

**THE EFFECT OF CLIMATIC AND SOIL CONDITIONS ON THE MINERAL
COMPOSITION IN THE LEAVES OF APPLE TREE CULTIVARS DEPENDING ON THE
TERM OF THEIR FRUIT RIPENING
KLIMATA UN AUGSNES APSTĀKĻU IETEKME UZ ĀBEĻU LAPU MINERĀLO
SASTĀVU ATKARĪBĀ NO ĀBOLU IENĀKŠANĀS LAIKA**

Zydlík Z. and Pacholák E.

Department of Pomology, Agricultural University in Poznań, Poland

Kopsavilkums

Tika testētas vasaras šķirnes 'Jersymac', 'Discovery', 'Geneva Early', 'Close', 'Katia'; rudens šķirnes 'Delikates', 'Lobo', 'Novamac', 'Paulared', 'Witos'; ziemas šķirnes 'Cox's Orange Pippin', 'Ligol', 'McIntosh', 'Redcroft', 'Shampion'; vēlas ziemas šķirnes 'Golden Delicious', 'Gloster', 'Elstar', 'Jonagold Rubin', visi uz M.26 potcelma. Koki tika stādīti 1992. gada pavasarī, 3.5x1.5 m attālumos. Augstākais minerālvielu saturs tika konstatēts vasaras šķirņu lapās, bet zemākais – vēlo ziemas šķirņu lapās.

Abstract

The objects of the study included apple trees of the following cultivars: summer cvs.: Jersymac, Discovery, Geneva Early, Close, Katia, autumn cvs.: Delikates, Lobo, Novamac, Paulared, Witos, Winter cvs.: Cox's Orange Pippin, Ligol, McIntosh, Redcroft, Šampion; late winter cvs.: Golden Delicious, Gloster, Elstar, Jonagold Rubin. All trees were planted in spring 1992 on M.26, in 3.5x1.5 m spacing.

The highest content of mineral components was found in the leaves of summer cultivars while the lowest content was found in the leaves of the late winter cultivar group.

Key words: apple cultivars, leaf chemical concentrations

Introduction

Fertilization is one of the most frequently applied agrotechnical treatments in orchards, however, the determination of fertilization needs of orchard plants is very difficult. Fruit trees and shrubs are perennial plants with comparatively low fertilization requirements which are additionally modified by the method of soil use (Nielsen *et al.* 1986, Horning and Büneman, 1993). Numerous studies have shown the effect of rootstock on the mineral composition of plants as well (Sharma and Chauchan 1991; Tagliavini *et al.*, 1992; Chun *et al.*, 2001). However, there are no data referring on the effect of cultivars on the mineral composition of the plant. One should believe that the knowledge of these relations might have a significant importance in the determination of the fertilization requirements of orchard trees.

The aim of the studies carried out in the experimental orchard of the Pomological Department on the area of the Agricultural and Pomological Experimental Farm in Przybroda was to investigate the effect of climatic and soil factors on the content of mineral components in apple tree leaves with different terms of fruit ripening

Materials and Methods

The estimation of the mineral component content in the leaves of apple tree cultivars was carried out in the years 2000-2002 in the experimental orchard. The object of the study included apple trees of the following cultivars:

- summer cv.: 'Jerseymac', 'Discovery', 'Geneva Early', 'Close', 'Katia';
- autumn cv.: 'Delikates', 'Lobo', 'Novamac', 'Paulared', 'Witos';
- winter cv.: 'Cox's Orange Pippin', 'Ligol', 'McIntosh', 'Redcroft', 'Sampion';
- late winter cv.: 'Golden Delicious', 'Gloster', 'Elstar', 'Jonagold', 'Rubin'.

All trees were planted in spring 1992 on M.26 rootstock, in 3.5 x 1.5 m spacing. The trees were grown on proper grey-brown podzolic soil created of medium sand lying on light boulder clay. The humus content was about 1.45% and the soil fractions did about 23%. The content of available

mineral nutrients in year 2000, was high in reference to phosphorus and magnesium as compared to soil nutrient standards in topsoil and subsoil layers (Sadowski *et.al.*, 1990). For potassium, it was optimal in the topsoil layer and high in the subsoil layer with a correct K:Mg ratio and acid soil reaction (Table 1).

Table 1. Content of mineral compounds in soil in 2000 year, mg per 100g⁻¹ soil

Soil level	pH	P	K	Mg	K:Mg
0-20 cm	5.4	5.8	10.5	7.8	1.3
21-40 cm	5.1	8.3	8.2	6.9	1.2

All agrotechnical practices including mineral fertilization were carried out as recommended for the commercial orchards.

Leaf sampling was done every year between the 15-th and the 20-th of July in 4 replications from 5 trees, separately for each cultivar (totally 20 trees for each cultivar). Leaves were collected from the middle part of long shoots growing in the central part of the crown. After drying at 70°C, the leaves were ground, wet burnt and the following elements were identified:

- phosphorus - colorimetrically with the use of molybdenum-vanadium mixture
- magnesium and potassium - according to atomic absorption method
- calcium - by atomic absorption in the presence of lanthanum in 1% concentration.

