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EFFECT OF NITROGEN FERTILIZATION ON THE CONTENT OF MINERAL COMPONENTS IN SOIL, LEAVES AND FRUITS OF 'ŠAMPION' APPLE TREES

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Abstract. The experiment was carried out in the Experimental Orchard Przybroda of the Department of Pomology, Poznań Agricultural University in the years 2001–2003. Trees of 'Šampion' on M.9 rootstock were planted in the spring 1994 on virus-free rootstock EMLA 9 at spacing of 3.5 × 1 m (2 857 trees per ha) on grey-brown sandy loam podsolic soil. The experiment included the following 5 treatments of nitrogen fertilization: 1. N_0 – control; 2. N_5 – 5 g $N \cdot m^{-2}$, applied once in early spring; 3. N_{10} – 10 g $N \cdot m^{-2}$ applied once in early spring; 4. N_{5+5} – 5 g $N \cdot m^{-2}$ in spring + 5 g $N \cdot m^{-2}$ at the end of May; 5. N_{5herb} – 5 g $N \cdot m^{-2}$ in early spring, within the herbicide strip only. Nitrogen fertilization had a significant effect on changes in the assimilable elements in soil. It exerted an effect on the decrease of assimilable potassium in the arable and subarable layer and an increase of assimilable magnesium improving the K : Mg ratio. A smaller effect was found in the changes of assimilable phosphorus content and in soil reaction. Nitrogen fertilization had an effect on the increase of total nitrogen content in leaves and it decreased the content of phosphorus. The content of assimilable components in soil was not correlated with the content of general components in leaves. The content of mineral components in fruits was closely correlated with the component content in leaves. Climatic conditions, and particularly the absence of atmospheric precipitations and the increase of temperature, as well as the aging of trees contributed to the decrease of the content of nitrogen, phosphorus, potassium and magnesium and to the increase of calcium content.

Key words: nitrogen fertilization, mineral contents, soil, leaves, fruits

INTRODUCTION

Fruit trees and shrubs as perennial plants have rather modest fertilization requirements and many experiments confirmed this thesis [Greenham 1979, Sadowski 1995].

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It is believed that a dose of 50–60 kg N per ha is sufficient for correct growth and fruiting as well as for good quality fruits. In spite of the knowledge in the field of physiology about the role and importance of particular components in the functioning of on organism, it is frequently repeated that the proper agrotechniques (cultivation, irrigation, protection, thinning out) have a greater effect on yielding than fertilization alone.

It must be stressed that this statement is true, however, in the absence of components, even the best agrotechnique will not replace fertilization. Sadowski [1995] called attention to the fact that when we have soils with different reserves of accumulated elements, it is difficult to determine the correct diagnosis and the proper recommendations. In order to find the fertilization needs, it is necessary to estimate the content of mineral components in the soil and in the plant material and at the same time to observe in detail the growth and yielding of trees [Zydlik et al. 2001].

The objective of studies carried out in the years 2001–2003 was to find the effect of diversified nitrogen fertilization on the soil content of general assimilable components in leaves and fruits of Šampion cultivar in the period of full fruiting of trees.

The first after tree plantation were presented in the work of Zydlik et al. [2001].

MATERIALS AND METHODS

Experiments were carried out in the years 1994–2003 in the apple orchards of the Agricultural and Pomological Experimental Farm in Przybroda. Apple trees of Šampion cv. on rootstock M.9 EMLA were planted in the spring 1994 at spacing of 3.5 × 1.0 m (2857 trees per ha) on proper grey-brown podzolic soil created of light boulder clay.

In the experiment, 5 nitrogen fertilization combinations were applied, each in 4 replications:

N_0 – control without fertilization,

N_5 – 5 g N per m^2 once in spring,

N_{10} – 10 g N per m^2 once in spring,

N_{5+5} – 5 g N per m^2 in spring + 5 g N per m^2 at the end of May,

N_{5herb} – 5 g N per m^2 once in spring within herbicide belts.

Fertilization was carried out using 34% ammonium nitrate. The fertilizer was applied by top-dressing 2–3 weeks before tree blooming. The soil was cultivated by using herbicide fallow in tree rows (1.25 m) and turf in interrows (2.5 m). All remaining agrotechnical treatment: cutting, irrigation, protection, thinning out were performed according to the recommendations for apple orchards.

