ACTA Acta Sci. Pol., Hortorum Cultus 4(1) 2005, 69-76

MINERAL STATUS OF 'KATJA' APPLE TREES DEPENDING ON IRRIGATION, FERTILISATION AND ROOTSTOCK

Anna Pietranek, Ewa Jadczuk
Warsaw Agricultural University (SGGW)

Abstract. 'Katja' apple trees on M.9 Emla, M.9 751, M.9 984 and P 60 were planted on a silty loam alluvial soil, strongly fixing K, in autumn 1992. They were grown on non-irrigated and irrigated plots, with different potassium fertilisation applied since 1980. Leaf samples were taken in the years 1999–2001. Irrigation had not any significant effect on leaf mineral element content. However, a tendency to increasing leaf K concentration and decreasing Mg concentration in irrigated trees was noted. Fertilisation, irrespective of the dose and mode of application, significantly affected leaf mineral status. The annual doses of 200 kg $K_2O \cdot ha^{-1}$ and cumulative dose of 800 kg $K_2O \cdot ha^{-1}$, applied once in every four years, significantly increased K and P concentration. Leaves of non-fertilised trees contained more Mg. Leaves of P 60 contained more Ca and less Mg.

Key words: apple, irrigation, potassium fertilisation, rootstock, leaf analysis, mineral elements

INTRODUCTION

Adequate nutrient supply is one of essential conditions for proper development of plants. However, many factors may modify plant nutritional status, of fruit plants in particular. Sadowski et al. [1982] and Jadczuk [1994] reported that leaf macroelement content was altered by weather conditions of a particular season. Levin et al. [1979] and Pacholak [1984] proved that mineral elements content of apple leaves increased along with increased soil moisture content.

Research on potassium fertilisation of apple trees has brought variable results. Mercik [1977], Leszczyński and Sadowski [1990] and Jadczuk [1994] pointed out to the positive effects of K fertilisation on the tree nutrient status, while Pacholak [1984] presented an opposite opinion.

Corresponding author – Adres do korespondencji: Anna Pietranek, Ewa Jadczuk, Department of Pomology and Basic Natural Sciences in Horticulture, Warsaw Agricultural University (SGGW), ul. Nowoursynowska 159, 02-776 Warszawa, Poland; e-mail: pietranek@sggw.waw.pl

Tree mineral status may also depend on the type rootstocks used, apparently due to their different ability of uptake or translocation of a particular macroelement [Westwood 1978].

The aim of this research was to assess the influence different potassium fertiliser treatments, combined with the effect of irrigation and rootstock on mineral status of apple trees grown on a soil low in K.

MATERIAL AND METHODS

The study was carried out in the years 1999–2001 in the Experimental Orchard of the Warsaw Agricultural University, in Warsaw-Wilanów. The soil was alluvial silty loam, containing minerals from the montmorillonite, kaolinite and illite group – with the tendency to strong potassium fixation in the interpack spaces. The humus content reached 2–2.5% at the depth of 0–30 cm. In spring 1992 one-year-old 'Katja' maiden apple trees, budded on M.9 EMLA, M.9 751, M.9 984 or on P 60, were planted in the double-row system at the distance of (4+1)×1.5 m. Herbicide strips (1-m wide) were maintained along tree rows and permanent sward in alleyways.

Non-irrigated plots were compared with the irrigated ones, with the soil water potential maintained at ≥-0.035 MPa. The following fertiliser treatments were applied: K-0 – control, no potassium; K-200 – 200 kg $K_2O{\cdot}ha^{-1}$, every year; K-800 – 800 kg $K_2O{\cdot}ha^{-1}$ once in every four years; K-400 – 400 kg $K_2O{\cdot}ha^{-1}$, once in every four years; K-200herb. – 200 kg $K_2O{\cdot}ha^{-1}$, every year, applied in herbicide strips only. These treatments have been used since 1980 in the preceding sour cherry orchard. Potassium chloride, containing 55% K_2O, was broadcasted by hand on a soil surface before the start of vegetation.