In order to define a correlation between the content of mineral components in leaves and in soil, samples of soil were taken at the same time as leaf samples, separately for the layers of 0-20 and 21-40 cm.

All obtained results were statistically analysed and the significance of differences between the combinations was evaluated on the basis of the confidence interval calculated by Duncan's test for significance level $p=0.05$. Additionally, linear correlation coefficients were calculated between the climatic conditions and the mineral composition of soil on the one hand and the mineral component content in apple tree leaves on the other hand using the STATISTICA program.

Results and Discussion

Climatic conditions are regarded as natural factors which have a significant effect on tree growth and yielding (Pacholak, Rutkowski 1999). Meteorological data (Table 2) indicate that weather conditions during the experiment (1999-2002) were diversified. It is noteworthy that in comparison with the mean annual temperature, the annual mean temperature as well as the mean temperatures of the vegetation period was higher by 1.4°C and 2.1 °C, respectively. Similarly to temperatures, also the precipitations were different between particular years. In comparison to the mean value of many years the precipitations were lower compared to mean annual precipitation. According to the accepted standards, 3 years (1999, 2000 and 2002) were dry years and one year (2001) was a moderately moist year.

Table 2. Mean temperatures and precipitation sums in 1999-2002 according to Meteorological station in Przybroda

Years	Mean yearly temperature	Mean temperature in growing period IV-IX	Sum of temperatures in growing period IV-IX	Annual precipitation	Sum of rainfalls in growing period IV-IX
		°C			mm
Mean of 1956-1992	8.1	14.2	2627.0	529.1	326.6
1999	10.2	17.0	3114.0	487.4	262.5
2000	10.6	16.6	3028.6	526.6	295.0
2001	9.1	15.6	2854.8	487.4	317.8
2002	9.9	17.1	3129.3	516.1	229.7
Mean of 1999-2002	9.95	16.6	2806.7	504.4	276.3

The content of mineral components in the leaves of 20 apple tree cultivars was different. This according to Wójcik (1996) may depend on the cultivars, yielding and the weather conditions. Therefore, the interpretation of results was considered with the analysis of the mineral composition of the leaves of the examined summer, autumn, winter and late winter cultivars.

Nitrogen content in leaves, depending on the group of cultivars, was diversified and it ranged from 1.94% DM (dry matter) in the group of late winter cultivars to 2.14% DM in the leaves of summer cultivars. Between the groups of autumn and winter cultivars, no significant differences were found (Table 3). In comparison to standard values, nitrogen content in leaves was low in autumn, winter and late-winter cultivars while in the group of summer cultivars nitrogen content was optimal. Regardless of the cultivars group, significant differences in nitrogen content were also found between the years 2001 - 2002 ranging from 1.93% to 2.10% DM, respectively. Linear correlation coefficients did not show any significant correlation between the nitrogen content in leaves as dependent on climatic conditions or the content of nutritive components in the soil (Table 4). This statement agrees with the earlier results obtained by Pacholak and Zydlik (2003).

Table 3. Content of mineral compounds in leave of apple tree cultivars depending on the term of their fruit ripening in % DM (mean in years 2000-2002)

Groups of cultivars	N	P	K	Mg	Ca
Summer	2.14 c*	0.18 c	1.58 ab	0.35 c	1.36 b
Autumn	2.00 b	0.16 b	1.54 ab	0.32 b	1.26 b
Winter	2.04 b	0.16 b	1.62 b	0.29 a	1.14 a
Late winter	1.94 a	0.15 a	1.51 a	0.35 c	1.59 c
Mean of years:					
2000	2.03 ab	0.15 a	1.28 a	0.33 b	1.41 b
2001	1.97 a	0.17 b	1.71 b	0.37 c	0.96 a
2002	2.10 b	0.17 b	1.70 b	0.28 a	1.63 c

* Mean marked with by the same letters are not significant at the $\alpha=0.05$

Table 4. Correlation coefficients between climatic conditions and the content of mineral components in the soil and the chemical composition of leaves

Analised factor	N	P	K	Mg	Ca
Temperature	-	-	-	-0.5347 **	0.6634 **
Rainfall	-	-	-	0.5308 **	-0.5765 **
pH topsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
pH subsoil	-	-0.3052 *	-0.5822 **	-	0.4217 **
P topsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
P subsoil	-	-0.3508 *	-0.6153 **	-	-
K topsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
K subsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
Mg topsoil	-	-0.2854 *	-0.5575 **	-0.2778 *	0.4725**
Mg subsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
K/Mg topsoil	-	-0.2854 *	-0.5575 **	-0.2778 *	0.4725**
K/Mg subsoil	-	-0.2897 *	-0.5631 **	-0.2676 *	0.4624 **
N content in leaves		-	-	-	-
P content in leaves			-	-	-
K content in leaves				-	-0.3200 *
Mg content in leaves					-
Ca content in leaves					

* Significant difference at $\alpha=0.05$ *** Significant difference at $\alpha=0.01$

The content of phosphorus depending on the group of cultivars changed between 0.15% DM in the late winter group of cultivars and 0.18% DM in the leaves of summer group of cultivars (Table 3).

