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THE EFFECT OF THE PERIOD OF WEED CONTROL AND DIFFERENTIATED NITROGEN FERTILIZATION ON YIELDING OF WHITE HEAD CABBAGE

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Abstract. In the field experiment with cabbage cv. 'Menza F_1' fertilized with 150 and 250 kg N·ha^{-1}, the first weeding started 3, 6, 9, 12 weeks after transplanting, including unweeded control. Higher dose of nitrogen especially in treatments with delayed weed control affected in significant increase of marketable yield, as well as the mean weight of cabbage heads in comparison to the dose of 150 N·ha^{-1}. The highest yielding was recorded in treatment where the first weeding was conducted 3 weeks after transplanting. The delay of this operation to 6, 9, and 12 weeks after transplanting caused the decrease in marketable yield by 16.0%, 33.1% and 48.4%, respectively. The dose of 250 N·ha^{-1} contributed to the slight decrease of dry matter, total and reducing sugar contents, and higher accumulation of nitrates in edible parts of cabbage heads. Late start of weed removal was disadvantageous for dry matter and sugars content and caused higher nitrates accumulation in cabbage.

Key words: white head cabbage, term of weed removal, N-fertilization, yield, plant composition

INTRODUCTION

The presence of weeds is one of the main factors reducing yield in field vegetables production. It is caused by competition between crop and weeds for all growing mediums such as light, water and nutrients [Dobrzański 2004]. Losses in yield and quality of the crop caused by weed infestation depend on their species, plant population and stage of growth. In some cases delay of weed control may result in 50% decrease of the yield and each day of the weed presence in the field leads to the reduction of potential yield by 0.5-2% [Dobrzański 1994]. According to Baumann et al. [1993], Orth and Hülsenberg [1969] Brassica crops grown from transplants are considered as the group of vegetables which are the most tolerant to weed infestation, especially in the second part of

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the growing period. Till now the literature does not provide the strict information about the critical period of weed infestation for this species. The only exception is Weaver's work [1984] indicating that the period of the highest susceptibility of this species for weeds lays between third and fifth week of cultivation. In studies conducted with spring cabbage by Lawson [1972] the severe weed competition resulted in smaller head size and decrease of internal head quality.

Because of the fact that weeds produce a lot of biomass they are very competitive for nutrients [Dobrzański et al. 2003], among which nitrogen is of a special importance [Sady 2000]. Therefore for cabbage which is recognized as a high demanding species regarding nutrition, the appropriate fertilization of N is especially important. On the other hand overfertilization with nitrogen can diminish the quality of cabbage yield as a result of high nitrates accumulation.

The aim of this investigation was to determine the effect of delayed weed removal and differentiated nitrogen fertilization on yielding and biological value of white head cabbage.

MATERIAL AND METHODS

The field experiment was conducted on a fine clay soil with 1.8% organic matter and pH 7.2 in Piastów Horticulture Research Station in 2001–2003. The available forms of phosphorus, potassium and magnesium were raised up by early spring fertilization to the standard level of 60 mg P, 200 mg K and 70 mg Mg per 1 dm^3 of the soil [Rumpel 2002].

Nitrogen fertilizer as ammonium nitrate (34% N) was supplied in the amounts of 150 and 250 kg $N \cdot ha^{-1}$ in split application as the preplant dose (50 or 100 $kg \cdot ha^{-1}$) and in two top dressing rates (50 + 50 or 75 + 75 $kg \cdot ha^{-1}$), conducted 3 and 7 weeks after planting the transplants in the field. In both fertilizer treatments the weeds removal on plots started in different terms: after 3, 6, 9 or 12 weeks from the date of transplanting, and was repeated in 3 week's intervals. As the control there were used the unweeded plots. The experiment was established in two factorial design in four replications, with plot area for harvest equal to 12 m^2 (3×4 m).

The seeds of cabbage were sown in the third decade of April in the plastic tunnel into the multiseeded trays with cell capacity 69.3 cm^3 filled with peat substrate. Well hardened transplants were planted in the third decade of May in spacing 50×50 cm. Crop management included pest control and irrigation in the rainfall deficiency periods. During the harvest of plants done in the end of October the samples of 5 heads from each plot were collected for chemical analyses.

The vertical cuttings from cabbage heads were used for evaluation the contents of dry matter (after drying at 105°C to constant weight), and after homogenization of plant tissue – vitamin C (Tillman's method), total and reducing sugars (Lane-Eynon's method) and nitrates (refractometrically).

The results of the experiment were analyzed by standard statistical procedure and the least significant differences were calculated by Duncan test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

According to Dobrzański [2004] the use of high doses of nitrogen in the cabbage growing leads to excessive presence of such weed species as: *Chenopodium album, