J. Elementol. 2008, 13(2): 255–260

THE EFFECTS OF NITROGEN FERTILIZATION ON YIELDING AND BIOLOGICAL VALUE OF CHINESE CABBAGE GROWN FROM SEEDLINGS FOR AUTUMN HARVEST

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Abstract

In a field experiment conducted in 1999-2001 the effect of nitrogen nutrition on yield and biological value of cv. Optiko Chinese cabbage grown from transplants for autumn harvest was evaluated. Nitrogen was supplied in a single pre-plant dose in the amounts of 50, 100, 150, 200 kg·ha^{-1} or in a split application: 100+50 or 100+50+50 kg·ha^{-1}, with top dressing conducted 2 and 4 weeks after planting.

The results of the study did not show any significant response of Chinese cabbage yield to higher nitrogen rates. The level of nitrogen raised from 50 to 150 kg·ha^{-1} was favourable for vitamin C and total sugars content, while the application of 200 kg·ha^{-1} had a negative effect on accumulation of these constituents. Split application of 150 and 200 kg N·ha^{-1} resulted in decreased vitamin C and dry matter contents in comparison to single pre-plant doses of nitrogen used in the same amounts. Plant heavily supplied with nitrogen contained the highest level of nitrates.

Key words: Chinese cabbage, nitrogen fertilization, yield, nitrate content, nutritional value.

WPŁYW NAWOŻENIA AZOTEM NA PLONOWANIE I WARTOŚĆ BIOLOGICZNĄ KAPUSTY PEKIŃSKIEJ UPRAWIANEJ Z ROZSADY NA ZBIÓR JESIENNY

Abstrakt

W doświadczeniu przeprowadzonym w latach 1999-2001 oceniano wpływ nawożenia azotem na plonowanie i wartość biologiczną kapusty pekińskiej, odmiany Optiko, uprawianej z rozsady

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na zbiór jesienny. Porównywano obiekty nawożone azotem w postaci saletry amonowej przedwegetacyjnie w dawkach 50, 100, 150, 200 kg $N \cdot ha^{-1}$ oraz w dawkach dzielonych 100+50 i 100+50+50 kg $N \cdot ha^{-1}$. Pogłównie nawóz wysiewano po 2 i 4 tygodniach od sadzenia

Stwierdzono bark istotnej reakcji kapusty pekińskiej na wzrastające dawki azotu. Wzrastające dawki azotu (od 50 do 150 kg $N \cdot ha^{-1}$) przyczyniały się do zwiększania zawartości witaminy C i cukrów ogółem w główkach kapusty, natomiast zastosowanie 200 kg $N \cdot ha^{-1}$ spowodowało ich zmniejszenie. Zastosowanie azotu w dawkach dzielonych 100+50 i 100+50+50 kg $N \cdot ha^{-1}$ miało wpływ na zmniejszenie poziomu witaminy C, azotanów i suchej masy w roślinach, w porównaniu z zawartością stwierdzoną w kapuście nawożonej takimi samymi dawkami azotu tylko przedwegetacyjnie. Zawartość azotanów w główkach kapusty pekińskiej wzrastała wraz ze zwiększeniem dawki azotu.

Słowa kluczowe: kapusta pekińska, nawożenie azotowe, plon, wartość odżywcza.

INTRODUCTION

Chinese cabbage is a “long day” plant and for optimal development it requires long period of light and high temperature during the initial phase of its growth, whereas low temperature and short day are required at the time of head formation (Balvoll 1995). Such optimal conditions usually occur in autumn (Felczyński 1997). This vegetable can be also cultivated for the spring or summer harvest, although then the risk of flower shoot formation is greater. It can be reduced by choosing cultivars less susceptible to bolting (Staugaitis and Starkute 1999, Krężel and Kołota 2002, Kalisz 2005) and using flat plant covers during the spring period (Balvoll 1995). Finally, Chinese cabbage can be seeded directly to the field or grown from bare root or potted transplants. For the spring harvest, however, it is particularly suitable to grow Chinese cabbage from transplants, which can also be done when cabbage is grown for summer and autumn harvest (Martyniak-Przybyszewska 2000, Kalisz and Cebula 2002).

This vegetable produces significant amount of leaf mass during a short vegetation period, which raises its nutritional demand, including particularly high nitrogen requirements. Unfortunately, high nitrogen intake is associated with high accumulation of nitrates in the foliage (Li Jun Liang et al. 2003, Wang Zheng Yin et al. 2003, Krężel and Kołota 2004, Ye Jing Xue et al. 2004).