In 2001, in mid-July, soil samples were taken from 0–20 and 21–40 cm levels. The samples were taken in mid-distance between the studied trees 10–20 cm from the edge of herbicide fallow. The samples were dried at room temperature and then the content of mineral components P, K, Mg and the pH values were identified in the Pomological Department. The content of assimilable P and K was determined by Egner-Rieman method, and Mg was identified by Schachtchabel method [Breś et al. 1991].

Leaf samples were taken in the years 2001–2003 in mid-July four times, separately from each combination from four studied trees. According to the recommendations of Sadowski et al. [1990], leaves were collected from one-year old schoots and the samples were dried at 70°C and subsequently they were ground. Analyses of the content of N, P, K, Mg and Ca were carried out in the laboratory of the Pomological Department according to the method given by Ostrowska et al [1992].

The content of components in the soil and in leaves was compared with the presently valid boundary values for orchard soil and apple tree leaves elaborated by Sadowski et al. [1990].

Statistical calculations were performed in the Department of Pomology, Agricultural University in Poznań with the use of STAT program. The significance of dependences between the combinations was evaluated on the basis of Duncan's test at p = 0.05 significance level.

Characteristics of climatic conditions in the years 1999–2003

The meteorological data presented in table 1 indicated that weather conditions in the experimental years differed significantly.

Table 1. Mean temperatures and precipitation sums in 1994–2003. Meteorological Station of the Experimental station Przybroda

Tabela 1. Charakterystyka średnich temperatur i sum opadów atmosferycznych w latach 1994–2003, Stacja meteorologiczna RSGD Przyroda

Years Lata	Mean annual temperature Średnia temperatura roczna	Mean temperature in growing period IV–IX Średnia temperatura w okresie wegetacji IV–IX	Sum of temperatures in growing period Suma temperatur w okresie wegetacji IV–IX	Annual precipitation Suma rocznych opadów	Sum of rainfalls in growing period IV–IX Suma opadów w okresie wegetacji IV–IX
	°C			mm	
Mean of Średnie z 1956–1992	8.1	14.2	2627.0	529.1	326.6
1994	9.9	16.4	3001.2	540.9	314.5
1995	9.3	16.1	2946.3	478.4	298.2
1996	7.6	15.0	2745.0	566.4	463.5
1997	9.2	15.7	2873.1	484.3	329.1
1998	10.0	16.9	3092.7	579.9	337.6
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
2003	9.3	17.0	3117.9	330.7	183.7
Mean of Średnie z 1994–2003	9.5	16.3	2990.3	499.8	303.2

It must be noted that during the last 10 years, the mean temperature of the vegetation period increased by 1.1°C in comparison to the mean value of many years. It has to be stressed that in the vegetation period in all years, the temperatures were higher than the mean temperature of many years. On the other hand, the distribution of atmospheric precipitations showed high oscillations in the vegetation period: from 183.7 mm in 2003 to 103 mm in 1996. According to the accepted standards, in the discussed period, there occurred 5 dry years (1995, 1999, 2000, 2002, 2003), 4 moderate years (1994, 1997, 1998, 2001) and one moist year (1996). The experimental years were dry and the year 2003 could be regarded as an unusually dry one when the precipitation sum in the vegetation period was 183.7 mm (tab. 1). Such a dry year was recorded earlier in 1982, i.e. more than 20 years ago [Pacholak 1986].

This situation indicated that in natural conditions, irrigation is a necessary treatment in order to supplement and insure proper soil moisture.

RESULTS AND DISCUSSION

Nitrogen fertilization in the 8-year period of orchard management, depending on the dose size, the technique or date, had an effect on the content of assimilable components in the arable and subarable layer of soil.

In the arable layer, nitrogen fertilization contributed to the decrease of assimilable phosphorus in four combinations except for the combination where 5 g N per m^2 was applied to herbicide belt and where P increase by 0.2 mg per 100 g soil was recorded (tab. 2). The greatest decrease by 0.3 mg per 100 g soil of assimilable phosphorus was found in the combination with 5 + 5 g N per m^2. On the other hand, in the subarable layer, only small changes of assimilable phosphorus were found in relation to the initial analysis except for the combination with a dose of 5 g N per m^2 applied to the herbicide belt. In that combination, P increase by 2.8 mg per 100 g soil was found (tab. 2).