Mid-shoot leaves were sampled after the cease of terminal shoot growth, i.e. at the turn of July and August. They were collected from the middle height of a tree canopy. A composed sample contained 48 leaves taken from 8 trees grown on the same rootstock. Leaves were dried at 60°C. Potassium content was determined by flame photometry, phosphorus – by the molybdate-vanadiate colorimetric method, magnesium and calcium – by ASA and nitrogen by Kjeldahl technique.

The experiment was set up in a split-plot-plot factorial randomised block design with 4 replications and 32 trees on the fertilised plot, 8 o each rootstock. Results were elaborated by the analysis of variance. The significance of differences between treatment means was evaluated using test of Tukey.

The years of study were characterised by relatively high mean monthly temperatures, in comparison to the many-year averages (tab. 1). The warmest vegetation season was 2000, when the average monthly temperature was 2.8°C higher than the many-year averages. Sums of monthly rainfall for particular years were higher than the many-year averages, too. The highest precipitation was noted in 1999 and the lowest in 2000. According to Kaczorowska [1962] in a „normal period" precipitation should not differ more than by 10% from a respective many-year average. Following this principle, the year 2000 may be considered as normal, because the total rainfall was only 5.5% higher than the long term average, whereas the years 1999 and 2001 should be ranked as wet.

Table 1. Mean monthly temperatures and total monthly rainfall
Tabela 1. Średnie temperatury miesięczne i sumy opadów miesięcznych

Month Miesiąc	Mean montly temperatures, °C				Total monthly rainfall, mm			
	Average long-term Średnie wieloletnie	1999	2000	2001	Average long-term Średnie wieloletnie	1999	2000	2001
I	-3.1	0.6	-0.9	0.3	22.0	23.7	30.9	27.1
II	-2.1	-0.7	3.2	0.2	24.4	32.3	42.2	21.6
III	2.1	5.1	4.0	3.0	26.7	23.7	39.8	38.3
IV	7.9	10.6	12.8	8.8	33.8	88.5	14.4	60.2
V	13.7	13.1	15.8	15.7	58.1	47.8	43.8	39.7
VI	16.9	18.6	18.3	16.0	67.8	168.9	25.9	33.7
VII	18.1	21.1	17.2	21.4	66.5	35.8	128.2	148.6
VIII	17.6	18.4	18.6	20.0	65.7	38.5	54.3	35.1
IX	13.5	16.0	21.1	12.6	43.1	25.2	55.9	73.2
X	8.6	8.0	11.6	11.4	35.9	50.1	3.0	32.6
XI	3.4	2.2	6.1	3.1	39.9	42.8	72.3	40.2
XII	-0.8	1.3	2.3	-3.6	36.6	22.1	38.7	28.6
Yearly mean Średnia roczna	8.0	9.5	10.8	9.1	520.5	599.4	549.0	579.0

Distribution of precipitation within a season is very important, the period from April to September being critical. It must be also taken into account that along with the increase of air temperature the needs of trees for water increase. So, in the period under study a significant water deficit occurred.

RESULTS

Irrigation, fertilisation and rootstocks had a varying effect on mineral status of ‘Katja’ apple trees. Irrigation significantly increased leaf nitrogen concentration in 2001 only (tab. 2). Nitrogen mineral status depended to the greatest extent on K fertilisation (tab. 3). On the average for the whole period of study (1999–2001) the leaf N concentration was significantly lower in leaves of trees fertilised at the rate of 200 kg K_2O ha^{-1}, applied every year in herbicide strips only (K-200herb.), in comparison to the other K treatments. Rootstock did not affect N mineral status of apple trees (tab. 4). According to the accepted standards for mineral element contents in leaves of apple trees, leaf N content was within an optimum range in the years 1999 and 2001, except for the high N content in leaves of non-fertilised trees in 2001. In 2000 low leaf N content was noted, irrespective of any experimental factor.

