

EVALUATION OF NUTRIENTS SUPPLY IN APPLE TREES CULTIVATED
IN LUBELSKIE REGION

*Przemysław Tkaczyk¹, Wiesław Bednarek², Sławomir Dresler³,
Jaromir Krzyszczak⁴*

¹Regional Chemical-Agricultural Station
ul. Sławinkowska 5, 20-810 Lublin
e-mail: ptkaczyk@schr.gov.pl

²Department of Agricultural and Environmental Chemistry, University of Life Sciences
ul. Akademicka 15, 20-950 Lublin

³Department of Plant Physiology, Biology and Biochemistry Institute,
Maria Curie-Skłodowska University
ul. Akademicka 19, 20-033 Lublin

⁴Institute of Agrophysics, Polish Academy of Sciences
ul. Doświadczalna 4, 20-290 Lublin

Abstract. An environmental study was performed in the years 2009-2011 to evaluate nutrients supply in apple trees in the Lubelskie Region. Apple tree leaves (cv. Szampion) were sampled from orchards situated in 17 localities, in the first half of August, from the central part of long shoots situated in various parts on the crown circumference, at mid-height, from ten trees chosen at random. The chemical analyses of those leaves were performed at the accredited laboratory of the Regional Chemical-Agricultural Station in Lublin. In the analysed material the following parameters were assayed: dry matter content, total nitrogen content, content of phosphorus, potassium, calcium, magnesium, copper, zinc, manganese, iron and boron. The average content and standard deviation of the macro- (N, P, K, Ca and Mg) and microelements (B, Cu, Zn, Fe, Mn) in the leaves were calculated. Additionally, correlations among those elements and coefficients of determination were calculated. Our evaluation has shown that apple trees cv. Szampion cultivated in the Lubelskie Region were optimally supplied in macro-elements, that is to say nitrogen, phosphorus, potassium, magnesium and calcium. The chemical analyses revealed also that the plants had optimum level of supply for boron. The occurrence of a relatively few (7) significant correlations among the assayed macro- (N, P, K, Mg, Ca) and microelements (B, Cu, Zn, Mn, Fe) was noted. For some of the microelements the values of the calculated coefficients of determination varied from 88.2 to 98.4%.

Keywords: apple tree, macroelements, microelements, fertilisation.

INTRODUCTION

Only on a fertile soil, with regulated reaction and with optimum supply of nutrients it is possible to harvest appropriate – under given conditions – yields of crop plants, with expected quality parameters (Andziak *et al.* 2004, Breś *et al.* 2009, Methodology of integrated apples production 2010). The levels of nutrients in soil may change, and therefore they should be supplemented through the application of natural, organic and mineral fertilisers (Pacholak *et al.* 2004, Pacholak 2008, Chelpiński *et al.* 2009, Szewczuk *et al.* 2009, Szewczuk *et al.* 2011). The content of an element in a plant depends, among other things, on the species, organ of the plant, development phase, rootstock, tree crown formation, shelterwood cutting, or the availability of the element in the environment. Those dependencies have been studied by many researchers. For example, Treder and Olszewski (2004) analysed the effect of the method of fertilisation on nitrogen content in apple tree leaves and noted that neither the kind of fertiliser (nitrogen, multi-component) nor the method of its application (sprinkling, fertigation) had any significant effect on the average content of that element for the period of their study (1993-1999). It depended primarily on the level of yield and on the age of the plant. Pacholak *et al.* (2004), studying the effect of nitrogen fertilisation on the content of minerals in, among other things, leaves of apple tree cv. Szampion, observed that it caused an increase in the content of total N, decreased the level of phosphorus, and had no significant effect on the other elements analysed. Fertilisation of apple trees cv. Golden Delicious with various forms of potassium had no significant effect on the content of N in their leaves (Komosa and Szewczuk, 2002). Fertilisation with increasing doses of various forms of potassium (chloride, sulphate, nitrate) had no distinct effect on the content of that element in leaves of apple tree cv. Golden Delicious (Komosa and Szewczuk 2002). Pietranek and Jadczyk (2005), estimating the status of mineral nutrition of apple trees cv. Katja with relation to irrigation, fertilisation and rootstock, found that irrigation had no significant effect on the content of macro-elements in the leaves, though there was a tendency towards a higher level of K and a lower content of Mg. Fertilisation, irrespective of the dose and method of application, had a significant effect on potassium nutrition of the trees. The highest content of K in the leaves of the trees was noted after the application of 166 kg K ha⁻¹ every year, or 664 kg K ha⁻¹ every four years. Moreover, leaves of trees fertilised in that way displayed a tendency of higher phosphorus content. Whereas, significantly the highest content of magnesium was noted in leaves of trees with no fertilisation, and the lowest in leaves of trees fertilised with 664 kg K ha⁻¹ every four years (i.e. in that case there appeared the classic ionic antagonism between those elements). No clear tendency was observed for the effect of potassium fertilisation on the content of calcium. It