The content of phosphorus in the arable layer in comparison to boundary values was in the high availability class in the combinations with dose of 5 g N per m^2 to herbicide belts, while in the remaining combinations, it was in the medium class of availability. In the subarable layer, in all combinations, the content of phosphorus was within the high availability class.

Nitrogen fertilization in the absence of potassium fertilization in the period of 9 years decreased the content of assimilable potassium in both layers (tab. 2). The greatest drop in the assimilable potassium content in the arable layer was 3.6 mg per 100 g soil in the combination with nitrogen dose of 5 + 5 g N per m^2. On the other hand, in the subarable layer, in the combination with nitrogen dose of 5 g N per m^2, the K content decreased by 3.8 mg per 100 g soil (tab. 2). The content of assimilable potassium in comparison with the valid boundary values [Sadowski et al. 1990] showed the optimal content of this element in both analysed soil layers. In 2001, after 8 years of orchard management, in all combinations, a decrease in the assimilable potassium was found in both the arable and subarable layers. In comparison to the boundary values, the K content was in the class of low potassium availability.

The content of magnesium, independent of fertilization in the arable and subarable layer, in comparison to the initial analyses, showed an increase (tab. 2). The highest increase of magnesium content in the arable layer (by 4.0 mg per 100 g soil) was found after a single application of nitrogen in the dose of 5 g N per m^2. In the subarable layer, the content of assimilable magnesium increased by 3.6 mg per 100 g soil in the combination with 5 g N per m^2 fertilization in herbicide belts. In comparison with boundary values, the content of assimilable magnesium in the arable and subarable layers was in the medium class of availability.

In comparison to the initial analysis, the K : Mg ratio in all combinations was correct and it decreased in both soil layers (tab. 2).

Diversified nitrogen fertilization had an influence on the change of soil pH which was low within 4.1–4.9 in all combinations (tab. 2). In the combination in which a single nitrogen dose of 5 g N per m^2 in the arable layer was applied, and in the combination where 5 g N per m^2 to herbicide belt in subarable layer was used, there occurred an insignificant increase of pH by 0.1 mg per 100 g soil in relation to the initial analysis. The greatest decrease of soil pH in both layers was found in the combination where the highest nitrogen fertilization of 10 g N per m^2 was applied; there, in the arable layer, the pH decreased by 0.6 mg per 100 g soil, and in the subarable layer, the pH decrease was by 0.5 mg per 100 g of soil.

Table 2. Changes by fertilization, in comparison with an initial analysis in 1994
Tabela 2. Zmiany zawartości składników mineralnych w glebie pod wpływem dziesięcioletniego stosowania zróżnicowanego nawożenia azotowego w porównaniu do analizy wyjściowej z 1994 roku

Component Składnik	Soil layer Warstwa gleby cm	Initial analysis Analiza wyjściowa 1994 mg·100 g^{-1} soil	Treatment – Kombinacje									
			N_0		N_5		N_{10}		N_{5+5}		N_{5herb}	
			2001	change zmiana	2001	change zmiana	2001	change zmiana	2001	change zmiana	2001	change zmiana
			mg·100 g^{-1} soil – mg·100 g^{-1} gleby									
P	0-20	4.4	3.9	-0.5	3.9	-0.5	3.7	-0.7	3.1	-1.3	4.6	+0.2
	21-40	3.3	3.5	+0.2	3.5	+0.2	3.3	0.0	3.1	-0.2	6.1	+2.8
K	0-20	8.6	6.6	-2.0	5.2	-3.4	5.9	-2.7	5.0	-3.6	6.3	-2.3
	21-40	7.1	5.2	-1.9	3.3	-3.8	3.6	-3.5	4.9	-2.2	4.6	-2.5
Mg	0-20	3.7	6.2	+2.5	7.7	+4.0	5.2	+1.5	5.6	+1.9	5.8	+2.1
	21-40	3.4	5.0	+1.6	5.8	+2.4	5.4	+2.0	5.9	+2.5	7.0	+3.6
K/Mg	0-20	2.3	1.1	-1.2	0.7	-1.6	1.1	-1.2	0.9	-1.4	1.1	-1.2
	21-40	2.1	1.0	-1.1	0.6	-1.5	0.7	-1.4	0.8	-1.3	0.7	-1.4
pH	0-20	4.7	4.6	-0.1	4.8	+0.1	4.1	-0.6	4.5	-0.2	4.5	-0.2
	21-40	4.8	4.4	-0.4	4.4	-0.4	4.3	-0.5	4.7	-0.1	4.9	+0.1

