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# EFFECT OF CHERRY NITROGEN FERTILIZATION ON THE CONTENT OF MINERALS IN THE LEAVES AND SOIL

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**Abstract**. The objective of studies carried out in years 2002–2009 was to determine the effect of nitrogen fertilization on the content of mineral components in the leaves of cherry trees and on the changes in assimilable components in the arable and subarable soil layers. Cherry orchards were established in spring 1999, 2001 and 2002 with the application of 'Łutówka' cultivar, type IR2. In the orchards planted in 2001 and 2002, trees were spaced in 4 × 1.3 m density (1920 trees · $ha^{-1}$). In the orchard planted in 1999, the tree density was 4 × 2 m (1250 trees · $ha^{-1}$). Orchards were planted on the same field, on grey-brown podzolic soil created on boulder clay sandy loam. In spring 2002, in each of the planted orchards, nitrogen fertilization was applied in the doses of 0, 50 and 120 kg · $ha^{-1}$. Our studies have shown that the fertilization with the differentiated nitrogen doses carried out for many years exerted an effect on changes in the soil chemical properties, in comparison with the initial soil status in the year 2002. Contents of assimilable phosphorus and potassium, both in the arable and the subarable magnesium decreased in a lesser degree, while in the orchard planted in 2002, magnesium showed even an increase. However, it must be stressed that in spite of the lapse of time, the soil contents of phosphorus and magnesium, in comparison with the critical values, were on a high level, while potassium showed an optimal or high level, with pH value from 5.7 to 6.6. General analysis revealed that nitrogen fertilization, as well as the age trees exerted an influence on the content of components indicating that N fertilization exerted an increasing effect on nitrogen and magnesium contents, but it decreased the contents of potassium and calcium.

**Key words**: cherry, fertilization, mineral components, soil, leaves

## INTRODUCTION

Development of fruit trees is in a high degree conditioned by the degree of soil fertility which depends on the cooperation of biological, chemical and physical soil proper-

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ties. In case of long-term cultivation, there develops a rhizosphere, an area of an intensive biological activity and symbiotic dependences between roots and microorganisms which settle there. These processes exert a significant effect in the mineral nutrition of trees and they increase the chemical and spatial accessibility. Mineral nutrition of plants is indissolubly bound with external factors, such as atmospheric conditions, temperature, rainfalls and insolation which decide about the availability of mineral components exerting an effect on the course of microbiological and chemical processes taking place in the substrate.

Microelements necessary to plants for correct development primarily include nitrogen, phosphorus, potassium, calcium, magnesium and sulphur. Plants utilize primarily the resources of these elements which already are in the soil, The content of these resources is different, depending on the soil type. Different are also the processes connected with the release of the particular components [Sadowski 1995, Sas-Paszt and Głuszak 2007].

In case of the utilization of compost recirculation, only nitrogen, being a very mobile element in the soil and necessary in plant development, requires a constant supplementation [Kozłowska 2007, Stark 2008].

Determination of fertilizer needs is not a simple and easy problem, but in case when nitrogen fertilization is recommended, a visual estimation is regarded as the basic procedure, but the correct diagnosis is easier when we have a broader information [Pacholak and Komosa 1993].

The objective of the presented paper was the determination of the effect of nitrogen fertilization on the content of mineral components in cherry tree leaves and in the soil of a cherry tree orchard.

## MATERIAL AND METHODS

Studies were carried out in the years 2002–2009 in the Pomology Department of the University of Life Sciences in Poznań, on the area of the Agricultural and Pomology Experimental Farm in Przybroda.

The experimental orchards were established in spring, in the years 1999, 2001 and 2002 on a grey-brown podzolic soil created of boulder clay sandy loam, the arable layer consists of mechanical medium sand, while the sub-arable layer consists of light medium sand. At the depth of 150–160 cm, there lies a strongly sandified light clay. The level of ground waters is maintained at the depth of 180 cm.

The orchards were established by plantation of one-year old budded plants of ‘Łutówka’ cultivar, type IR2 on mahaleb cherry rootstock. In the orchard established in 1999, the applied tree density was 4 × 2 m (1250 trees $\cdot$ $ha^{-1}$), while in the orchards established in the years 2001 and 2002 the plant density was 4 × 1.3 m (1920 trees $\cdot$ $ha^{-1}$).

From spring 2002, in each orchard, nitrogen fertilization was applied in the following combinations:

1. control – without fertilization,
2. dose of 60 kg N $\cdot$ $ha^{-1}$,
3. dose of 120 kg N $\cdot$ $ha^{-1}$.

