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THE EFFECT OF NITROGEN FERTILIZATION ON YIELD AND QUALITY OF RADICCHIO

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Abstract

In a field experiment conducted in 2005-2006 the effects of the rate and method of nitrogen fertilization on yield and chemical composition of cv. Indygo radicchio cultivated for summer cropping were studied. Nitrogen was used in a single pre-plant dose or in two rates: as a pre-plant and top dressing application conducted at the start of head formation in the total amounts of 50, 100, 100+100, 150, 100+50, 200, 100+100 kg $N \cdot ha^{-1}$. The highest yield and accumulation of nitrates were achieved in the treatment with 100+100 kg $N \cdot ha^{-1}$. The content of nitrates in radicchio leaves varied from 1,070 to 1,350 $mg \cdot kg^{-1}$ f.m. for the nitrogen rate of 200 kg $N \cdot ha^{-1}$ supplied in one pre-plant dose, and from 1,160 to 1,380 $mg \cdot kg^{-1}$ f.m. when the same rate was applied in two doses. The method of nitrogen fertilization had little effect on P and Mg concentration. Potassium and calcium level in leaves of radicchio decreased at higher nitrogen fertilization rates.

Key words: radicchio, nitrogen fertilization, yield, nitrates, macroelements.

WPŁYW NAWOŻENIA AZOTEM NA PLONOWANIE I JAKOŚĆ CYKORII TYPU RADICCHIO

Abstrakt

W doświadczeniu polowym przeprowadzonym w latach 2005-2006 oceniano wpływ dawki i sposobu nawożenia azotem na plonowanie i skład chemiczny cykorii typu radicchio odmiany Indygo uprawianej na zbiór letni. Azot stosowano w całości przedwegetacyjnie lub w dwóch dawkach przedwegetacyjnie i pogłównie, w ilości 50, 100, 50+50, 150, 100+50, 200, 100+100 kg $N \cdot ha^{-1}$ z użyciem saletry amonowej. Istotnie największy plon główek w doświadczeniu, lecz

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również największą zawartość azotanów w liściach, uzyskano wnosząc N w dwóch dawkach przedwegetacyjnie i pogłównie w ilości 200 (100+100) kg $N \cdot ha^{-1}$. Zawartość azotanów po zastosowaniu N w całości przedwegetacyjnie była nieco mniejsza i wahała się od 1070 do 1350 $mg \cdot kg^{-1}$ św.m., zaś w przypadku dzielenia dawki N na dwie części wynosiła 1160-1380 $mg \cdot kg^{-1}$ św.m. Sposób wnoszenia azotu miał mały wpływ na zawartość P i Mg. Poziom potasu i wapnia w liściach radicchio malał pod wpływem wzrastających dawek N.

Słowa kluczowe: radicchio, nawożenie azotem, plon, azotany, makroskładniki.

INTRODUCTION

Radicchio is a form of chicory (*Cichorium intybus* var. *foliosum* Bisch.), known also as red chicory or Italian chicory. The most popular types of this leaf vegetable are Radicchio di Treviso with loose upright heads and Radicchio di Chioggia with round dense heads (Illert 2004, Hill 2004). Edible burgundy red colored leaves with white midribs have a low content of protein 1.4 g of and carbohydrates 4.5 g in 100 g of fresh matter. While considerable amounts of fiber (0.9 g), vitamins A (27.0 IU), C (8-14 mg), B_6 (0.1 mg), niacin (0.3 mg), carotenoids such as lutein and zeaxantin (8832 µg) as well as macro- and microelements: phosphorus (40 mg), potassium (302 mg), zinc (0.6 mg), cuprum (0.3 mg), iron (0.6-1.5 mg), selenium (0.9 µg). It also contains anthocyanins belonging to flavonoids that have numerous health benefits (Ćustić and Toth 2000, Ćustić et al. 2000b, USDA National Nutrient Database 2006).

Radicchio is often eaten raw in salads, but in Italy it is usually grilled in olive oil or mixed into dishes such as risotto. Also salad mixes sold in supermarkets and grocery stores often contain some radicchio. It adds vibrant color to mixes of head lettuce and romaine. Served alone, radicchio is slightly bitter because it contains sesquiterpene lactones, but when mixed with other salad greens, its tangy taste is muted (Hill 2004). In Poland, radicchio is a rather unknown vegetable, cultivated sometimes on a small scale in home gardens.