Nitrogen fertilization had an influence on the content of this element in the leaves of apple trees Šampion cv. and its level increased independently of the dose and time of application when compared with trees without fertilization. In comparison with boundary values, nitrogen content in leaves in the years 2001–2003 was in the class of optimal content for control combination and for the combinations with nitrogen doses of 5 g N per m^2, 5+5 g N per m^2 and 5 g N per m^2 to herbicide belts applied once in spring, as well as in the class of high N content with greatest nitrogen doses of 10 g N per m^2. Noteworthy is the fact that in the particular years, the content of nitrogen decreased with the ageing of trees (tab. 3). The increase of nitrogen content in leaves under the influence of nitrogen fertilization in the years 2001–2003 was similar as in the years 1995–2000 [Zydlik et al. 2001].

Phosphorus content in the leaves in comparison with control combination decreased after nitrogen fertilization (tab. 3). This dependence was visible particularly during the last three years in comparison to the previous experimental years. When compared with boundary values, the content of this element in leaves was at the optimal level. Similarly as in the case of nitrogen content, also in the case of phosphorus content in leaves, the concentration on of this element decreased with the ageing of trees (tab. 3).

Table 3. Concentration of nutrients in leaves in the years 1995–2003
Tabela 3. Zawartość składników mineralnych w liściach w latach 1995–2003

Treatment Kombinacja	Component Składnik	Concentration of nutrients in level, % d.m. Zawartość składników w liściach, % s.m mean values for years średnia z lat 1995-2000	2001	2002	2003	Mean for fertilization Średnia dla nawożenia 2001-2003
N_0	N	2.30 a*	2.56 a	2.19 a	1.79 a	2.18 a
N_5		2.56 b	2.48 a	2.37 ab	2.11 b	2.32 b
N_{10}		2.69 b	2.49 a	2.45 b	2.24 b	2.39 b
N_{5+5}		2.58 b	2.56 a	2.44 b	2.22 b	2.41 b
$N_{5herb.}$		2.61 b	2.46 a	2.38 ab	2.26 b	2.37 b
Mean values for years Średnia dla lat			2.51 c	2.36 b	2.12 a	
N_0	P	0.24 a	0.21 a	0.22 b	0.14 a	0.19 b
N_5		0.19 a	0.20 a	0.18 a	0.13 a	0.17 a
N_{10}		0.17 a	0.19 a	0.17 a	0.13 a	0.16 a
N_{5+5}		0.18 a	0.20 a	0.17 a	0.13 a	0.17 a
$N_{5herb.}$		0.18 a	0.18 a	0.17 a	0.13 a	0.16 a
Mean values for years Średnia dla lat			0.20 c	0.18 b	0.13 a	
N_0	K	1.19 b	2.00 a	2.28 a	1.08 a	1.79 b
N_5		1.71 a	2.22 a	2.20 a	0.99 a	1.80 b
N_{10}		1.71 a	2.05 a	2.08 a	0.90 a	1.68 b
N_{5+5}		1.69 a	2.10 a	2.03 a	1.02 a	1.72 b
$N_{5herb.}$		1.59 a	2.02 a	1.17 a	0.91 a	1.37 a
Mean values for years Średnia dla lat			2.1 c	1.8 b	1.0 a	
N_0	Mg	0.17 a	0.38 b	0.19 a	0.24 a	0.27 a
N_5		0.19 a	0.34 ab	0.21 a	0.27 a	0.27 a
N_{10}		0.20 a	0.36 b	0.21 a	0.28 ab	0.28 a
N_{5+5}		0.19 a	0.38 b	0.23 a	0.32 b	0.31 b
$N_{5herb.}$		0.20 a	0.33 a	0.23 a	0.30 b	0.29 a
Mean values for years Średnia dla lat			0.36 c	0.21 a	0.28 b	
N_0	Ca	1.24 a	0.96 b	1.26 a	1.23 a	1.15 a
N_5		1.21 a	0.71 a	1.53 a	1.43 ab	1.22 a
N_{10}		1.19 a	0.69 a	1.49 a	1.35 ab	1.18 a
N_{5+5}		1.19 a	0.70 a	1.50 a	1.48 b	1.23 a
$N_{5herb.}$		1.19 a	0.90 ab	1.52 a	1.33 ab	1.25 a
Mean values for years Średnia dla lat			0.79 a	1.46 c	1.36 b	