Irrigation did not have any significant effect on phosphorus status either (tab. 2). However, some effect of K fertilisation on the leaf P content was noted (tab. 3). On the average for three years, the lowest P concentration was in the leaves of non-fertiliser trees. In this study K-treatment with the doses of 200 kg $K_2O \cdot ha^{-1}$ applied every year or with 800 kg $K_2O \cdot ha^{-1}$ applied once in every four years, were more effective in increasing the leaf P concentration than the dose of 400 kg $K_2O \cdot ha^{-1}$ applied once in every four years or 200 kg $K_2O \cdot ha^{-1}$ every year, applied in herbicide strips only. The leaf P content was within the optimum range, except for the control treatment in 1999. The effect of

Table 2. Concentration of macroelements in 'Katja' apple leaves (mg·100 g d.m.$^{-1}$), depending on irrigation; mean values for different K fertilisation and rootstock
Tabela 2. Zawartość makroelementów w liściach jabłoni 'Katja' (mg·100 g d.m.$^{-1}$) w zależności od nawadniania; średnio dla różnego nawożenia potasem i podkładki

Element Składnik	Treatment Kombinacja	Year – Rok			Average Średnio
		1999	2000	2001	
N	non-irrigated – nienawadniane	2.35 a[1]	1.92 a	2.36 a	2.21 a
	irrigated – nawadnianie	2.32 a	1.90 a	2.39 b	2.20 a
P	non-irrigated – nienawadniane	0.18 a	0.20 a	0.25 a	0.21 a
	irrigated – nawadnianie	0.17 a	0.21 a	0.24 a	0.20 a
K	non-irrigated – nienawadniane	1.22 a	1.35 a	1.56 a	1.38 a
	irrigated – nawadnianie	1.22 a	1.36 a	1.61 a	1.40 a
Ca	non-irrigated – nienawadniane	1.56 a	1.13 a	1.42 a	1.37 a
	irrigated – nawadnianie	1.54 a	1.13 a	1.47 a	1.38 a
Mg	non-irrigated – nienawadniane	0.35 a	0.31 b	0.46 a	0.37 b
	irrigated – nawadnianie	0.34 a	0.30 a	0.43 a	0.36 a

[1] Mean values followed by the same letter (within column) are significantly different at α = 0.05.
[1] Średnie oznaczone tą sama literą (w obrębie kolumny) nie różnią się istotnie, przy α = 0,05.

Table 3. Concentration of macroelements (mg·100 g s. m.$^{-1}$) in 'Katja' apple leaves, depending on K fertilisation; mean values for irrigation and different rootstocks
Tabela 3. Zawartość makroelementów (mg·100 g s. m.$^{-1}$) w liściach jabłoni 'Katja' w zależności od nawożenia potasem; średnio dla nawadniania i różnych podkładek

Element Składnik	Fertilisation Nawożenie kg K_2O·ha^{-1}	Rok – Year			Average of three years Średnio z trzech lat
		1999	2000	2001	
N	K-0	2.33 a[1]	1.90 b	2.42 b	2.22 b
	K-200	2.34 a	1.95 b	2.34 a	2.21 b
	K-800	2.32 a	1.92 b	2.37 ab	2.20 b
	K-400	2.35 a	1.97 b	2.38 ab	2.23 b
	K-200herb.	2.30 a	1.82 a	2.37 ab	2.16 a
P	K-0	0.14 a	0.17 a	0.25 ab	0.19 a
	K-200	0.18 b	0.22 b	0.26 b	0.22 c
	K-800	0.19 b	0.21 b	0.25 ab	0.22 c
	K-400	0.17 b	0.21 b	0.22 a	0.20 ab
	K-200herb.	0.17 b	0.22 b	0.25 ab	0.21 bc
K	K-0	0.65 a	0.73 a	0.59 a	0.66 a
	K-200	1.50 c	1.67 c	1.91 c	1.69 c
	K-800	1.47 c	1.61 c	2.02 c	1.70 c
	K-400	1.28 b	1.38 b	1.55 b	1.40 b
	K-200herb.	1.17 b	1.38 b	1.85 c	1.47 b
Ca	K-0	1.59 b	1.14 a	1.89 b	1.54 b
	K-200	1.50 ab	1.12 a	1.81 b	1.48 b
	K-800	1.47 a	1.15 a	1.16 a	1.26 a
	K-400	1.62 b	1.16 a	1.18 a	1.32 a
	K-200herb.	1.57 b	1.10 a	1.18 a	1.28 a
Mg	K-0	0.47 b	0.44 b	0.69 c	0.53 d
	K-200	0.30 a	0.27 a	0.47 b	0.35 c
	K-800	0.30 a	0.26 a	0.35 a	0.30 a
	K-400	0.32 a	0.27 a	0.36 a	0.32 ab
	K-200herb.	0.33 a	0.28 a	0.37 a	0.33 b

