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Effect of nitrogen fertilization on growth, cropping and fruit quality of 'Šampion' apple trees during 9 years after planting

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ABSTRACT

The experiment was established in autumn 1993 at Warsaw-Wilanów, Central Poland, on alluvial loamy soil. 'Šampion' on M.9 one-year-old unfeathered trees were spaced at 3 × 1 m. Herbicide strips (1 m wide) were maintained along tree rows and sward in alleyways. Beginning in 1994, five N fertilizer treatments were applied: (1) N - 0, check, without nitrogen; (2) N - 50, 50 kg N ha^{-1}, applied in early spring on the whole soil surface; (3) N - 100, 100 kg N ha^{-1}, in early spring on the whole surface; (4) N - 50 + 50, 50 kg ha^{-1} in early spring + 50 kg N ha^{-1} 5 weeks later, on the whole surface; (5) N - $50_{herb.}$, 50 kg N ha^{-1} on the herbicides strips only, in early spring. Neither dose N or mode of N fertilization had any effect on the tree growth. Nitrogen fertilization had no effect on the cumulative yield of apple trees for the years 1995 – 2002. Cropping efficiency coefficient for 8 years of

bearing (1995 – 2002), calculated in relation to the trunk cross-sectional area in autumn 2002, did not depend on N fertilization either. In 2002 fruit firmness and the content of soluble solids before and after storage was not affected by N fertilization. The percentage of fruits with blush over 75% of skin surface was affected by N fertilization. The higher dose, i.e. 100 kg N ha^{-1}, reduced the number of fruits with blush >75% of surface.

INTRODUCTION

Under the soil and climatic conditions of Poland nitrogen is a major factor determining soil fertility and yields. From the ecological point of view it is, however, important to minimize nitrogen fertilization, taking into account natural soil resources of N, and thus to reduce the risk of pollution of soil environment with the excess of nitrates.

Information concerning response of trees in intensive orchards to N fertilization is rather scarce. Neilsen at al. (1999) and Ernani and Dias (1999) in experiment concerning N fertilization in apple orchards, very often do not take into account the response in yield and fruit quality. Greenham (1980) and Papp (1997) demonstrated that apple trees have rather moderate nutrient requirements, in relation to nitrogen in particular. This has been explained mainly by nutrient cycling in the orchard. Hikasa et al. (1986) pointed out that very high doses of nitrogen often decreased yield and worsened fruit quality. Reports of Wrona and Sadowski (1997, 1999) and Wrona and Kot (2002) indicated that N fertilization had no significant effect on growth, cropping, and mean fruit mass, but had a significantly negative effect on fruit blush.

MATERIAL AND METHODS

The experiment was established in the Experimental Orchard of the Departament of Pomology, Warsaw Agricultural University, at Warsaw-Wilanów, on a fertile silty loam alluvial soil. ‘Šampion’ apple trees, on rootstock M.9 were planted in autumn 1993, spaced 3 × 1 m. Starting from spring 1994, five fertilizer treatments were applied: (1) N - 0, check, without nitrogen; (2) N - 50, 50 kg N ha^{-1}, applied in early spring on the whole soil surface; (3) N - 100, 100 kg N ha^{-1}, in early spring on the whole surface; (4) N - 50 + 50, 50 kg ha^{-1} in early spring + 50 kg N ha^{-1} 5 weeks later, on the whole surface; (5) N - $50_{herb.}$, 50 kg N ha^{-1} of the herbicides strips only, in early spring. Nitrogen was applied as ammonium nitrate, the basic dose before the start of vegetative growth. In the years 1996 – 2002 NAA sprays were applied shortly after petal fall, for chemical thinning of fruitlets.

Effect of fertilization with nitrogen on growth, yield, and fruit quality was determined on the basis of the following indices:

- trunk cross-sectional area after 9 years,
- yield and mean fruit weight,
- flesh firmness and soluble solids at harvest and after storage,
- fruit blush (surface red colour), by visual evaluation (scale 1-4).

Firmness was investigated by an INCO penetrometer with the tang diameter of 11 mm immediately after harvesting and after 4 months of storage.