was noted that leaves from trees on P 60 contained more calcium and less magnesium whose content was higher in leaves from trees on sub-clones M 9. Szewczuk *et al.* (2011), estimating the effect of potassium fertilisation and of the kinds of potassium fertilisers on the yields and the status of apple trees nutrition with macro-elements and chlorine after the trees entered the phase of fruition, did not observe any such effect on the content of N, P, K, Ca, Mg, S and Cl in leaves of apple trees cv. Golden Delicious. The status of nitrogen nutrition of the trees was optimum (fertilisation with KCl and K_2SO_4) or high (KNO_3). As a result of application of the potassium fertilisers studied, optimum status of nutrition with P, K, Ca and Cl was observed, and high in the case of Mg. Chelpiński *et al.* (2009) studied the effect of the fertilisers Fructus Ogrodnik and Timac 37 N Pro on the chemical composition of fruits and leaves of apple trees cv. Idared and noted a significant effect of those fertilisers on the leaf content of potassium, calcium, magnesium and nitrates, and also a significant effect of Timac 37 N Pro on the content of total N. The fertilisers did not affect, in any statistically proven way, the content of phosphorus in the leaves. Pacholak (2008), who studied the effect of 25-year varied fertilisation with NPK and Mg on, among other things, the content of minerals in leaves of apple trees cv. Cortland, concluded that he did not observe any correlation between the occurrence of those elements in the soil and in the leaves, taking note of the fact that irrespective of the fertilisation applied the content of those elements was at the optimum level. Domagała-Świątkiewicz (2006), studying the effect of non-root feeding with calcium nitrate on the content of minerals in leaves, ovaries and fruits of apple trees cv. "Elise", observed a significant increase in calcium content in ovaries of fruits sprayed three times with 0.4% solution of $Ca(NO_3)_2$ at the turn of June and July, compared to fruits without such treatment; the treatments caused a decrease in the N/Ca and K/Ca ratio in the fruit ovaries, but had no significant effect on the content of Ca in the fruits at the time of harvest. Zydlik *et al.* (2011), studying the effect of multi-year cultivation of apple tree and of the application of re-planting on the content of, among other things, minerals in leaves, found that the soil status and the content of minerals in the soil had an effect on the composition of minerals (content of N, P, K, Mg, Ca) of that organ of apple trees cv. Topaz.

Supplying plants with components at doses adapted to their requirements has a beneficial effect on their growth, flowering and setting, as well as on the ripening of fruits, and in consequence on the yielding and on fruit quality. Balanced fertilisation of various species of fruit trees and berry bushes with macro- and microelements has a beneficial effect on the consumption value of the fruits, and also on their transport, processing and storage capacities. The correction of pre-sowing fertilisation (applied prior to establishing a plantation) is performed with the use of analysis of index parts sampled in specific development phases of the plants. Such organs, frequently used in plant diagnostics, include leaves taken for

chemical analyses (Treder and Olszewski 2004, Breś *et al.* 2009, Methodology of integrated apples production 2010).

The objective of the study was to evaluate the status of supply of apple trees grown in the Lublin Region in certain macro- and microelements.