Worthy of attention is the fact that in comparison to boundary values the phosphorus content in leaves of the summer cultivars was a low. The phosphorus content of the leaves showed lowest concentration in 2000 on the average 0.15% DM. In the successive two years, there was no difference. A negative linear correlation was identified between phosphorus content in leaves and the mineral composition of soil and its pH (Table 4). The course of climatic conditions had no effect on the concentration of this component in the leaves of apple trees.

Potassium content in leaves ranged from 1.51% DM in late winter cultivars to 1.62% DM in winter cultivars (Table 3). In comparison with boundary values, independent of the cultivar group, potassium content was at a high level. The analysis of potassium content in the particular years of studies showed a significantly lower K content in leaves in 2000 and the mean value was 1.29% DM. The linear correlation coefficients indicated the existence of a negative correlation between potassium content in leaves and the mineral composition of soil and its pH, and a positive correlation with phosphorus concentration in apple tree leaves (Table 4). Similarly as in the case of phosphorus, climatic conditions had no effect on the potassium content in leaves.

Magnesium content in leaves of the analysed groups of cultivars changed between 0.29% DM in winter cultivars, and 0.35% DM in either summer or late winter cultivars. Similarly, as in case of nitrogen, the content of magnesium in the leaves of summer and late winter cultivars in comparison with boundary values, was high, whereas in the autumn and winter cultivars, its content was optimal. The lowest mean magnesium content in leaves was found in 2002 while the highest content occurred in 2001. A negative correlation between magnesium concentration and the content of mineral components in the soil and its reaction was found as well (Table 3). An essential negative dependence was revealed between magnesium in leaves and the temperature in the vegetation period, while a positive dependence was found between magnesium in leaves and the amount of precipitation.

Calcium content ranged from 1.11% DM in leaves of the winter cultivars to 1.54% DM in the leaves of late winter cultivars (Table 3). The remaining groups of cultivars did not differ significantly. The lowest content of calcium was found in 2001 and the highest one in 2002. The linear correlation coefficients indicated a positive dependence on the mineral composition of the soil and its reaction (Table 4). The course of climatic conditions had an effect on the Ca content in apple tree leaves showing a positive dependence on temperature and a negative dependence on precipitation.

The effect of climatic conditions on the content of magnesium and calcium in leaves was found earlier by Pacholak *et al.* (1998) and by Pacholak and Zydlik (2003).

Conclusions

The obtained results permit to state the significant differences in the mineral content of leaves depending on the analysed component and on the group of cultivars. Noteworthy is the fact that independent of the cultivars, the highest content of mineral components was found in the leaves of summer cultivars while the lowest content was found in the leaves of late winter cultivar group.

Linear correlation coefficients between climatic conditions (temperature and precipitations in the vegetation period) and the content of mineral components in the soil and the chemical composition of leaves showed that of climatic conditions influenced and the content of magnesium and calcium in the leaves. Also the content of mineral components in the soil was significantly correlated to the chemical composition of the leaves. Only in case of nitrogen, no effect of climatic and soil conditions on the content of mineral components in leaves was found.

References

1. Chun I., Fallahi E. and Neilsen G. (2001) Net photosynthesis, leaf mineral nutrition, and tree vegetative growth of 'Fuji' apple trees on three rootstocks. *Acta Hort.*, 564, 77-82.
2. Neilsen G., Hoque E.J. and Brought B.G. (1986) The effect of orchard soil management on soil temperature and apple tree nutrition. *Can. J. Soil Sci.*, 4, 701-711.
3. Pacholak E., Przybyła C. and Cwynar M. (1998) Nawadnianie i nawożenie a efektywność produkcyjna jabłoni w sadzie po replantacji. *Pr. Kom. Nauk Rol. i Leśn. PTPN*, 71, 75-83.
4. Pacholak E. and Zydlik Z. (2003) Wpływ nawożenia i nawadniania na zawartość składników mineralnych w glebie oraz liściach jabłoni odmiany 'Sampion' w sadzie replantowanym. *Pr. Kom. Nauk Rol. i Leśn. PTPN*, 95, 281-289.

5. Sadowski A., Nurzyński J., Pacholak E. and Smolarz K. (1990) Racjonalizacja nawożenia i zwiększania produktywności roślin sadowniczych. Instrukcja upowszechnieniowa nr 3 określania potrzeb nawożenia roślin sadowniczych. II Zasady, liczby graniczne i dawki nawożenia, Warszawa.
6. Sharma D.D. and Chouchan J.S. (1991) Effects of different rootstocks and training system on the mineral composition of 'Delicious' apple leaves. J. Hort. Sci., 66, 703-707.
7. Tagliavini M., Scudellari D., Marangoni B., Bastianel A., Franzin F. and Zamborlini M. (1992) Leaf mineral composition of apple tree: Sampling date and effects of cultivar and rootstock. J. Plant Nutr., 15, 605-619.
8. Wójcik P.(1996) Skład mineralny liści drzew sadowniczych a nawożenie. Sad Nowoczesny, 7, 4-6.