Less attention has been paid in literature to the relationship between nitrogen doses and methods of fertilization versus the yield of this vegetable. Also, the question of its tendency to accumulate nitrates in edible parts of this type of chicory is insufficiently recognized.

Most of the data indicate the advantageous reaction of this plant to intensive nitrogen fertilization. (Ćustić et al. 1994, Osinga 1997, Ćustić et al. 2000a, Reich and Coffey 2002). The aim of the experiment established in 2005-2006 was to investigate the effect of doses and methods of nitrogen fertilization on yield and quality of radicchio chicory.

MATERIAL AND METHODS

In a field experiment on radicchio, nitrogen was supplied in a single pre-plant rate of 50, 100, 150 and 200 kg $N \cdot ha^{-1}$ or was divided into pre-plant and top dressing treatments: 50+50, 100+50, 100+100 kg $N \cdot ha^{-1}$. In all the treatments ammonium nitrate was used as the source of nitrogen. Transplants of cv. Indygo radicchio chicory were produced in a greenhouse. The seeds were sown on 24 April in multicells filled with peat substrate. Individual cells of plug trays contained approximately 76.2 cm^3 of substrate. At the end of May the seedlings were planted out into the field at a spacing 30x20 cm. A one factorial experiment with seven treatments was established in four replications, with a plot area of 1.8 m^2.

During the harvest in the first decade of August, the total and marketable yields of heads were determined. The content of nitrates (potentiometrically), dry matter (according to PN-90/A-75101/03 method), and total and reducing sugars (according to PN-90/A-75101/07 method) were determined in edible parts of the heads. The content of macronutrients: phosphorus, potassium, magnesium and calcium was determined according to Nowosielski method.

The results were analysed with a standard statistical procedure and the least significant differences were calculated by Tukey's test at α=0.05.

RESULTS AND DISCUSSION

Nitrogen fertilization significantly influenced the yielding of radicchio in both years of the study. In the treatments with one pre-plant dose, the highest yield of heads was obtained when nitrogen rates increased to 150-200 kg $N \cdot ha^{-1}$. The response to this method of nitrogen feeding was more pronounced in 2005 because of the more favourable rainfall distribution during the growing season.

The nitrogen fertilization with a dose of 200 kg $N \cdot ha^{-1}$ supplied in two rates as pre-plant and top dressing appeared to be more efficient for the plant growth and assured significantly higher total and marketable yields of heads in comparison to a single pre-plant application. These results confirmed the previous finding of OSINGA (1997), who noticed that in radicchio rosso the highest yield of quality class I+II was provided in a treatment where a total dose of 150 kg $N \cdot ha^{-1}$ was divided in two rates: pre-plant 50 kg $N \cdot ha^{-1}$ and supplementary top dressing of 100 kg $N \cdot ha^{-1}$.

ĆUSTIĆ et al. (1994) did not observe significant differences in yield of radicchio chicory under different nitrogen fertilization. The results of our experiment are in agreement with ĆUSTIĆ et al. (1994, 2000b), who found

Table 1

The effect of nitrogen fertilization on yielding of radicchio ($kg \cdot m^{-2}$)

N Rate ($kg \cdot ha^{-1}$)	Total yield			Marketable yield		
	2005	2006	mean	2005	2006	mean
50	4.53	4.24	4.39	3.86	3.32	3.59
100	5.49	4.45	4.97	4.58	3.38	3.98
150	5.72	4.62	5.17	4.73	3.57	4.15
200	6.37	4.56	5.46	5.66	3.37	4.51
50+50	5.56	4.65	5.10	4.68	3.45	4.06
100+50	6.62	4.77	5.69	5.39	3.85	4.62
100+100	6.98	5.29	6.14	5.92	4.29	5.10
NIRα=0.05	0.32	0.37	0.39	0.47	0.37	0.44

that a dose of 200 kg $N \cdot ha^{-1}$ was too high for radicchio when supplied in a single pre-plant dose.

