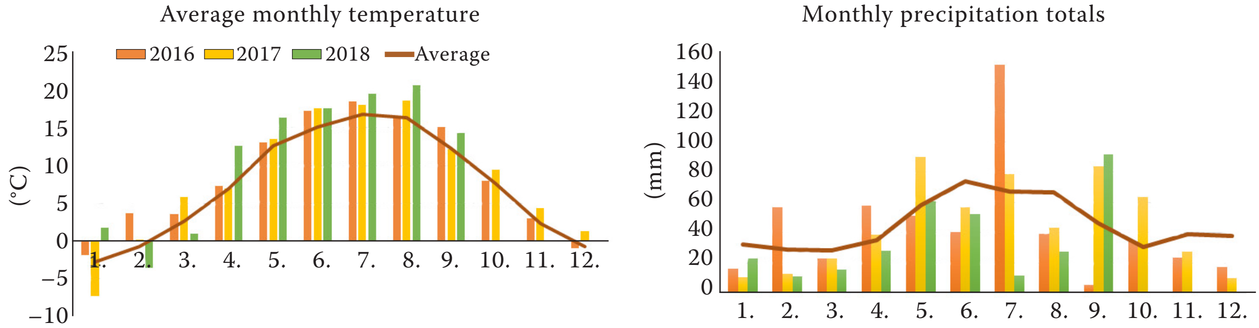

Figure 1. The average monthly temperature and precipitation in 2016–2018

bilization of Zn is enhanced when sink demand (fruit) is stronger. Wojcik et al. (2008) concluded that in apple orchards established on coarse-textured soils with low B availability, early-season B sprays were successful in improving the reproductive growth. The foliar application of Zn and B improved fruit quality at harvest and increased the leaf concentration of both microelements in August, reflecting the improvements in tree nutrient status (Davarpanah et al. 2016). The application of Mn at two levels (0.3% and 0.6%) improved some characters like the fruit yield of pomegranate trees, the weight of 100 arils, fruit diameter, total soluble solids (TSS), juice content of arils, the aril/peel ratio, anthocyanin index, and leaf area (Hasani et al. 2012). This study aimed at evaluating the effect of leaf-applied fertilizers containing microelements on the nutritional status of apple trees (cv. Rubinola) growing at the same site under different soil conditions and the ability of apple leaves to absorb nutrients and to transport them.

MATERIAL AND METHODS

The experiment was conducted for three years (2016–2018) in the orchard located in Vanovice (49°30'N; 16°40'W); the Czech Republic, 410–420 m a.s.l., annual precipitation and temperature were 545 mm and 7.4°C (Figure 1). The cv. Rubinola apple trees were grown on two different soils (Table 1): Rubinola I (loamy haplic Luvisol), and Rubinola II (loamy-sandy Cambisol) (WRB 2015).

The experiment was arranged with 160 trees in one treatment divided into four replications, each with 40 trees. The trees were planted in rows 3.5 m apart, and 1.2 m apart within the rows. The foliar

Table 1. Basic soil properties of the orchard

Locality		Rubinola I loamy haplic Luvisol			Rubinola II loamy-sandy Cambisol		
		0–30 cm	30–60 cm	60–90 cm	0–30 cm	30–60 cm	60–90 cm
pH_{KCl}		6.97	6.83	6.62	6.93	6.23	6.75
Oxidizable carbon	(% DW)	1.46	0.72	0.28	1.22	0.32	0.25
Total nitrogen		0.168	–	–	0.154	–	–
P	(mg/kg)	260	21	15	180	19	6
K		281	167	139	281	180	139
Ca		8510	3445	4069	6258	3112	5934
CO_3^-	(% DW)	> 2	0.3–2.0	0.3–2.0	> 2	0.3–2.0	0.3–2.0
Mg	(mg/kg)	342	231	239	263	211	241
Cu		2.8	6.8	2.8	5.6	2.3	6.2
Fe		45	62	42	40	39	51
Mn		50	54	42	46	42	44
Zn		0.8	4.0	1.2	4.9	0.6	4.7
B		0.8	1.1	0.8	1.3	0.8	1.3

DW – dry weight

application was performed after blooming (BBCH 70) during 2016 and 2017. For the experiment, two types of fertilizer were used: A – commercial fertilizer Yara Vita Frutrel (N 0.64 – as urea, P 0.63, Ca 1.88, Mg 0.56, B 0.195 and Zn 0.375 kg/ha) and B – the mixture of nutrients prepared in laboratory (N 0.64 – as urea, B 0.018, Zn 0.300, Mn 0.225 and Fe 0.004 kg/ha). The dose was applied fortnightly in three repetitions. The liquid fertilizer was diluted to 400 L/ha for spraying. One row for each Rubinola (I, II) was used as a control variant (C).

Samples of leaves were collected from extension shoots of trees from the four blocks of 40 trees. Leaves were picked from the middle third of the tree crown; 30 leaves per sample. The samples were taken at the beginning of August (BBCH 77) and before leaf fall (BBCH 92). There were two extra leaf sample dates, one in September 2017 (BBCH 85) and one in June 2018 (BBCH 72). Samples from 2018 were collected to determine the influence of foliar fertilization during the next growing season. Leaves were rinsed, dried at 70°C, and then ground to a fine powder and stored in dark for analysis. Fruit samples were collected at harvest maturity from trees of the four blocks. Five pieces of fruit of each block were washed and divided into small parts and dried at 70°C, then ground to a fine powder and stored in dark for macro and micronutrient analysis.

The concentrations of elements (P, K, Ca, Mg, Mn, Cu, Fe, Zn and B) were determined after digestion in conc. HNO_3, 30% H_2O_2 using the microwave system. After that, all plant extracts were analyzed by the iCAP 7400 ICP-OES (Thermo Fisher Scientific, Waltham, USA). Total N was analyzed using the Kjeldahl method, dried ground samples of plant tissues were mineralized with sulfuric acid and selenium as a catalyst. N analyses of plant extracts were performed on a Sanplus system (Skalar Analytical, Breda, the Netherlands). Measurements of the apples included the analysis of the soluble solids content by refractometer (RWN10-ATC) readings (°Brix). Depending on the amount of sugar in the sample, the refractometer, which works similarly to a prism, gives reading of the index. Statistical analysis, including graphical outputs, was carried out using the Statistica 13 (TIBCO Software Inc., Palo Alto, USA). For the statistical data processing and evaluation, exploratory data analysis (EDA), two-way analysis of variance (ANOVA) and Fisher's *LSD* (least significant difference) test were applied. Statistical significance was assessed at a significance level of $P = 0.05$.

The principal component analysis (PCA) was used for calculating a component weight for the investigated variables (Meloun and Militký 2011).

RESULTS AND DISCUSSION

Determination of leaf nutrient concentration is often used as a method of monitoring nutritional status of apple trees. At standard sampling time (110–125 days after full bloom, BBCH 77) when annual concentration changes are minimal for most nutrients (Nielsen and Nielsen 2003). The content of macro elements in leaves differed between Rubinola I and Rubinola II only slightly; there was no statistically significant difference. The concentration of macronutrients in dry mater (DM) was in the range of optimal level (Nielsen and Nielsen 2003). Nitrogen content in leaves of Rubinola I was on average slightly higher (about 1.9–2.0%) than in leaves of Rubinola II (1.7–1.8%). There was no statistically significant difference between the nitrogen content in control and variants of fertilization. In 2016, the average calcium concentration was mostly in the optimum range (1.6–2.2%) for apple trees grown on both types of soil.