MATERIALS AND METHODS

In the years 2009-2011, in the Lublin Region, an environmental study was performed with the aim of evaluation of the supply of apple trees in certain macro- and microelements. That evaluation was made after performing chemical analyses of leaves of those plants. Apple tree leaves (cv. Szampion) were sampled from orchards situated in the localities of Kurów, Nowe Osiedle, Stryjno Kolonia, Ludwinów, Boiska Kolonia, Motycz, Biała Podlaska, Okręglica Kolonia, Zarzecze, Końskowola, Zastów Polanowski, Komarówka Osada, Bochoznica, Hrubieszów, Wyganowice and Platerów. Samples of apple tree leaves were taken in the first half of August, from the central part of long shoots situated in various parts on the crown circumference, at mid-height, from ten trees chosen at random. Approximately 20 leaves were collected from a single tree. When collecting the plant material attention was paid to the health status of the apple trees, and primarily to whether they had been infected with diseases or infested by pests, and whether the trunks were not damaged by frosts. Simultaneously, soil samples from the topsoil (0-20 cm) were collected and examined. Analysis of these samples indicated that plantation soils were characterised by a high or medium supply of rated elements. The chemical analyses were performed at the accredited laboratory of the Regional Chemical-Agricultural Station in Lublin. The following parameters were assayed in the material analysed: dry matter content, total nitrogen content acc. to the Kjeldahl method, content of phosphorus – with the vanadium-molybdenum method, potassium and calcium – flame photometry method, magnesium, copper, zinc, manganese and iron – ASA method, and boron – with the curcumin method (Methods of laboratory tests at chemical-and-agricultural stations 1972). The average content and standard deviation of the macro- (N, P, K, Ca and Mg) and microelements (B, Cu, Zn, Fe, Mn) were calculated and correlations among those elements were determined (correlation coefficients, $p = 0.05$).

RESULTS AND DISCUSSION

The mean content of nitrogen in apple tree leaves was 2.31% N d.m., with standard deviation of 0.40 (Tab.1, Fig. 1). Comparing those values with the limit numbers (Komosa and Szewczuk 2002, Breś *et al.* 2009, Methodology of integrated apples production 2010), it was concluded that the plants from the analysed

orchards in the Lublin Region had optimum status of supply in that element. The mean content of phosphorus in apple tree leaves was 0.18% P d.m., with standard deviation of 0.03. The content of that element also indicates that those index parts of the plants had optimum supply of phosphorus (Breś *et al.* 2009, Methodology of integrated apples production 2010). The mean content of potassium in apple tree leaves was 1.33% K d.m., with standard deviation of 0.30 (Fig. 1). Comparison with the limit values (Breś *et al.* 2009, Methodology of integrated apples production 2010) indicates that the leaves of those plants had optimum levels of that element. The content of magnesium in the leaves collected from the studied orchards of the Lublin Region (0.26% Mg d.m., standard deviation 0.07) indicates that the plants had optimum supply of that element (Breś *et al.* 2009, Methodology of integrated apples production 2010). Estimating the content of calcium in the leaves (1.62% Ca d.m., standard deviation 0.73), it should also be considered as optimal. The content of boron in apple tree leaves was 26.9 mg B kg⁻¹ d.m., with standard deviation of 4.36, which indicates optimum level of that element acc. to the limit values (Breś *et al.* 2009, Methodology of integrated apples production 2010). However, it was notably lower than in leaves of apple tree cv. Golden Delicious (Komosa and Szewczuk 2002). The mean content of manganese in apple tree leaves (146 mg Mn kg⁻¹ d.m.) (Tab. 2) indicates that it was high acc. to the limit values (Breś *et al.* 2009), while the value of standard deviation (15.6) indicates a certain variation in Mn content in that index part and a potential need of increasing the sample size. Szewczuk *et al.* (2009), studying the effect of increasing doses and various forms of potassium fertilisers on the status of nutrition of apple trees cv. Golden Delicious with microelements, found that there was a significant decrease in the level of manganese in the leaves, while the levels of iron, copper and boron remained stable. The mean content of copper in apple tree leaves was 6.30 mg Cu, zinc 26.2 mg Zn, and iron 89.3 mg Fe kg⁻¹ d.m. The levels of copper and zinc in leaves of apple trees cv. Golden Delicious were similar, while the content of iron about 10% higher. Potassium fertilisation, especially in the chloride and sulphate forms, significantly decreased the content of Fe in leaves of that apple cultivar, relative to the control (Komosa and Szewczuk 2002).