Each combination was done in four replications, of 5 trees in each combination and between the combinations, isolation belts were applied with successive two trees.

Fertilization was carried out with a 34% ammonium nitrate in spring, between the 15th and the 20th of April.

Soil preparation under each orchard was carried out very carefully with the consideration of a 2-year period in which green limed fertilizers were applied (20 g · $m^{-2}$) and before ploughing, each orchard received 250 kg · $ha^{-1}$ of 46% superphosphate, of 57% potassium chloride and 60 t · $ha^{-1}$ of manure.

Agrotechnical treatments included soil cultivation with a black herbicide fallow and plant protection was carried out according to the recommendations for this type of culture. Crown of trees was in spindle form with the application of shoot bending. From the time of fruiting sanitary renewing shoot pruning was applied by removing 3–4 years old shoots. In the years 2002–2009, each year, at the turn of July and the beginning of August, leaf and soil samples from the arable layer (at 0–20 cm) and from the sub-arable layer (20–40 cm) were taken for analyses.

Leaves were analysed for the content of N, P, K, Mg, Ca and soils were analysed for the content of assimilable components P, K, Mg content and the pH and they were analysed in the laboratory of the Pomology Department, according to the accepted and approved research methods.

Contents of components in the soil and in leaves were compared with the actually valid critical values [Sadowski et al. 1990].

Furthermore, the results were statistically analysed by the analysis of variance for multi-factorial experiments. The significances between the mean values were estimated using Duncan's test for confidence interval $\alpha = 0.05$.

## RESULTS AND DISCUSSION

Effect of the long-term fertilization on the growth and yield of trees has been described in other paper. Here, we present changes in nitrogen abundance in soil and in the chemical composition of leaves.

Before the establishment of the experiment, the content of assimilable components in the soil, in both soil layers was on a high level with pH ranging from 6.1 to 6.5 and with a correct K: Mg proportion (tab. 1)

Ammonium nitrate fertilization carried out for many years caused a decrease of assimilable phosphorus and potassium content in both soil layers and in all orchards (tab. 2). Furthermore, fertilization with nitrogen decreased the magnesium content, although these changes were not so great as the decreased levels of potassium and phosphorus (tab. 2). Changes in potassium and magnesium contents did not exert any significant effect on their proportion which was on a correct level in both analysed soil layers in all orchards (tab. 2).

Nitrogen applied for many years in the form of ammonium nitrate did not cause any significant acidification of soil (tab. 2).

This fact indicates that studies carried out by Haynes [1980], Komosa [1990], Komosa and Pacholak [1995], Pacholak and Komosa [1995] referring to a significant ef-

Table 1. P, K, Mg contents and soil pH before starting the experiments (2002 year)
Tabela 1. Zawartość P, K, Mg oraz pH gleby przed założeniem doświadczenia (2002 rok)

| Orchard<br>Sad | Year of plantation<br>Rok założenia | Depth<br>Głębokość | mg · 100 $g^{-1}$ of soil<br>mg 100 $g^{-1}$ gleby | | | K : Mg | pH in KCl<br>pH w KCl |
|---|---|---|---|---|---|---|---|
| | | | P | K | Mg | | |
| 1. | 1999 | 0–20 | 10.1 a* | 8.9 a | 11.2 a | 0.8 a | 6.4 a |
| | | 21–40 | 11.3 a | 9.0 a | 9.8 a | 0.9 a | 6.5 a |
| 2. | 2001 | 0–20 | 11.4 a | 17.4 b | 12.0 a | 1.5 b | 6.1 a |
| | | 21–40 | 11.9 a | 15.2 b | 10.7 a | 1.4 b | 6.3 a |
| 3. | 2002 | 0–20 | 13.1 b | 17.6 b | 12.2 a | 1.4 b | 6.1 a |
| | | 21–40 | 13.5 b | 16.8 b | 11.0 a | 1.5 b | 6.5 a |

* Means marked with the same letters do not differ significantly at the probability level of α = 0.05; Analysis of variance was carried out separately for each variable
* Średnie oznaczone tymi samymi literami nie różnią się istotnie między sobą na poziomie prawdopodobieństwa α = 0,05; Analizy wariancji wykonano oddzielnie dla każdej z cech