On the contrary, in 2017, calcium concentration in leaves was relatively low. Mainly, there was surprisingly lower content in August 2017 both in Rubinola I and Rubinola II. The magnesium concentration in leaves was generally lower for Rubinola II (0.2%) than that of Rubinola I (0.3%). The application of Mg in foliar fertilizer A did not have a statistically significant effect on the Mg concentration in the apple leaves. Fruit macronutrient contents (N, P, K, Ca and Mg) were similar to those reported previously for mature apple fruit (Henríquez et al. 2010, Reig et al. 2018). Nitrogen content in fruit was higher in 2016 than in 2017. There was no significant difference in the concentration of other macronutrients in fruit between 2016 and 2017. Foliar application is effective, especially for the replenishment of microelements (Fernández and Brown 2013). This is in agreement with our results in this experiment. The application of solution A, which contained the macro elements N, Mg, P and Ca, did not result in an increase in the concentration of these nutrients in the leaves or in the fruit compared to the controls. Ca is the most problematic nutrient in terms of its reception through the leaf, and it moves hard. The foliar application of boron may affect calcium uptake (Wojcik and Wojcik 2003). In our experiment, the

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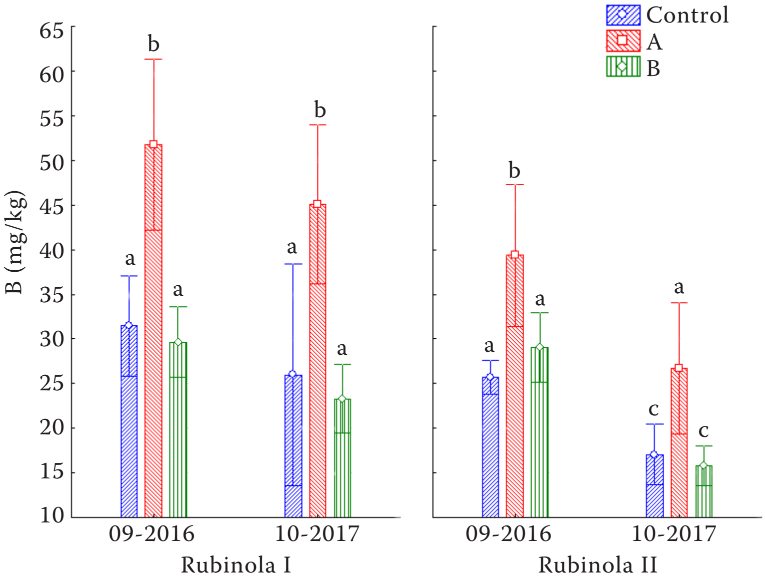

Figure 2. The concentration of boron (B) in the dry matter of fruit. The error bars show standard deviation. Means differ significantly ($P < 0.05$) if they are not marked with the same letter. A – fertilizer A (containing N, Mg, Ca, B and Zn); B – fertilizer B (N, B, Zn, Mn and Fe)

influence of B fertilizer on the Ca concentration in leaves and fruit was not observed. The effect of Ca in solution A was not significant in the trial.

A high variation in the concentration of Fe in the leaves was observed. This can be explained not only by low concentration of this nutrient in the solutions but also by the poor ability of leaves to absorb it and by low Fe mobility within the plant (Morrissey and Guerinot 2009).

The application of solution A increased the Zn and B content in leaves (Table 1) compared to the control. According to the analysis of the fruit, the increase of these elements in the fruit compared to the control variant was also found. It is in contrast to variant B, where boron was used in only a small amount (Figure 2).

Foliar application of solution B containing micronutrients Zn and Mn increased the concentrations of these two trace elements both in leaves (Table 2) and fruit (Figures 2, 3 and 4). Zhang et al. (2013) reported that foliar application of $ZnSO_4$ significantly increased the Zn content of apple fruit. This corresponds to findings obtained at observation of the behavior of the trace elements after the spot application of solutions of individual nutrients on the leaf surface performed by authors (not shown). According to the increase of Zn content in the petiole, it was concluded that it is transported in the phloem