It was found that among the ten elements under consideration the content of nitrogen in apple tree leaves displayed a significant positive correlation only with the content of phosphorus ($r_{xy} = 0.536$) and potassium ($r_{xy} = 0.362$) (Tab. 2), the content of phosphorus a positive correlation with the level of potassium ($r_{xy} = 0.616$), and that of magnesium – a positive correlation with the level of zinc ($r_{xy} = 0.941$) and manganese ($r_{xy} = 0.944$) and a negative one with iron ($r_{xy} = -0.939$), while the content of zinc – a positive correlation with the level of manganese ($r_{xy} = 0.992$).

Table 1. Mean contents of macro- and microelements in apple tree leaves (% d.m.)

Element	Statistical characteristic, n = 41		Element	Statistical characteristic n = 6	
Nitrogen	Content	2.31	Copper	Content	6.30
	Standard deviation	0.40		Standard deviation	2.20
Phosphorus	Content	0.18	Zinc	Content	26.2
	Standard deviation	0.03		Standard deviation	18.2
Potassium	Content	1.33	Manganese	Content	145.8
	Standard deviation	0.30		Standard deviation	15.6
Calcium	Content	1.62	Iron	Content	89.3
	Standard deviation	0.73		Standard deviation	34.9
Magnesium	Content	0.26	Boron	Content	26.9
	Standard deviation	0.07		Standard deviation	4.36

n – means the sample size.

Table 2. Correlations between the contents of macro- and microelements in apple tree leaves (correlation coefficients)

Variable	N	P	K	Ca	Mg	B	Cu	Zn	Mn	Fe
N	–	0.536	0.362	*	*	*	*	*	*	*
P	0.536	–	0.616	*	*	*	*	*	*	*
K	0.362	0.616	–	*	*	*	*	*	*	*
Ca	*	*	*	–	*	*	*	*	*	*
Mg	*	*	*	*	–	*	*	0.941	0.944	0.939
B	*	*	*	*	*	–	*	*	*	*
Cu	*	*	*	*	*	*	–	*	*	*
Zn	*	*	*	*	0.941	*	*	–	0.992	*
Mn	*	*	*	*	0.944	*	*	0.992	–	*
Fe	*	*	*	*	-0.939	*	*	*	*	–

* insignificant correlation.