*Significant at the level α = 0.05 - Istotność różnic na poziomie α = 0,05

When we analyse the potassium content in leaves, we find that the lowest concentration of this component was found in the combination where fertilization was applied to herbicide belts. In comparison to boundary values, the content of potassium in laves was on a high level except for the combination with the fertilization dose of 5 g N per m^2 to herbicide belts where the content of this element was at the optimal level. With the aging of trees, the content of potassium in leaves decreased (tab. 3).

The content of magnesium in leaves showed a tendency to increase under the effect of nitrogen fertilization. The greatest increase by 0.01% d.m. in comparison to control combination was recorded when nitrogen fertilization was applied twice in the dose of 5+5 g N per m^2. In comparison with boundary values, the content of magnesium ranged at the optimal level. In particular years, magnesium content in leaves was differentiated, the highest Mg content was in 2001 showing 0.36% d.m., and the lowest one was in 2002 – 0.21% d.m. (tab. 3).

The analysis of calcium in leaves showed that nitrogen fertilization did not have any essential effect on the change in Ca content. However, in the particular years, the concentration of this element, independent of the dose and time of application was significantly different ranging from 0.79% d.m. in 2001 to 1.46% d.m. in 2002 (tab. 3).

The variable effect of fertilization on the content of mineral components in leaves was explained by Zydlik, Pacholak [1997] who argued that the concentration of the particular nutritive components in leaves depends on the cultivar, on the yielding level and on weather conditions. The effect of climatic conditions on the content of mineral components in leaves was also stressed by Pacholak and Zydlik [2003].

Nitrogen fertilizations also had an effect on the content of particular components in fruits (tab. 4).

Nitrogen content in fruits increased under the influence of nitrogen fertilization independent of the dose and time of application (tab. 4). The concentration of this component in particular years was very diversified. The greatest concentration in fruits was found in 2003 showing 0.33% d.m. An analysis of the mean value from the years 2001–2003 indicated that nitrogen fertilization increases the content of this element in fruits in comparison to control combination.

The content of phosphorus in fruits depended on nitrogen fertilization (tab. 4). In the control combination, the highest content of this element was found in fruits and it amounted to 0.061% d.m. On the other hand, in the combinations where the dose of 5 g N per m^2 was used the P concentrations was also significantly higher than in the remaining fertilization combinations and amounted to 0,059% d.m. The concentration of this component decreased with the aging of trees from 0.060% d.m. in 2001 to 0.042% d.m. in 2003.

The analysis of potassium content in fruits indicated that the highest concentration was in the combination where a single dose 5 g N per m^2 was applied in spring (tab. 1). The same dependence was shown also in the earlier studies carried out by Zydlik at al. [2001].

The content of magnesium in fruits did not depend on the combinations of nitrogen fertilization (tab. 1). Also in the particular years of the experiment, the mean content of this element did not differ statistically.

The content of calcium in fruits was less dependent on nitrogen fertilization (tab. 4). However, it must be stressed that in spite of the absence of essential differences, the highest concentration of this component was in the control combination. Similar results were earlier obtained by Zydlik and Pacholak [1997].

An analysis of linear correlation between the climatic factors showed that they have the greatest effect an the nitrogen content in leaves and there is no correlation with magnesium content in leaves (tab. 5).