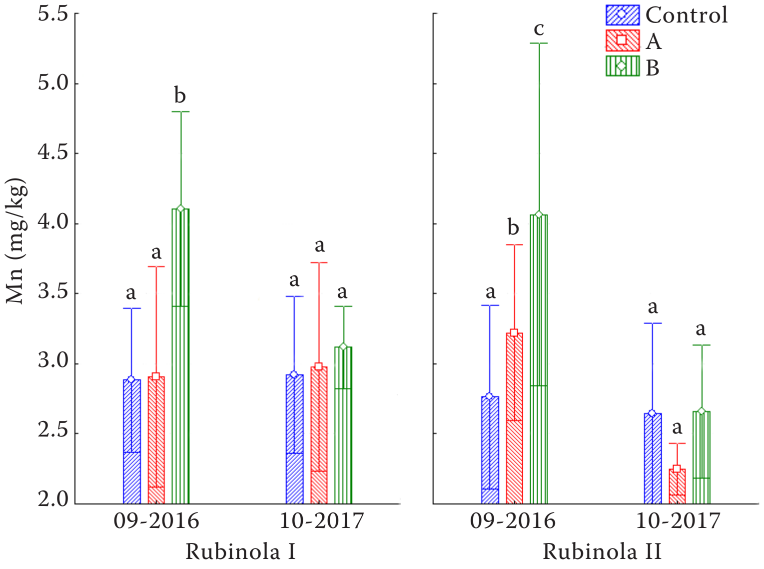

Figure 3. The concentration of manganese (Mn) in dry matter of fruit. The error bars show standard deviation. Means differ significantly ($P < 0.05$) if they are not marked with the same letter. A – fertilizer A (containing N, Mg, Ca, B and Zn); B – fertilizer B (N, B, Zn, Mn and Fe)

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Table 2. Concentration of copper (Cu), iron (Fe), mangase (Mn), zinc (Zn) and boron (B) in leaves