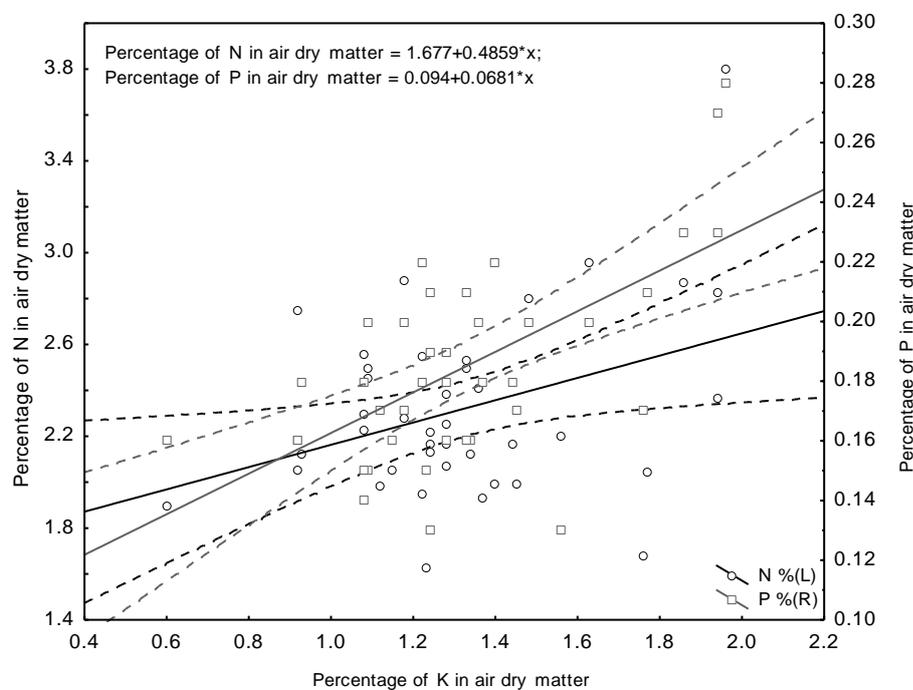


Fig. 1. Content of nitrogen (%N d.m.) and phosphorus (%P d.m.) in leaves of apple trees in relation to the level of potassium (%K d.m.) in that plant part

CONCLUSIONS

1. Apple trees cv. Szampion grown in the Lublin Region had optimum status of supply in macro-elements, i.e. nitrogen, phosphorus, potassium, magnesium and calcium, which was related to high macroelements supply in evaluated plantations soil.

2. Chemical analyses of apple tree leaves revealed that the plants had also optimum supply of boron and sufficient supply in the remaining microelements (Cu, Zn, Mn and Fe). This supply was a result of soil supply in the rated elements at the individual plantations.

3. In the apple tree leaves the occurrence of a relatively low number (7) of significant correlations was noted among the assayed macro- (N, P, K, Mg, Ca) and microelements (B, Cu, Zn, Mn, Fe). In the case of some of the microelements the values of the calculated coefficients of determination was high and varied from 88.2 to 98.4%.

REFERENCES

- Andziak J., Tomala K., Sadowski A., Dziuban R., 2004. Nutritional status and quality of 'šampion' apples depending on rootstock (in Polish). *Acta Sci. Pol. Hortorum Cultus*, 3(2), 179-187.
- Breś W., Golcz A., Komosa A., Kozik E., Tyksiński W., 2009. Feeding of horticultural plants (in Polish). *Wyd. UP w Poznaniu*, 1-191.
- Chelpiński P., Mikiciuk G., Krzywy-Gawrońska E., Puszczewicz G., 2009. Influence of fertilizers Fructus Ogrodnik and Timag 37 N Pro on chemical composition of fruits and leaves of apple trees of cv. Idared (in Polish). *Zesz. Prob. Post. Nauk Roln.*, 538, 35-40.
- Domagała-Świątkiewicz I., 2006. Effect of foliar calcium nitrate spray on the mineral nutrient content in leaves and fruit of 'Elise' apples. *Acta Agrophys.*, 7(4), 867-877.
- Komosa A., Szewczuk A., 2002: Effect of soil potassium level and different potassium fertilizer forms on nutritional status, growth and yield of apple trees in the first three years after planting. *J. Fruit Ornament. Plant Res.*, X, 41-54.
- Methodology of integrated apples production (in Polish), 2010. *Wyd. II. PIORiN*, 1-34.
- Methods of laboratory tests at chemical-and-agricultural stations. Part II. Analyses of plant material (in Polish), 1972. *IUNG Puławy*, 1-97.
- Pacholak E., 2008. Effect of 25 years of differentiated fertilization with NPK and magnesium on growth and fruit field of apple 'Cortland' and on the content of minerals in soil and leaves. *J. Fruit Ornament. Plant Res.*, 16, 201-214.
- Pacholak E., Zachwieja M., Zydlik Z., 2004. Effect of nitrogen fertilization on the content of mineral components in soil, leaves and fruits of Szampion apple trees. *Acta Sci. Pol. Hortorum Cultus*, 3(2), 207-217.
- Pietranek A., Jadczyk E., 2005. Mineral status of Katja apple trees depending on irrigation, fertilization and rootstock. *Acta Sci. Pol. Hortorum Cultus*, 4(1), 69-76.
- Szewczuk A., Komosa A., Gudarowska E., 2009. Effect of different potassium soil levels and forms of potassium fertilizers on micro-elemental nutrition status of apple trees in early fruiting period. *J. Elem.*, 14(3), 553-562.
- Szewczuk A., Komosa A., Gudarowska E., 2011. Effect of soil potassium levels and different potassium fertilizers on yield, macroelement and chloride nutrition status of apple trees in full fruiting period. *Acta Sci. Pol. Hortorum Cultus*, 10(1), 83-94.
- Treder W., Olszewski T., 2004. The estimation of the influence of the way of fertilization on the content of nitrogen in the leaves of apple trees (in Polish). *Acta Sci. Pol., Hortorum Cultus*, 3(2), 111-122.
- Zydlik Z., Pacholak E., Styła K., 2011. Effect exerted on soil properties by apple-tree cultivation for many years and by replantation. Part II. Content of mineral components in soil and leaves. *Acta Sci. Pol. Hortorum Cultus*, 10(1), 123-130.