[1] For explanation – see table 2 – Objaśnienia – patrz tabela 2.

rootstock on P content appeared in 2001 only; a significantly higher P concentration in leaves of trees on M.9 EMLA was noted (tab. 4).

Irrigation did not influence potassium mineral status (tab. 2). Leaf K content depended on fertilisation and rootstock (tab. 3 and 4). In every year of study, except for 2000, leaf K content of non-fertilised trees was in the range considered as deficient. This was confirmed by the incidence of deficiency symptoms on leaves. On the average, leaves of trees in this treatment contained 2.4 times less K than leaves of fertilised trees. Significantly more K was noted in leaves of trees in the K-400 and in the K-200herb. treatment, where K content was optimal. The highest K content, likewise in case of P, was found in the leaves of trees from the K-200 or K-800 treatment. The highest K content was noted in the leaves of trees grown on M.9 EMLA and significantly lower in leaves of trees on P 60 or on M.9 751.

Likewise in case of the other elements, irrigation did not influence the leaf Ca content (tab. 2). On the average for all years of study, a significantly higher Ca content was noted in leaves of non-fertilised trees or of trees fertilised with 200 kg $K_2O\cdot ha^{-1}$ doses, applied every year, in contrast to the other treatments (tab. 3). It was found that P 60 rootstock was significantly conducive to create higher leaf Ca content (tab. 4).

Table 4. Concentration of macroelements ($mg\cdot 100$ g $s.m.^{-1}$) in ‘Katja’ apple leaves, depending on rootstock; mean values for irrigation and different K fertilisation

Tabela 4. Zawartość makroelementów ($mg\cdot 100$ g $s.m.^{-1}$) w liściach jabłoni ‘Katja’ w zależności od podkładki; średni dla nawadniania i różnego nawożenia potasem

Element Składnik	Rootstock Podkładka	Year – Rok			Average of three years Średnio z trzech lat
		1999	2000	2001	
N	M.9 Emla	2.30 a[1]	1.88 a	2.41 a	2.20 a
	M.9 751	2.35 a	1.95 a	2.38 a	2.23 a
	M.9 984	2.33 a	1.90 a	2.37 a	2.20 a
	P 60	2.36 a	1.92 a	2.35 a	2.21 a
P	M.9 Emla	0.17 a	0.22 a	0.27 b	0.21 a
	M.9 751	0.16 a	0.20 a	0.23 a	0.20 a
	M.9 984	0.16 a	0.21 a	0.24 a	0.21 a
	P 60	0.17 a	0.19 a	0.25 ab	0.21 a
K	M.9 Emla	1.23 a	1.48 c	1.62 a	1.44 c
	M.9 751	1.25 a	1.29 a	1.50 a	1.35 a
	M.9 984	1.18 a	1.39 b	1.59 a	1.39 b
	P 60	1.21 a	1.26 a	1.63 a	1.37 a
Ca	M.9 Emla	1.54 b	1.08 a	1.45 a	1.36 a
	M.9 751	1.48 a	1.16 ab	1.49 a	1.38 a
	M.9 984	1.52 ab	1.08 a	1.35 a	1.32 a
	P 60	1.66 c	1.20 b	1.49 a	1.45 b
Mg	M.9 Emla	0.35 a	0.31 b	0.45 a	0.37 a
	M.9 751	0.34 a	0.32 b	0.47 a	0.38 a
	M.9 984	0.36 a	0.30 b	0.44 a	0.37 a
	P 60	0.34 a	0.29 a	0.43 a	0.35 a