All data were elaborated by analysis of variance, for a randomised block design. Significance of differences between treatment means was estimated using the Newman-Keuls test at $p = 0.05$.

RESULTS

Trunk cross-sectional area after nine years, used as a measure of the overall tree growth and final tree size, was not affected by N fertilization (Table 1).

Table 1. Effect of N fertilization on growth of apple trees after 9 years (autumn 2002)

Treatment	Trunk cross section area (TCSA) [cm^2]
N – 0	25.4 a
N – 50	24.8 a
N – 100	25.6 a
N - 50 + 50	21.6 a
N - $50_{herb.}$	25.5 a

Explanation: Means followed by the same letter do not differ significantly at $p = 0.05$

Nitrogen fertilization had no effect on yield and mean fruit weight in 2002 (Table 2). Neither dose or mode of N fertilization had any effect on the cumulative yield of apple trees for the years 1995 – 2002 (Fig. 1). Cropping efficiency coefficient for 8 years of bearing (1995 – 2002), calculated in relation to the trunk cross-sectional area in autumn 2002 did not depend on N fertilization either (Fig. 2). In 2001 fruit firmness, both before and after storage, were affected by N fertilization (Table 3). The higher dose, i.e. 100 kg N ha^{-1}, resulted in the lowest flesh firmness. In 2002 fruit firmness before and after storage was not affected by N fertilization. In both years (2001 and 2002) no significant response to N fertilization in the content of soluble solids was noted. The percentage of fruits with blush over 75% of skin surface was affected by N fertilization. The highest dose, i.e. 100 kg N ha^{-1}, reduced the number of fruits with blush >75% of surface (Table 3).

Table 2. Effect of N fertilization on yield and mean fruit weight of apple after 9 years (2002)

Treatment	Yield [kg tree^{-1}]	Mean fruit weight [g]
N - 0	21.6 a	287 a
N - 50	21.1 a	292 a
N - 100	22.1 a	288 a
N - 50 + 50	17.9 a	305 a
N - 50$_{herb.}$	18.9 a	301 a