Table 4. Concentration of nutrients in fruits in the years 1995-2003
Tabela 4. Zawartość składników mineralnych w owocach w latach 1995-2003

Treatment Kombinacja	Component Składnik	Concentration of nutrients in fruits in mg kg^{-1} s.m. Zawartość składników w owocach w mg kg^{-1} s.m.				
		mean values for years średnia z lat 1995-2000	2001	2002	2003	Mean for fertilization Średnia dla nawożenia 2001-2003
N_0	N	220 ab	160 a	280 a	180 a	210 a
N_5		230 b	260 c	300 ab	230 b	260 b
N_{10}		190 a	240 c	310 b	230 b	260 b
N_{5+5}		200 ab	220 b	330 c	240 b	260 b
$N_{5herb.}$		210 ab	160 a	410 d	210 b	260 b
Mean values for years Średnia dla lat			210a	330 c	220 b	
N_0	P	400 a	620 ab	670 c	550 c	640 b
N_5		540 b	670 b	570 b	470 bc	590 b
N_{10}		390 a	540 a	410 a	410 b	470 a
N_{5+5}		410 a	530 a	520 ab	370 ab	470 a
$N_{5herb.}$		380 a	640 b	600 bc	310 a	510 a
Mean values for years Średnia dla lat			600 c	560 b	420 a	
N_0	K	670 a	840 bc	620 a	630 a	700 ab
N_5		770 c	890 c	660 a	580 a	710 b
N_{10}		750 bc	790 ab	630 a	600 a	670 a
N_{5+5}		690 ab	810 ab	620 a	610 a	680 a
$N_{5herb.}$		710 a-c	780 a	670 a	620 a	690 ab
Mean values for years Średnia dla lat			820 c	640 b	610 a	
N_0	Mg	300 a	280 a	250 a	250 a	270 a
N_5		320 a	280 a	250 a	240 a	250 a
N_{10}		310 a	280 a	250 a	260 a	260 a
N_{5+5}		300 a	270 a	240 a	240 a	250 a
$N_{5herb.}$		300 a	280 a	250 a	250 a	260 a
Mean values for years Średnia dla lat			280 a	350 a	250 a	
N_0	Ca	250 a	430 a	290 a	310 a	340 a
N_5		270 a	420 a	490 a	290 a	400 a
N_{10}		240 a	430 a	490 a	380 a	430 a
N_{5+5}		290 a	390 a	460 a	310 a	390 a
$N_{5herb.}$		350 a	410 a	450 a	250 a	500 a
Mean values for years Średnia dla lat			410 a	430 a	310 a	

*Significant at the level α = 0.05 – Istotność różnic na poziomie α = 0,05

Table 5. Linear correlation coefficients between climatic factors, concentration of nutrients in the soil, leaves, fruits and the total concentration of nutrients in the leaves
Tabela 5. Współczynnik korelacji liniowej miedzy czynnikami klimatycznymi zawartością składników w glebie oraz owocach a zawartością składników w liściach

	Factors Czynniki	Concentration of components in leaves Zawartość składników w liściach				
		N	P	K	Mg	Ca
1.	Mean temperature in year Średnia temperatura roku	-	-	-	-	+0.74**
2.	Mean temperature in growing period Średnia temperatura okresu wegetacji	-0.60**	-0.58**	-	-	-
3.	Sum of rainfall in year Suma opadów roczna	+0.70**	-	-	-	-
4.	Sum of rainfall in growing period Suma opadów okresu wegetacji	+0.76**	-	+0.73**	-	-
5.	Concentration of nutrients in soil Zawartość składników w glebie					
	P 0–20 cm	-	-	-	-	-
	P 21–40 cm	-	-	-	-	-
	K 0–20 cm	-	-	-	-	-
	K 21–40 cm	-	-	-	-	-
	Mg 0–20 cm	-	-	-	-	-
	Mg 21–40 cm	-	-	-	-	-
6.	Concentration of nutrients in leaves Zawartość składników w liściach					
	N	-	+0.61**	+0.70**	-	-
	P	-	-	-	-	-
	K	-	-	-	-	-
	Mg	-	-	-	-	-
	Ca	-	-0.58**	-	-0.78**	-
7.	Concentration of nutrients in fruits Zawartość składników w owocach					
	N	-	-	-	+0.61**	+0.52*
	P	-	+0.71**	+0.65**	-	-
	K	+0.66**	+0.69**	+0.57**	+0.73**	-
	Mg	-	+0.72**	-	-	-0.74**
	Ca	-	-	-	-	-

*Correlation significant at the level of $\alpha = 0.05$ – Istotna korelacja przy poziomie $\alpha = 0,05$
** Correlation significant at the level of $\alpha = 0.01$ – Istotna korelacja przy poziomie $\alpha = 0,01$

It is surprising, but at the same time it confirms the view that there is no correlation between the content of assimilable elements in the soil and the general components in leaves (tab. 5).