The goal of the present experiment was to evaluate the effects of nitrogen fertilisation on the yielding and biological value of Chinese cabbage grown from seedlings for the autumn harvest.

MATERIALS AND METHODS

The experiment was designed using the method of random blocks in four replications, and it was performed at the Experimental Station of the Horticulture Department UP, Wrocław in 1999-2001. Nitrogen was used as ammonium nitrate at the doses of 50, 100, 150 or 200 kg $N \cdot ha^{-1}$ applied prior to planting or in split doses of 100+50, 100+50+50 kg $N \cdot ha^{-1}$, applied pre-planting and top dressing 2 and 4 weeks after planting the seedlings. Phosphorus and potassium were applied according to the results of the soil analyses to attain the levels of 60 mg P dm^{-3} and 200 mg $K \cdot dm^{-3}$ of soil.

Chinese cabbage (cv. Optiko) was planted using pot seedlings produced in multicell trays. The seeds treated with fungicide *Zaprawa nasienna* T ($4g \cdot kg^{-1}$ seed) were sown in the second part of July. The seedlings were planted out in the fields in mid-August, at spacing of 45x30 cm. At harvest, conducted in mid-October, total yield of aerial mass as well as total and marketable yield of heads were evaluated. In addition, plant samples were collected for determination of dry matter, sugars (Lane-Eynona method), vitamin C (Tillmans method) and nitrates (calorimetric method).

The results were analysed using Tukey's test at the confidence coefficient α=0.05.

RESULTS AND DISCUSION

As it is shown in Table 1, the highest yield of aerial mass, as well as total and marketable yield of heads were obtained using the highest dose of nitrogen applied in the amount of 100 $kg \cdot N\ ha^{-1}$ prior to planting and 50+50 kg $N \cdot ha^{-1}$ as top dressing at 2 and 4 weeks after planting (86.99, 56.44 and 49.14 $t \cdot ha^{-1}$ respectively). The differences in the head yield, including both the total and marketable yield, were not statistically significant. There was, however, a tendency towards higher head yields when the nitrogen doses had increased from 50 to 150 kg $N \cdot ha^{-1}$, but it was followed by lower yields at 200 kg $N \cdot ha^{-1}$. Split application of nitrogen (100+50 kg $N \cdot ha^{-1}$) did not modify yielding as compared to an analogous single dose used prior to the vegetation period. At 200 kg $N \cdot ha^{-1}$, the change nitrogen application from single pre-vegetation to split application (100+50+50) treatment slightly enhanced the crop yield. These data are in contrast with those reported by WANG ZHENG YIN et al. (2003), who observed increased yielding along with enlarged doses of nitrogen up to 225 kg $N \cdot ha^{-1}$.

The highest percentage of marketable heads with respect to total yield were found in the experiment with 100 and 100+50 kg $N \cdot ha^{-1}$ (87.86%), whereas the lowest performance was observed when using 150 kg $N \cdot ha^{-1}$

Table 1

Effect of nitrogen fertilization on yielding of Chinese cabbage grown from seedlings for autumn harvest

Rate of nitrogen ($kg \cdot ha^{-1}$)	Total yield of aerial mass ($t \cdot ha^{-1}$)	Total yield of heads ($t \cdot ha^{-1}$)	Marketable yield of heads ($t \cdot ha^{-1}$)	Share in total yield	
				marketable heads	small non marketable heads
50	77.01	52.36	45.99	87.84	7.91
100	82.12	55.50	48.77	87.86	7.19
150	84.85	55.69	48.46	87.01	8.50
100+50	84.54	55.38	48.66	87.86	8.67
200	79.82	52.01	45.55	87.58	8.83
100+50+50	86.99	56.44	49.14	87.07	9.62
$LSD_{\alpha=0.05}$	7.51	r.n.	r.n.	-	-

before planting. The smallest percentage of small and not fully grown heads in total yield occurred when using 100 kg $N \cdot ha^{-1}$ (7.19%), whereas the highest one after split application of 100+50+50 kg $N \cdot ha^{-1}$ (9.62%). A similar tendency had been observed and reported previously by KRĘŻEL and KOŁOTA (2004).