Locality	Date	Treatment	Cu	Fe	Mn	Zn	B
			(mg/kg)				
Rubinola I	08/2016	control	5.79 ± 0.53^{a}	84.71 ± 9.73^{a}	29.18 ± 3.63^{a}	13.50 ± 1.01^{a}	31.17 ± 1.30^{a}
		A	6.58 ± 0.80^{b}	93.26 ± 15.81^{a}	27.69 ± 3.74^{ac}	181.76 ± 38.8^{b}	50.62 ± 11.88^{bc}
		B	5.94 ± 0.28^{a}	98.73 ± 12.90^{b}	119.56 ± 11.3^{bd}	159.06 ± 22.60^{b}	32.76 ± 1.99^{ad}
	11/2016	control	5.19 ± 0.27^{a}	93.48 ± 2.87	32.67 ± 2.01^{a}	14.06 ± 2.01^{a}	23.67 ± 1.09
		A	5.80 ± 0.15^{b}	88.90 ± 5.01	29.54 ± 5.85^{ac}	67.23 ± 3.85^{b}	27.87 ± 0.74
		B	5.23 ± 0.14^{a}	96.65 ± 6.28	60.66 ± 7.75^{bd}	68.56 ± 2.57^{b}	26.2 ± 1.25
	08/2017	control	5.27 ± 1.19	63.92 ± 4.63	33.48 ± 4.40^{a}	14.88 ± 0.80^{a}	25.24 ± 2.32^{a}
		A	4.87 ± 0.31	66.57 ± 2.46	27.16 ± 1.12^{ac}	80.74 ±19.21^{b}	41.01 ± 4.21^{bc}
		B	5.10 ± 0.42	66.27 ± 2.33	50.94 ± 5.10^{bd}	55.10 ± 2.31^{a}	25.13 ± 0.51^{ad}
	09/2017	control	7.55 ± 0.69	122.45 ± 3.63^{a}	41.25 ± 6.23^{a}	16.36 ± 0.90^{a}	33.71 ± 0.98^{a}
		A	7.70 ± 0.33	122.30 ± 6.61^{a}	33.55 ± 0.50^{c}	170.73 ± 7.40^{bc}	46.17 ± 3.55^{bc}
		B	7.62 ± 0.20	140.04 ± 9.66^{b}	108.66 ± 9.50^{bd}	178.50 ± 16.00^{bd}	32.91 ± 1.73^{ad}
	11/2017	control	6.15 ± 0.16	115.24 ± 8.69	41.81 ± 9.76^{a}	18.35 ± 2.19^{a}	27.64 ± 0.52
		A	6.60 ± 0.35	124.74 ± 6.84	35.90 ± 8.94^{ac}	266.34 ± 62.39^{bc}	31.02 ± 1.83
		B	6.86 ± 0.46	123.14 ± 2.19	101.95 ± 19.5^{bd}	187.86 ± 20.27^{bd}	28.20 ± 0.43
	06/2018	control	4.52 ± 0.09	60.81 ± 8.99^{a}	32.24 ± 4.29	19.51 ± 1.09	22.57 ± 1.86
		A	5.18 ± 0.22	81.61 ± 10.05^{b}	39.34 ± 1.85	15.37 ± 1.62	27.92 ± 1.88
		B	4.86 ± 0.19	83.22 ± 9.5^{b}	35.64 ± 5.25	18.06 ± 1.08	23.10 ± 0.58^{a}
	08/2018	control	5.62 ± 0.25	83.89 ± 1.95	38.80 ± 1.95	33.28 ± 3.63	21.59 ± 1.37
		A	4.96 ± 0.14	92.75 ± 5.96	48.82 ± 12.64	26.67 ± 8.96	25.95 ± 1.30
		B	5.86 ± 0.47	92.14 ± 2.33	40.19 ± 6.74	33.14 ± 0.67	20.82 ± 1.11
Rubinola II	08/2016	control	5.63 ± 0.26	90.21 ± 3.98	27.81± 13.1^{a}	12.83 ± 1.44^{a}	25.32 ± 0.97^{a}
		A	5.58 ± 0.49	91.92 ± 3.12	31.82 ± 4.00^{bc}	159.09 ± 14.85^{b}	27.52 ± 1.02^{ac}
		B	5.82 ± 0.38	90.09 ± 1.63	114.30 ± 1.97^{ad}	153.43 ± 12.00^{b}	32.20 ± 1.05^{bd}
	11/2016	control	7.49 ± 0.05^{a}	83.07 ± 5.11^{a}	28.45 ± 2.88^{a}	15.48 ± 1.93^{a}	24.29 ± 1.20^{a}
		A	5.64 ± 0.04^{b}	99.29 ± 3.78^{b}	38.81 ± 4.86^{bc}	173.20 ± 5.54^{b}	47.57 ± 0.69^{bc}
		B	6.32 ± 0.05^{b}	92.99 ± 4.62^{b}	124.40 ± 5.79^{bd}	178.50 ± 4.01^{b}	26.78 ± 1.02^{ad}
	08/2017	control	4.80 ± 0.14	69.69 ± 8.09	26.18 ± 0.49^{a}	15.14 ± 1.50^{a}	24.29 ± 0.59^{a}
		A	4.66 ± 0.18	68.70 ± 2.61	30.31 ± 2.25^{ac}	153.49 ± 25.90^{b}	47.57 ± 6.13^{bc}
		B	5.76 ± 0.39	67.78 ± 1.29	107.35 ± 19.85^{bd}	149.92 ± 30.52^{b}	26.78 ± 1.51^{ad}
	09/2017	control	7.20 ± 0.60	121.64 ± 6.53^{a}	35.86 ± 3.70^{a}	28.62 ± 10.26^{a}	28.45 ± 1.17
		A	6.55 ± 1.06	112.21 ± 11.12^{ac}	37.60 ± 4.56^{ac}	107.24 ± 21.87^{b}	27.58 ± 2.46
		B	6.46 ± 1.07	139.32 ± 33.20^{b}	103.27 ± 15.93^{bd}	112.28 ± 22.71^{b}	27.07 ± 2.02
	11/2017	control	7.27 ± 0.16	107.42 ± 6.54	44.17 ± 6.77^{a}	54.67 ± 86.64^{a}	20.22 ± 0.76
		A	7.43 ± 0.19	108.32 ± 5.06	64.64 ± 31.72^{bc}	229.83 ± 4.07^{bc}	27.57 ± 0.64
		B	7.07 ± 0.85	102.12 ± 1.56	116.90 ± 2.60^{bd}	178.72 ± 1.60^{bd}	27.07 ± 0.22
	06/2018	control	5.13 ± 0.27	55.25 ± 3.53	35.81 ± 1.43	13.70 ± 0.68	20.22 ± 0.33
		A	5.04 ± 0.19	57.67 ± 3.19	39.64 ± 5.02	15.21 ± 0.86	21.16 ± 0.58
		B	5.08 ± 0.11	56.98 ± 2.94	36.95 ± 1.94	14.14 ± 0.28	20.91 ± 0.56
	08/2018	control	6.05 ± 0.44	82.39 ± 6.52	43.88 ± 3.31	23.03 ± 2.90	22.50 ± 0.31
		A	5.56 ± 0.25	86.57 ± 6.30	52.36 ± 6.07	23.88 ± 3.28	23.72 ± 0.92
		B	5.77 ± 0.57	81.20 ± 5.33	44.96 ± 4.66	21.71 ± 3.57	22.77 ± 9.75