[1] For explanation – see table 2 – Objaśnienia – patrz tabela 2.

Irrigation significantly decreased leaf Mg content (tab. 2). K fertilisation, irrespective of the dose and mode of application, decreased leaf Mg content (tab. 3). On the average for the period 1999–2001, leaves of trees in the fertilised treatments contained 1.6 times less Mg than leaves of non-fertilised trees. Nevertheless the leaf Mg content remained in the optimal or high range. The rootstock effect on leaf Mg content was noted only in 2000 when it was lower in leaves of trees on P 60 (tab. 4).

DISCUSSION

The results of this study do not confirm that irrigation influences mineral element content of apple leaves. The literature did not present any clear evidence in this respect either [Levin et al. 1979, Olszewski et al. 1995]. It seems that a more important role could play weather conditions during vegetation. The least favourable conditions for the nutrient uptake were noted in 2000. In this season the greatest deficit of rainfall in summer time occurred. This was accompanied with a decrease of nitrogen, calcium and magnesium content in the leaves in this year. Sadowski et al. [1982] and Jadczuk [1994] pointed out to the fluctuations of leaf mineral content due to seasonal conditions. In this study a tendency to a better N, K and Ca nutrition in irrigated trees was noted, while a decrease due to irrigation was noted in case of Mg.

Considering the results on the effect of potassium fertilisation on leaf mineral content, it must be taken into account that the experimental orchard was grown on the soil with a very strong ability of fixing potassium. Our results do not confirm the opinion of Bojič et al. [1996] that the increase of K fertiliser dose results in an increase of leaf N content. Basing on the average data for three years, it may be stated that K fertilisation, irrespective of the doses or mode of application, influences P and K content in a similar way. The most effective were annually used 200 kg $K_2O \cdot ha^{-1}$ or the doses of 800 kg $K_2O \cdot ha^{-1}$ applied once in four years. In these treatments, fertiliser was applied on the all the orchard floor. Increase of K content in apple leaves under the influence of fertilisation with this element was observed by Mercik [1977], Jadczuk and Sadowski [1986], Jadczuk [1994] and by Lipecki and Jadczuk [1998]. An opposite effect of K fertilisation was noted on Mg content. Leaf Mg concentration of non-fertilised trees was higher than that of the fertilised ones. It is understandable in view of the antagonism between K and Mg. The same relationship was reported from the research of Vang-Petersen [1980], Mengel and Kirkby [1987], Jadczuk [1997a], Lipecki and Jadczuk [1998]. Likewise as in the study of Pacholak et al. [1999], Ca content was more modified by environmental conditions than by fertilisation.

Many authors indicated to the important effects of rootstock on leaf mineral element content of apple trees [Tagliavini et al. 1992, Jadczuk and Bogdanowicz 1995, Jadczuk 1997b, Ben 1999, Kurlus and Ugolik 1999]. Analysing effect of rootstock on leaf nutrient content it was found that P 60 contributes to a better Ca nutrition. According to Leszczyński and Sadowski [1990] effect of rootstock is due to the genetically determined ability of absorption of a particular nutrient. The same tendency was noted with A2, which is the maternal form of P 60. Leaves of trees on M.9 EMLA contained more phosphorus and potassium. In this experiment the tendency was found to inducing a higher Mg content by use of M.9 clones as rootstocks. Tukey and Cline reported this already in 1962.