The nitrogen fertilization influenced the content of nitrates in edible parts of radicchio (Table 2). At 50 kg $N \cdot ha^{-1}$ the level of nitrates in leaves was 375-493 $mg \cdot kg^{-1}$ f.m. Intensive nitrogen fertilization at 200 kg N ha^{-1} caused an increase in nitrates up to 1,160-1,380 $mg \cdot kg^{-1}$ f.m. in both years of the experiment

Table 2

The effect of nitrogen fertilization on content of nitrates and macronutrients in radicchio leaves

N Rate ($kg \cdot ha^{-1}$)	NO_3-N ($mg \cdot kg^{-1}$ f.m.)		P	K^+	Mg^{2+}	Ca^{2+}
	2005	2006	mean for 2005–2006 (%)			
50	375	493	0.44	5.42	0.23	0.37
100	896	776	0.49	5.22	0.24	0.35
150	961	998	0.50	5.12	0.25	0.32
200	1350	1070	0.49	4.80	0.20	0.28
50+50	728	630	0.57	5.12	0.23	0.29
100+50	1200	910	0.48	5.08	0.24	0.30
100+100	1380	1160	0.49	5.26	0.24	0.27

When nitrogen was split into pre-plant and top dressing fertilization, the concentration of nitrates was higher than when it was applied in a single pre-plant dose.

Ćustić et al. (1994) stated that radicchio has a rather limited tendency to accumulate nitrates and, at the rate of 160 kg $N \cdot ha^{-1}$, the level of NO_3-N did not exceed 1,000 $mg \cdot kg^{-1}$ f.m. This agrees with the results of our experiment, which showed that the content of nitrates in edible parts of radicchio was considerably lower than admissible amounts for salad vegetables in Poland, equal 2,500 mg $NO_3 \cdot kg^{-1}$ f.m. According to Ćustić et al. (2003), the effect of weather conditions on accumulation of nitrates in radicchio plants may be stronger than that of differentiated organic and mineral fertilization.

The nitrogen fertilization had a negligible effect on the concentration of phosphorus and magnesium in radicchio leaves. The content of phosphorus in leaves varied from 0.44 to 0.57% d.m. and magnesium from 0.20 to 0.25% d.m. The calcium concentration decreased under heavy nitrogen fertilization to 5.42 % in the treatment with a nitrogen dose of 50 kg $N \cdot ha^{-1}$ and to 4.80% when the dose of 200 kg $N \cdot ha^{-1}$ was used.

CONCLUSION

1. The highest yield of radicchio heads was obtained when a dose of 200 kg $N \cdot ha^{-1}$ was supplied in split treatments (100+100 kg $N \cdot ha^{-1}$).

2. Radicchio fertilized with 200 kg $N \cdot ha^{-1}$ supplied in a single pre-plant dose had a lower concentration of nitrates in leaves, ranging from 1,070 to 1,350 $mg \cdot kg^{-1}$ f.m, whereas the split application of the same amount of nitrogen increased their level to 1,160-1,380 $mg \cdot kg^{-1}$ f.m.

3. The method of nitrogen application had a negligible effect on the content of P, K and Mg. The calcium level in radicchio leaves decreased under heavy nitrogen fertilization.

4. The concentration of phosphorus in leaves of radicchio varied from 0.44 to 0.57%, potassium from 4.80 to 5.42%, magnesium from 0.20 to 0.25% and calcium from 0.27 to 0.37%.

REFERENCES

Ćustić M., Poljak M., Coga L., Cosic T., Toth N., Pecina M. 2000a. *The influence of organic and mineral fertilization on nutrient status, nitrate accumulation, and yield of head chicory*. Plant. Soil Environ., 49(5): 218-222.

Ćustić M., Poljak M., Cosic T. 1994. *Nitrate content in leafy vegetables as related to nitrogen fertilization in Croatia*. Acta Hort., 371: 407-412.

Ćustić M., Poljak M., Toth N. 2000b. *Effects of nitrogen upon the quality and yield of head chicory (Cichorium intybus* var. *foliosum)*. Acta Hort., 533: 401-410.

Ćustić M., Toth N. 2000. *Effects of nitrogen upon the quality and yield of head chicory (Cichorium intybus var. foliosum)*. Acta Hort., 533: 401-405.

Hill D. 2004. *Radicchio trials 2002-2003*. The Connecticut Agricultural Experiment station. New Haven.

Illert S. 2004. *Die Kleine Marktstudie: Radicchio*. Gemüse. 6:42-43.

Osinga K. 1997. *Nitrogen fertilizing of radicchio rosso*. PAV-Bulletin-Vollegrondsgroenteteelt. February, 27-29.

PN-90/A-75101/03 *Oznaczenie zawartości suchej masy*.

PN-90/A-75101/07 *Oznaczenie zawartości cukrów*.

Reich V.H.. Coffey D.L. 2002. *Studies on radicchio*. The University of Tennessee, 1-4. http://bioengr.ar.utk.edu/Extension/ExtProg/Vegetable/year/VegInitReport01/29studies

USDA National Nutrient Database for Standard Reference. Release 19. 2006.