Means for the same date and location differ significantly ($P < 0.05$) if they are not marked with the same letter. Values are in the form of the mean ± standard deviation. A – fertilizer A (containing N, Mg, Ca, B and Zn); B – fertilizer B (N, B, Zn, Mn and Fe)

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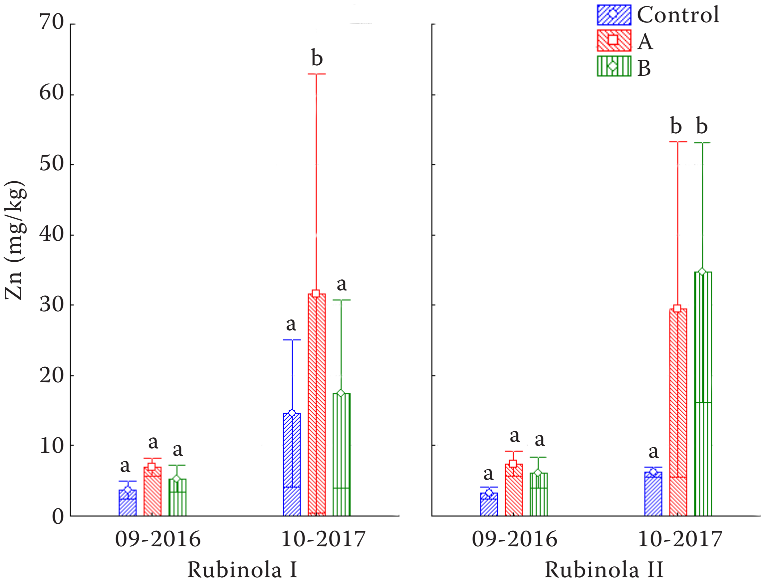

Figure 4. The concentration of zinc (Zn) in dry matter of fruit. The error bars show standard deviation. Means differ significantly ($P < 0.05$) if they are not marked with the same letter. A – fertilizer A (containing N, Mg, Ca, B and Zn); B – fertilizer B (N, B, Zn, Mn and Fe)

to another place of utilization (Kurešová et al. 2018). Even though Mn is considered to be poorly mobile (White 2012), the higher concentration of Mn was observed in fruit, when the B solution was applied. Transport of Mn was observed, similarly to Zn, after spotting a salt solution of this element (Kurešová et al. 2018). Foliar application of Zn in the experiment increased its concentration in leaves up to the toxicity limit (130–160 mg/kg, Nielsen and Nielsen 2003) (Table 2). Toxicity of Zn was reported in apple trees if its content in leaves was naturally high. However, the toxicity was not observed after its application on the leaf, although its concentration in the leaves was elevated above the limit (Nielsen and Nielsen 2003). This may be due to the transport of nutrients to another site of use in a plant. An increased content of Zn in fruit after the foliar application is currently desirable due to Zn deficiency in the food chain (Miller and Welch 2013). To minimize the risk of excessive concentrations, the doses of Zn should be lower than those used in the experiment.