Table 2. The influence of nitrogen fertilization on the content of P, K, Mg nutrients and on pH in 2005–2009
Tabela 2. Wpływ nawożenia azotowego na zawartość P, K, Mg oraz pH (średnie z lat 2005–2009)

| Orchard<br>Sad | Rok założenia<br>Year of plantation | Nitrogen dose<br>Dawki azotu<br>kg · $ha^{-1}$ | mg · 100 $g^{-1}$ soil – gleby | | | | | | K : Mg | | pH in KCl<br>pH w KCl | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | P | | K | | Mg | | | | | |
| | | | depth – głębokość | | | | | | | | | |
| | | | 0–20 | 21–40 | 0–20 | 21–40 | 0–20 | 21–40 | 0–20 | 21–40 | 0–20 | 21–40 |
| 1. | 1999 | 0 | 7.2 b | 6.8 ab | 7.1 a | 4.8 a | 11.8 b | 9.0 b | 0.6 a | 0.5 a | 6.1 a | 6.1 a |
| | | 60 | 9.3 d | 7.7 b | 8.3 b | 6.1 b | 11.6 b | 7.7 a | 0.7 a | 0.8 bc | 6.6 c | 6.7 d |
| | | 120 | 8.3 cd | 7.5 b | 10.5 d | 7.4 c | 10.9 b | 7.7 a | 1.0 b | 1.0 d | 6.1 ab | 6.6 d |
| Mean – Średnio | | | 8.3 b | 7.3 c | 8.6 a | 6.1 a | 11.4 b | 8.1 a | 0.8 a | 0.8 a | 6.3 a | 6.5 a |
| 2. | 2001 | 0 | 6.4 a | 5.9 a | 8.0 b | 8.1 dc | 10.4 ab | 9.3 b | 0.8 a | 0.9 cd | 6.0 ab | 5.9 a |
| | | 60 | 7.7 b | 7.3 b | 8.8 bc | 7.8 c | 9.5 a | 8.2 a | 0.9 ab | 0.9 cd | 6.1 a | 6.4 b |
| | | 120 | 7.6 bc | 7.8 b | 9.3 cd | 9.0 d | 9.5 a | 8.4 a | 1.0 b | 1.1 d | 5.7 a | 6.1 a |
| Mean – Średnio | | | 7.2 a | 7.0 a | 8.7 a | 8.3 b | 9.8 a | 8.6 a | 0.9 a | 1.0 b | 5.9 a | 6.1 a |
| 3. | 2002 | 0 | 11.1 a | 9.4 c | 11.7 e | 9.8 de | 14.0 c | 12.3 c | 0.8 a | 0.8 bc | 6.4 b | 6.2 bc |
| | | 60 | 9.1 d | 6.1 a | 10.3 d | 8.8 c | 14.4 c | 11.7 c | 0.7 a | 0.8 bc | 6.2 ab | 6.0 a |
| | | 120 | 12.5 f | 10.8 d | 13.0 f | 10.7 d | 13.4 c | 11.4 c | 1.0 b | 0.9 c | 6.0 a | 6.4 b |
| Mean – Średnio | | | 10.9 c | 8.8 b | 11.7 b | 9.8 c | 13.9 c | 11.8 b | 0.8 a | 0.8 a | 6.2 a | 6.2 a |

* see remark in table 1
* patrz uwaga tabela 1

fect of a differentiated fertilization on essential changes in the content of assimilable compounds in the soil have not been confirmed. The decrease of phosphorus and potassium and partially of magnesium was the result of many-year cultivation and not because of essential changes of pH in the soil environment. This fact confirms the study results of Terts [1968] that a good soil preparation before orchard establishment is of significant importance in the correct functioning of the soil environment during many years of its cultivation. This fact was also the reason why there was no reaction of trees to the additional fertilization with nitrogen [Bould et al. 1972; Pacholak and Komosa 1995; Parynow and Piątkowski 1973].

Effects of nitrogen fertilization on changes in the content of N, P, K, Mg and Ca in leaves have been shown in tables 3 and 4. It was found that it exerted a significant influence on their content, depending on the analysed factor. Also the age of trees and the course of weather conditions in the particular years exerted an influence on the content of components in the leaves of cherry trees.

Table 3. Effect of nitrogen fertilization on component content in leaves, depending on tree age (mean values from 2005–2009)
Tabela 3. Wpływ nawożenia azotem na zawartość składników w liściach w zależności od wieku drzew (średnie z lat 2005–2009)