The mean weight of Chinese cabbage marketable head decreased gradually with doses of nitrogen increasing from 100 kg $N \cdot ha^{-1}$ to 200 kg $N \cdot ha^{-1}$ when used as single application treatments before planting (Figure 1). Interestingly, application of the same total amounts in split doses of nitrogen (100+50 and 100+50+50 kg $N \cdot ha^{-1}$) resulted in an increased mean head weight (657 g and 664 g respectively).

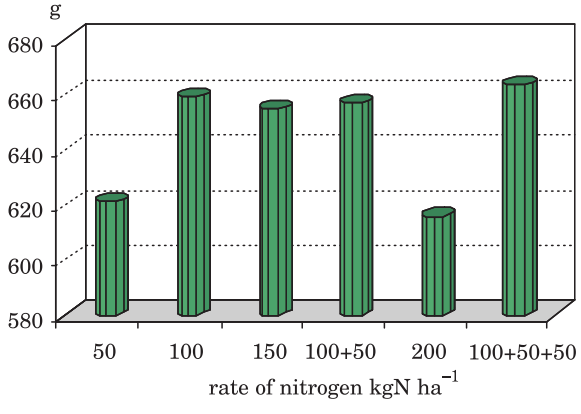

Fig. 1. The effect of nitrogen fertilization on mean weight of head of Chinese cabbge grown from seedlings for autumn harvest

Table 2

Effect of nitrogen fertilization on content of dry matter, sugars, vitamin C and NO_3, in Chinese cabbage grown from seedling for autumn harvest

Rate of nitrogen ($kg \cdot ha^{-1}$)	Dry matter (%)	Reducing sugars (%)	Total sugars (%)	Vitamin C ($mg \cdot kg^{-1}$ fresh weight)	NO_3 ($mg \cdot kg^{-1}$ fresh weight)
50	5.80	2.09	2.30	307.3	630
100	6.14	2.11	2.34	325.7	980
150	6.29	2.11	2.40	376.1	1103
100+50	5.61	2.12	2.25	328.9	1068
200	6.29	2.17	2.24	358.7	1186
100+50+50	6.14	2.19	2.28	336.6	1126

The dry mass content was the highest (6.29%) under a single application of 150 and 200 kg $N \cdot ha^{-1}$ prior to the vegetation period, whereas the application the same amounts in split doses 100+50 and 100+50+50 kg $N \cdot ha^{-1}$ lead to significant reduction of dry matter (Table 2). The content of reducing sugars was not significantly affected by the dose or the term of nitrogen application, although a increasing tendency was observed with higher doses of nitrogen. The total sugar and vitamin C content increased proportionally to the nitrogen doses up to 150 kg $N \cdot ha^{-1}$, attaining 2.40% and 376.1 $mg \cdot kg^{-1}$ of fresh weight, respectively. The application of 200 kg $N \cdot ha^{-1}$ in a single dose before the vegetation period and in split doses (100+50 and 100+50+50 kg $N \cdot ha^{-1}$) caused reduction of total sugar and vitamin C levels. The sugar content reported by STAUGAITIS and STARKUTE (1999), was significantly higher, whereas the vitamin C levels were strongly reduced in comparison with the present study. The accumulation of nitrates increased with increasing doses of nitrogen and varied from 630 mg kg^{-1} of fresh weight after the application of 50 kg $N \cdot ha^{-1}$ up to 1186 $mg \cdot kg^{-1}$ of fresh weight at the dose of 200 kg $N \cdot ha^{-1}$. Such relations between nitrogen fertilization and nitrates content are in agreement with previous reports of WANG ZHENG YIN et al. (2003).

CONCLUSIONS

1. An increase of a nitrogen dose from 50 to 100 kg $N \cdot ha^{-1}$ caused a slight but not significant enhancement of the yield of commercial heads of Chinese cabbage. This effect was not observed at higher doses equal to 150 and 200 kg $N \cdot ha^{-1}$.

2. The highest content of dry matter and nitrates occurred after the application of 200 kg $N \cdot ha^{-1}$, whereas the highest total sugars and vitamin C were found in the cabbage after the application of 150 kg $N \cdot ha^{-1}$.

3. The use of split doses of 100+50 and 100+50+50 kg $N \cdot ha^{-1}$ caused a higher reducing sugars content, but lower levels of vitamin C, nitrates and content the dry matter compared to treatments with a single application of 150 and 200 kg $N \cdot ha^{-1}$ before planting.

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