The content of total nitrogen in leaves was positively correlated with the content of phosphorus and potassium, while the content of calcium in leaves was negatively correlated with phosphorus and magnesium (tab. 5). The content of components in fruits showed a significant positive correlation with the content in leaves with the exception of a negative correlation of Mg in fruits with Ca in leaves. Worthy of attention is the fact of no correlation between Ca content in fruits and the content of components in leaves (tab. 5).

CONCLUSION

1. Nitrogen fertilization had a significant effect on changes in the assimilable elements in soil. It exerted an effect on the decrease of assimilable potassium in the arable and subarable layer and an increase of assimilable magnesium improving the K : Mg ratio. A smaller effect was found in the changes of assimilable phosphorus content and in soil reaction.
2. Nitrogen fertilization had an effect on the increase of total nitrogen content in leaves and it decreased the content of phosphorus.
3. The content of assimilable components in soil was not correlated with the content of general components in leaves.
4. The content of mineral components in fruits was closely correlated with the component content in leaves.
5. Climatic conditions, and particularly the absence of atmospheric precipitations and the increase of temperature, as well as the aging of trees contributed to the decrease of the content of nitrogen, phosphorus, potassium and magnesium and to the increase of calcium content.

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WPŁYW NAWOŻENIA AZOTEM NA ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH W GLEBIE, LIŚCIACH I OWOCACH JABŁONI ODMIANY ŠAMPION

Streszczenie. Celem przeprowadzonych w latach 2001-2003 badań było poznanie wpływu zróżnicowanego nawożenia azotem na zawartość składników przyswajalnych w glebie, ogólnych w liściach i owocach odmiany Šampion w okresie pełnego owocowania drzew. Badania przeprowadzono w latach 1994–2003 w sadzie jabłoniowym Rolniczo-Sadowniczego Gospodarstwa Doświadczalnego w Przybrodzie. Drzewa odmiany Šampion na podkładce M.9 EMLA zostały wysadzone wiosną 1994 r., w rozstawie 3,5 × 1,0 m (2857 drzew z ha) na glebie płowej właściwej wytworzonej z gliny lekkiej zwałowej. W doświadczeniu zastosowano 5 kombinacji nawożenia azotem, każda w 4 powtórzeniach: 1. N_0 – kontrola bez nawożenia, 2. N_5 – 5 g $N{\cdot}m^{-2}$ jednorazowo wiosną, 3. N_{10} – 10 g $N{\cdot}m^{-2}$ jednorazowo wiosną, 4. N_{5+5} – 5 g $N{\cdot}m^{-2}$ wiosną + 5 g $N{\cdot}m^{-2}$ w końcu maja, 5. $N_{5herb.}$ – 5 g $N{\cdot}m^{-2}$ jednorazowo wiosną w obrębie pasów herbicydowych. Otrzymane wyniki pozwalają stwierdzić, że nawożenie azotem miało istotny wpływ na zmiany zawartości przyswajalnych składników w glebie. Wpływało na obniżenie przyswajalnego potasu w warstwie ornej i podornej oraz wzrost przyswajalnego magnezu, co poprawiło stosunek K/Mg. Mniejszy wpływ nawożenia azotem stwierdzono na zmiany zawartości przyswajalnego fosforu i odczynu gleby. Nawożenie azotem wpływało na wzrost zawartości azotu ogólnego w liściach, a obniżało zawartości fosforu, na pozostałe analizowane składniki nie stwierdzono istotnego wpływu. Na uwagę zasługuje fakt, że zawartość składników przyswajalnych w glebie nie była skorelowana z zawartością składników ogólnych w liściach. Natomiast zawartość składników mineralnych w owocach była ściśle skorelowana z zawartością składników w liściach. Warunki klimatyczne, a w szczególności brak opadów atmosferycznych i wzrost temperatury w latach 2001–2003, a także starzenie się drzew wpływały na obniżenie zawartości azotu, fosforu, potasu w liściach a wzrost w porównaniu do lat 1995–2000 magnezu.

Słowa kluczowe: nawożenie azotowe, zawartość składników, gleba, liście, owoce

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