CONCLUSIONS

1. Irrigation had no significant effect on the leaf macroelement content, but the tendency was noted to an increase of K and decrease of Mg content in leaves of the non-irrigated trees.

2. Fertilisation, irrespective of the dose or mode of application, significantly influenced the potassium nutritional status. The highest K content was noted in the leaves of trees treated with 200 kg $K_2O{\cdot}ha^{-1}$ every year or with 800 kg $K_2O{\cdot}ha^{-1}$ once in four years. Leaves of fertilised trees showed also a tendency to an increased P content.

3. Potassium fertilisation decreased leaf Mg content.

4. No clear effect of K fertilisation on leaf Ca content was found.

5. Leaves of trees on M.9 EMLA contained more K and those of trees on P 60 more Ca. The N, P and Mg contents did not depend on rootstock.

REFERENCES

Ben J. M., 1999. Effect of rootstocks on mineral element concentration in ‘Gloster’ apples. Apple Rootstocks for Intensive Orchards, Proc. Intern. Seminar, Warsaw-Ursynów, 18-21 August 1999, 13-14.

Bojič M., Jankovič R., Miloševič T., 1996. Effect of different rates of potassium fertilization on the yield and dynamics of N, P, K, Ca, and Mg levels in the leaves of apple cv. Golden Delicious Zemljište i Biljka, 45 (1), 13-22.

Jadczuk E., 1994. Wpływ podkładki, odmiany i nawożenia potasem na poziom odżywienia, wzrost i owocowanie wiśni. Wyd. SGGW Warszawa. Rozprawy Naukowe i Monografie 193.

Jadczuk E., 1997a. Leaf K and Mg content of ‘Katja’ apple trees in relation to potassium fertilisation, rootstock and water supply. IXth. Inter. Coll. for the Optimization of Plant Nutrition, Praga, Czech Republic, 8–15 September 1996. In Developments in Plant and Soil Sciences, 340–343.

Jadczuk E., 1997b. Growth and cropping of ‘Jonagold’ apple trees depending on rootstock. Inter. Conf. Modern orchards Achievements and Tendencies (Babtai, Lithuania 9–11 September 1997), Coll. Sci. Articles, 42–47.

Jadczuk E., Bogdanowicz N., 1995. Ocena przydatności ośmiu podkładek dla odmiany Jonagold. Mat. Konf. „Nauka Praktyce Ogrodniczej” AR Lublin, 13–15 August 1995, 5–8.

Jadczuk E., Sadowski A., 1986. Potassium nutrition of sour cherries in relation to rootstock, season and K fertilisation. Hort. Sci. 21 (3), 668.

Kaczorowska B., 1962. Opady w Polsce w przekroju wieloletnim. Wyd. Geologiczne, Warszawa.

Kurlus R., Ugolik M., 1999. Wpływ podkładki na zawartość składników mineralnych w liściach jabłoni odmiany Šampion. Zesz. Nauk. AR w Krakowie 351, 205–213.

Leszczyński A., Sadowski A., 1990. Response of apple rootstocks and of apple maiden trees to different levels of potassium supply in sand culture. Acta Hort. 274, 277–286.

Levin I., Assaf R., Bravdo T., 1979. Irrigation water status and nutrient uptake in an apple orchard. [In:] Mineral Nutrition of Fruit Trees. D. Atkinson, J.E. Jackson, R.D. Sharples, W.M. Waller eds. Butterworths, London-Boston, 255–264.

Lipecki M., Jadczuk E., 1998. Wpływ dawek i sposobu nawożenia potasem na poziom odżywiania mineralnego jabłoni. Zesz. Nauk. AR w Krakowie 333, 499–501.

Mengel K., Kirkby E. A., 1987. Principles of Plant Nutrition. International Potash Institute, Bern..