OCENA ZAOPATRZENIA W MAKRO- I MIKROELEMENTY JABŁONI
UPRAWIANYCH NA LUBELSZCZYŹNIE

*Przemysław Tkaczyk¹, Wiesław Bednarek², Sławomir Dresler³,
Jaromir Krzyszczyk⁴*

¹Okręgowa Stacja Chemiczno-Rolnicza w Lublinie
ul. Sławinkowska 5, 20-810 Lublin
e-mail: ptkaczyk@schr.gov.pl

²Katedra Chemii Rolnej i Środowiskowej, Uniwersytet Przyrodniczy
ul. Akademicka 15, 20-950 Lublin,

³Zakład Fizjologii Roślin, Instytut Biologii i Biochemii, Uniwersytet Marii Curie-Skłodowskiej
ul. Akademicka 19, 20-033 Lublin

⁴Instytut Agrofizyki Polskiej Akademii Nauk
ul. Doświadczalna 4, 20-290 Lublin

Streszczenie. Celem przeprowadzonych na Lubelszczyźnie w latach 2009-2011 badań środowiskowych była ocena zaopatrzenia jabłoni w makro- i mikroelementy. Liście jabłoni (odmiana Szampion) pobrano z sadów prowadzonych w 17 miejscowościach, w pierwszej połowie sierpnia, ze środkowej części długopędów rozmieszczonych w różnych miejscach w obwodzie korony, znajdujących się w połowie jej wysokości i z dziesięciu losowo wybranych drzew. Analizy chemiczne zostały wykonane w akredytowanym laboratorium Okręgowej Stacji Chemiczno-Rolniczej w Lublinie. W analizowanym materiale oznaczono: suchą masę, ogólną zawartości azotu, fosforu, potasu, wapnia, magnezu, miedzi, cynku, manganu i żelaza oraz boru. W liściach roślin obliczono średnią zawartość i odchylenie standardowe makro- (N, P, K, Ca i Mg) i mikroelementów (B, Cu, Zn, Fe, Mn,.) określono współzależności występujące pomiędzy tymi pierwiastkami (współczynniki korelacji) oraz obliczono niektóre współczynniki determinacji. Dokonana ocena wskazuje, iż jabłonie odmiany Szampion uprawiane na Lubelszczyźnie były optymalnie zaopatrzone w makroelementy, tzn. azot, fosfor, potas, magnez i wapń. Analizy chemiczne liści jabłoni wykazały również, że rośliny te były optymalnie zaopatrzone w bor. W liściach jabłoni odnotowano wystąpienie stosunkowo niewielu (7) istotnych korelacji pomiędzy oznaczanymi makro (N, P, K, Mg, Ca) i mikroelementami (B, Cu, Zn, Mn, Fe). Wartość obliczonych współczynników determinacji w przypadku niektórych mikroelementów wahała się od 88,2 do 98,4%.

Słowa kluczowe: jabłoń, makroelementy, mikroelementy, nawożenie