| Year of orchard plantation<br>Rok założenia sadu | Nitrogen dose<br>Dawka azotu<br>kg · ha$^{-1}$ | Nutrient content (% of d.m.) – Zawartość składników (w % s.m) | | | | |
|---|---|---|---|---|---|---|
| | | N | P | K | Mg | Ca |
| 1.<br>(1999) | 0 | 2.06 a | 0.28 f | 1.69 h | 0.44 a | 2.43 b |
| | 60 | 2.37 c | 0.18 b | 1.89 i | 0.44 a | 2.26 ab |
| | 120 | 2.52 de | 0.17 a | 1.11 a | 0.43 a | 2.15 a |
| Mean – Średnio | | 2.32 a | 0.21 a | 1.57 c | 0.44 a | 2.28 a |
| 2.<br>(2001) | 0 | 2.01 a | 0.23 d | 1.13 b | 0.59 c | 2.29 ab |
| | 60 | 2.33 bc | 0.19 c | 1.14 c | 0.56 b | 2.22 a |
| | 120 | 2.60 f | 0.19 c | 1.17 d | 0.56 b | 2.23 ab |
| Mean – Średnio | | 2.31 a | 0.20 a | 1.15 a | 0.57 b | 2.25 a |
| 3.<br>(2002) | 0 | 2.27 b | 0.25 e | 1.19 e | 0.59 c | 2.19 a |
| | 60 | 2.46 f | 0.22 d | 1.21 f | 0.56 b | 2.15 a |
| | 120 | 2.57 ef | 0.19 c | 1.23 g | 0.56 b | 2.32 b |
| Mean – Średnio | | 2.47 b | 0.22 b | 1.21 b | 0.57 b | 2.22 a |

* Means marked with the same letter (in columns) are not significantly different at $\alpha = 0.05$
* Średnie oznaczone tymi samymi literami (w kolumnach) nie różnią się istotnie przy $\alpha = 0,05$

Nitrogen fertilization exerted a significant effect on the increase of this element in the leaves (tab. 4), independent of the tree age (tab. 3). Nitrogen content in cherry tree leaves significantly decreases with the tree age (tab. 3 and 4).

Inverse dependence was found in the content of phosphorus in leaves. Older trees showed a higher content of this element than the younger ones (tab. 3 and 4), and fertilization with nitrogen decreased its content (tab. 4).

Similar dependences were found in the content of potassium in leaves. With tree age increase, its content increased as well. However, it must be stressed that with the dose of 60 kg N · ha$^{-1}$, a significantly higher content of potassium was found in relation to the control, while with a dose of 120 kg · ha$^{-1}$, the K content was significantly lower (tab. 4).

Changes in magnesium content under the effect of nitrogen fertilizer did not exert any significant effect, although a tendency to its decrease was observed when doses of nitrogen were applied (tab. 4). The age of trees exerted a high influence in the orchards established in 2001 and 2002, the content of magnesium was much higher than in the orchard established in 1999 (tab. 3).

Table 4. Nitrogen fertilization and the content of nutrient in leaves on cherry trees in 2005–2009 (in % d.m.)
Tabela 4. Nawożenie azotem wiśni a zawartość składników w liściach w latach 2005–2009 (w % s.m.)

| Nutrient Składnik | Nitrogen dose Dawka azotu kg · ha$^{-1}$ | Years – Lata | | | | | Means Średnio |
|---|---|---|---|---|---|---|---|
| | | 2005 | 2006 | 2007 | 2008 | 2009 | |
| N | 0 | 2.59 fg* | 2.16 c | 2.02 b | 2.00 b | 1.79 a | 2.11 a |
| | 60 | 2.61 fg | 2.46 e | 2.45 e | 2.23 c | 2.17 c | 2.38 b |
| | 120 | 2.71 h | 2.33 d | 2.68 gh | 2.56 f | 2.55 ef | 2.56 c |
| Mean – Średnio | | 2.64 d | 2.31 b | 2.38 c | 2.26 b | 2.17 a | |
| P | 0 | 0.17 a | 0.29 e | 0.23 d | 0.30 de | 0.28 de | 0.25 c |
| | 60 | 0.17 a | 0.18 ab | 0.20 bc | 0.20 bc | 0.24 d | 0.20 b |
| | 120 | 0.18 ab | 0.17 a | 0.18 ab | 0.17 a | 0.20 c | 0.18 a |
| Mean – Średnio | | 0.17 a | 0.21 c | 0.20 b | 0.22 c | 0.24 d | |
| K | 0 | 1.30 b | 1.32 bc | 1.34 cd | 1.35 cd | 1.37 d | 1.34 b |
| | 60 | 1.38 c | 1.40 ef | 1.42 f | 1.43 f | 1.45 g | 1.42 c |
| | 120 | 1.16 a | 1.16 a | 1.17 a | 1.17 a | 1.18 a | 1.17 a |
| Mean – Średnio | | 1.28 a | 1.30 b | 1.31 c | 1.32 d | 1.33 e | |
| Mg | 0 | 0.47 ab | 0.55 d | 0.52 c | 0.64 f | 0.51 bc | 0.54 a |
| | 60 | 0.46 a | 0.53 cd | 0.53 cd | 0.63 ef | 0.45 a | 0.52 a |
| | 120 | 0.49 b | 0.52 c | 0.50 b | 0.60 e | 0.47 ab | 0.52 a |
| Mean – Średnio | | 0.47 a | 0.53 b | 0.51 b | 0.62 c | 0.48 a | |
| Ca | 0 | 1.63 b | 2.66 g | 1.89 c | 3.08 i | 2.26 e | 2.30 b |
| | 60 | 1.55 a | 2.48 f | 2.13 d | 2.94 h | 1.95 c | 2.21 a |
| | 120 | 1.67 b | 2.42 f | 2.14 d | 2.65 g | 2.26 e | 2.23 a |
| Mean – Średnio | | 1.62 a | 2.52 d | 2.05 b | 2.89 e | 2.16 c | |