Explanation: as in Table 1

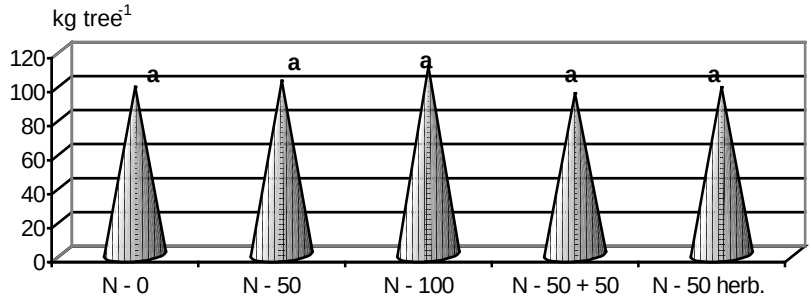

Figure 1. Cumulative yield 1995 – 2002 depending on N fertilization

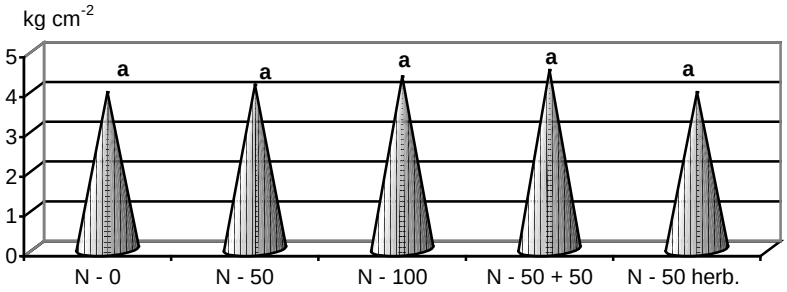

Figure 2. Cropping efficiency coefficient (CEC) depending on N fertilization

Table 3. Influence of N fertilization on fruit quality in years 2001 and 2002

Treatment	Firmness [kG]				Soluble solids [%]				% of fruit with blush >75% of fruit surface	
	before storage		after storage		before storage		after storage			
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
N - 0	4.37 b	5.08 a	3.01 b	3.29 a	12.7 a	13.3 a	12.4 a	13.9 a	38.3 ab	65.9 b
N - 50	4.29 ab	5.00 a	2.93 ab	3.31 a	12.6 a	12.9 a	12.1 a	14.0 a	43.3 ab	56.8 b
N - 100	4.06 a	5.04 a	2.82 a	3.21 a	12.4 a	13.1 a	12.3 a	13.6 a	23.3 a	46.7 a
N - 50 + 50	4.11 ab	5.29 a	2.98 ab	3.39 a	12.5 a	13.6 a	12.1 a	14.3 a	30.0 ab	60.2 b
N - 50$_{herb.}$	4.26 ab	5.05 a	3.08 b	3.23 a	12.7 a	13.5 a	12.3 a	14.1 a	60.0 b	56.7 b

Explanation: as in Table 1

DISCUSSION AND CONCLUSIONS

Results of this experiment have shown that the N nutritional state of apple trees was optimal, irrespective of fertilization. After nine years neither dose N or mode of N fertilization had any effect on the growth and crops of apple trees. Similar results were also obtained by Papp (1997) and Neilsen at al. (1999). Wrona and Sadowski (1999) showed that herbicide strips were additionally enriched by organic matter with grass mown in alleyways. Greenham (1976) found that 50 to 70 kg N ha^{-1} per year may be released from soil organic matter under clean cultivation. Thus, in the authors' experiments, the root system of trees inherits ideal conditions for nitrogen supply, particulary when the soil is rich in organic matter. This may explain the absence of growth and yield response to N. Neumann and Neumann (1981) and Kulesza and Szafranek (1978) pointed out the negative effect of high dose of N fertilization on yield and fruit quality. The high dose of N fertilization decreased the content of soluble solids and lowered fruit coloration. Similar results were confirmed in part in the present experiment. With increasing doses of N fertilizer the fruit coloration was adversely affected.

The present experiment was established on the soil rich in humus and the depth of the humic horizon exceeded 30 cm. Perhaps, on light soils, less rich in humus, which prevail in Poland, N fertilization is necessary, but at the small dose only.

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WPŁYW NAWOŻENIA AZOTEM NA WZROST, OWOCOWANIE I JAKOŚĆ JABŁEK 'ŠAMPION' PO 9-CIU LATACH WZROSTU DRZEW W SADZIE

Streszczenie: Drzewa odmiany 'Šampion' na podkładce M.9 wysadzono jesienią 1993 na polu doświadczalnym w Warszawie-Wilanowie, na glebie typu mada wykazującej skład pyłu ilastego w rozstawie 3 × 1 m. Zastosowano pięć kombinacji nawożenia: (1) N - 0 (bez azotu, kontrola); (2) N - 50 (50 kg N ha^{-1}, jednorazowo wiosną na całej powierzchni); (3) N - 100 (100 kg N ha^{-1}, jednorazowo wiosną na całej powierzchni); (4) N - 50 + 50 (50 kg N ha^{-1} wczesną wiosną + 50 kg N ha^{-1} około 5 tygodni później na całej powierzchni); (5) N - $50_{herb.}$ (50 kg N ha^{-1} wiosną tylko na pasach herbicydowych). Pole przekroju poprzecznego pnia po 9-ciu latach od posadzenia nie zależało w sposób istotny ani od dawki, ani od sposobu nawożenia. Wraz ze wzrastającą dawką nawozów azotowych zaobserwowano tendencję do wzrostu owocowania, jednak różnice pomiędzy kombinacjami nie zostały udowodnione statystycznie. Podobną sytuację odnotowano w przypadku wskaźnika intensywności owocowania wyrażonego stosunkiem sumy plonów (1995 – 2002) do pola przekroju poprzecznego pnia mierzonego jesienią 2002 roku. Jędrność owoców oraz zawartość ekstraktu zarówno przed, jak i po przechowaniu nie różniła się w sposób istotny w zależności od kombinacji nawożenia. Najbardziej wybarwione były owoce pochodzące z drzew rosnących na glebie nie nawożonej, natomiast dawka 100 kg N ha^{-1} powodowała istotne zmniejszenie udziału owoców z wybarwieniem >75% powierzchni.

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