Another finding resulting from this experiment is that the foliar application did not alter the nutritional status of apple trees in the following year after application. If the availability of nutrients from the soil does not change significantly, the use of deficient nutrients should be repeated every year. According to the eigenvalue results, the first two axes are significant at the PC1 and PC2 component figure (PCA), which together represent about 89% of the variability (2016–2017, Figure 5). The PC1 axis in Figure 5 (PC1 × PC2) represents the content of N, Fe, Cu, Ca, Mg and K, that go directly along this axis and are correlated with –0.99 to –0.96 (negative correlation), and P (r = –0.93) and Mn (r = –0.81) and Zn (r = –0.72). The PC2 axis represents a negative correlation with parameter B (r = –0.81). In the component scatter diagram (Figure 5, bottom left), the leaves are clearly distributed along the PC1 axis, with N, Fe, Cu, Ca, Mg and K content. On the PC2 axis, the leaves and fruit are divided by the B content and partly by the Zn content. PCA analysis significantly differentiated the fertilization variants of both sites (Rubinola I, II) and the cluster of fertilization variants control; values of variant B show that the objects are very similar (close to each other). On the other hand, variant A is far from the variants of fertilization control, B (objects are dissimilar); at Rubinola II (worse habitat, Cambisols) this distance is even more significant (Figure 5.). The type of fertilization A is significantly more conclusive, it has been proven by a significant increase in the content of B and Zn in the leaves, which distinguished this variant A from the other ones. The application of Mn was effective too, but it did not have so much importance in a complex view. The application of both solutions was effective, as manifested by an increase in the concentration of the required nutrients in leaves and fruit. In 2016, the Rubinola I fruit yield was higher than that of Rubinola II. There was not a significant difference between treatments. In 2017, the yield of fruit was affected due to freeze damage; the yield of fruit was not evaluated in this year. There was not a significant difference in the size of fruit between fertilization treatments in 2016. The Rubinola II fruit was smaller than Rubinola I (Table 3). There was

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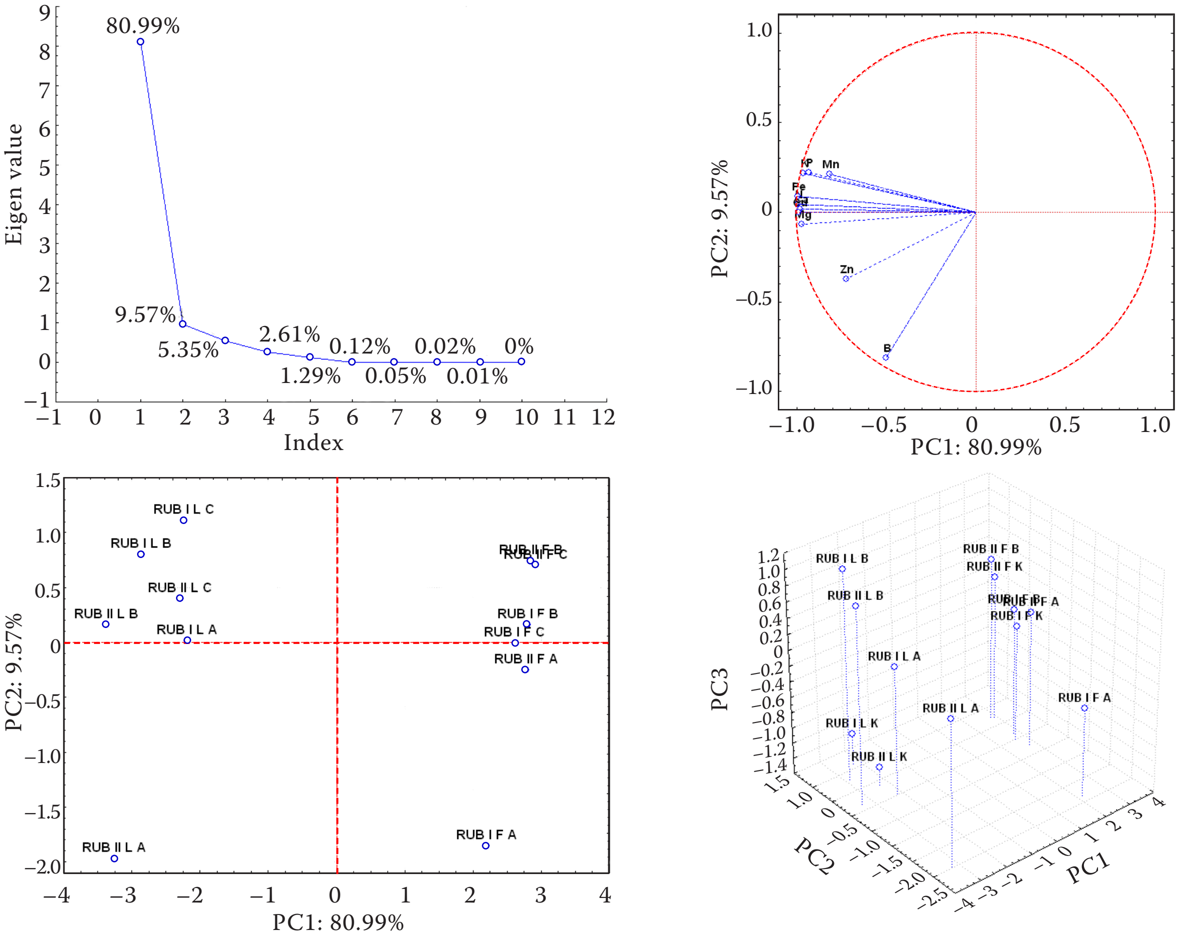