* Means marked with the same letters are not significantly differ at $\alpha = 0.05$
* Średnie oznaczone tymi samymi literami przy danym składniku nie różnią się istotnie na poziomie prawdopodobieństwa $\alpha = 0,05$

Calcium content was very differentiated and it depended on the tree age, on the year of studies and on fertilization (tab. 3 and 4).

Changes in the content of components in leaves depended on many factors, hence the estimation of the nutritional status and an absence of a correlation between the element content in leaves and in the soil can be explained by a specific effect of the rootstock and the cultivar [Pacholak 1988], by soil moisture and weather conditions [Pacholak 1991, Pacholak and Łysiak 1993] as well as by the soil properties and the method of soil maintenance in the orchard [Komosa 1990], but the highest effect is exerted by the soil preparation under an orchard.

## CONCLUSIONS

1. Nitrogen fertilization carried out for many years did not exert any major effect on changes in the content of assimilable components in the arable layer and in the subarable layer of soil. In comparison with an initial analysis, a decrease of the content of assimilable components in the soil, resulted because of the nutritional needs of the trees. A good soil preparation exerted an influence on the fact that during the whole time of orchard cultivation, the content of components was on a high level.

2. Mineral component content in leaves depended on the fertilization, the age of trees and on the course of weather conditions.

3. Nitrogen fertilization exerted a significant effect in leaves on the increase of nitrogen content and on the decrease of phosphorus, calcium and magnesium contents. Potassium content increased at the dose of 60 kg N · $ha^{-1}$ and it decreased at the dose of 120 kg N · $ha^{-1}$.

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## WPŁYW NAWOŻENIA AZOTEM WIŚNI NA ZAWARTOŚĆ SKŁADNIKÓW W GLEBIE I LIŚCIACH

**Streszczenie**. Celem badań przeprowadzonych w latach 2002–2009 było określenie wpływu nawożenia azotem na zawartość składników mineralnych w liściach wiśni odmiany 'Łutówka' typ IR2 i zmian przyswajalnych składników w glebie w warstwie ornej i podornej. Drzewa wysadzono wiosną w rozstawie 4 × 1,3 m (1920 drzew · $ha^{-1}$) w sadach z 2001 i 2002 r. oraz 4 × 2 m (1250 drzew · $ha^{-1}$) w sadzie założonym w 1999 r. Sady zostały założone na tym samym polu na glebie płowej właściwej, wytworzonej z glin lekkich zwałowych. Wiosną 2002 r. w każdym z sadów zastosowano nawożenie azotem w następujących dawkach: 0, 60 i 120 kg · $ha^{-1}$. Badania wykazały, że stosowane przez wiele lat nawożenie zróżnicowanymi dawkami azotu wpływało na zmianę właściwości chemicznych gleby w porównaniu z analizą wyjściową z 2002 r. Zawartość przyswajalnego fosforu i potasu zarówno w warstwie ornej, jak i podornej uległa wyraźnemu obniżeniu. Natomiast zawartość przyswajalnego magnezu obniżała się w mniejszym stopniu, a w sadzie z 2002 r. stwierdzono nawet wzrost. Należy jednak podkreślić, że pomimo upływu lat zawartość fosforu i magnezu w porównaniu z liczbami granicznymi była na poziomie wysokim, a potasu optymalnym lub wysokim przy pH w granicach 5,7 do 6,6. Analizując zawartość składników ogólnych w liściach, stwierdzono, że zarówno nawożenie azotem, jak i wiek drzew miał istotny wpływ na ich zawartość. Generalizując, nawożenie azotowe wpływało na wzrost zawartości azotu i magnezu, a obniżało zawartość potasu i wapnia.

**Słowa kluczowe**: wiśnia, nawożenie, zawartość składników, gleba, liście

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