Mercik S., 1977. Działanie wysokich dawek potasu na glebach silnie wyczerpanych z dostępnych form tego składnika. Rocz. Glebozn. 28 (2), 105–123.
Olszewski T., Mika A., Szczepański K., Piątkowski M., 1995. Influence of orchard cultural practices on the mineral composition of apple leaves and fruit. J. Fruit Ornamental Plant Res. 3 (4), 9–20.
Pacholak E., 1984. Wpływ nawożenia i nawadniania na zawartość składników pokarmowych w liściach drzew i w glebie sadu jabłoniowego. Prace Kom. Nauk Roln. Leśn. PTPN 57, 233–243.
Pacholak E., Rutkowski K., Przybyła Cz., 1999. Wpływ nawożenia i nawadniania na zawartość składników w glebie i liściach jabłoni odmiany Szampion w sadzie replantowanym. I Ogólnopol. Symp. Min. Odż. Rośl. Sad. Skierniewice, 1–2 grudnia 1998, 29–40.
Sadowski A., Jadczuk E., Ścibisz K., Dąbrowska W., 1982. Fertilization of sour cherries. Abstracts XXIst Internat. Hort. Congress 1982, I, 1266.
Tagliavini M., Scudellari D., Marangoni B., Bastianel A., Franzizi F., Zamborlini M., 1992. Leaf mineral composition of apple tree: sampling date and effects of cultivar and rootstock. J. Plant Nutr. 15 (5), 605–619.
Tukey H. B., Cline R. A., 1962. Relative influence of rootstocks, interstocks and scion upon the performance of apple trees. Proc. XVIth Intern. Hort. Congress (1), 251–254.
Westwood M.N., 1978. Mahaleb × Mazzard hybrid cherry stocks. Fruit Var. J. 32, 39.
Vang-Petersen O., 1973. Leaf dry matter contents in apple, pear, plum, cherry, black currant and red current in relation to nitrogen, potassium and magnesium supply. Tidsskrift for Planteavl 77 (3), 393–398.

STAN ODŻYWIENIA MINERALNEGO JABŁONI ODMIANY KATJA W ZALEŻNOŚCI OD NAWADNIANIA, NAWOŻENIA I PODKŁADKI

Streszczenie. Drzewa, z których w latach 1999–2001 pobierano liście do analiz, zostały posadzone wiosną 1992 r. na glebie typu mada, silnie wiążącej potas. Jabłonie zaokulizowane na M.9 Emla, M.9 751, M.9 984 i P 60 rosły na poletkach nawadnianych i nienawadnianych, na których od 1980 r. stosowano zróżnicowane nawożenie potasem. Nawadnianie nie wpłynęło istotnie na zawartość makroelementów w liściach, jednak wystąpiła tendencja do wyższej zawartości K, a jednocześnie niższej Mg w liściach drzew nawadnianych. Nawożenie, niezależnie od dawki i sposobu stosowania nawozu, istotnie wpłynęło na odżywienie drzew K. Największą zawartość K w liściach drzew stwierdzono przy zastosowaniu 200 kg $K_2O \cdot ha^{-1}$ corocznie lub 800 kg $K_2O \cdot ha^{-1}$, co cztery lata. Ponadto, liście drzew nawożonych w ten sposób potasem wykazywały tendencję do wyższej zawartości P. Istotnie najwyższą zawartość Mg wykazywały liście drzew nienawożonych, a najniższą, liście drzew nawożonych 800 kg $K_2O \cdot ha^{-1}$, co cztery lata. Nie wykazano jednoznacznej tendencji co do wpływu nawożenia K na zawartość Ca. Stwierdzono, że liście z drzew na P 60 zawierają więcej Ca, a mniej Mg, którego zawartość była wyższa w liściach drzew na podklonach M.9.

Słowa kluczowe: jabłoń, nawadnianie, nawożenie potasem, analiza liści, podkładka, składniki mineralne

Accepted for print – Zaakceptowano do druku: 9.12.2004