Figure 5. Multidimensional mathematical and statistical analysis (PCA) of macro and micro nutritional parameters for leaves and fruit at Rubinola (location I and II). RUB I, II – location; L – leaves; F – fruit; C – control; A – fertilizer A (containing N, Mg, Ca, B and Zn); B – fertilizer B (N, B, Zn, Mn and Fe)

Table 3. Fruit yield, weight of fruit and soluble solids content (SSC)

Locality	Date	Treatment	Yield (t/ha)	Weight of fruit (g)	SSC (°Brix)
Rubinola I Loamy haplic Luvisol	2016	control	16.56	140.9 ± 24.4	13.3 ± 0.9
		A	17.80	139.3 ± 23.6	12.9 ± 0.9
		B	17.57	143.8 ± 28.1	13.1 ± 0.8
	2017	control	–	148.3 ± 30.4	16.2 ± 1.8
		A	–	136.4 ± 25.8	16.4 ± 1.8^{a}
		B	–	133.3 ± 24.9	14.7 ± 1.4^{b}
Rubinola II Loamy-sandy Cambisol	2016	control	9.33	117.1 ± 24.0	12.7 ± 0.7
		A	9.16	118.2 ± 26.7	12.7 ± 0.7
		B	9.49	118.4 ± 24.8	12.7 ± 0.9
	2017	control	–	116.0 ± 30.0	15.6 ± 1.9
		A	–	116.8 ± 25.9	14.3 ± 1.8
		B	–	124.2 ± 27.3	14.8 ± 0.8

Means differ significantly ($P < 0.05$) if they are not marked with the same letter. Values are in the form of the mean ± standard deviation. A – fertilizer A (containing N, Mg, Ca, B and Zn); B – fertilizer B (N, B, Zn, Mn and Fe) a seasonal difference in the soluble solids content (SSC). The fertilization treatment did not affect the SSC parameter (Table 3). In the high-density apple orchards, foliar application of trace elements is a common part of the cultivation technology without determination of the need for these nutrients. Diagnosis of some nutrients deficiency at the beginning of the growing season is difficult for perennial crops. The results of our experiment suggest – if the insufficient intake of some microelement from the soil was detected – it could be applied without costly leaf analysis in the following seasons at the time of its anticipated need. Effectiveness of foliar application was better at trees that grew under worse conditions. Foliar fertilization is an effective way to correct the nutritional status disorders of apple trees, although it has not a long-term effect. The application of nutrients did not affect the fruit yield under the conditions of the experiment.

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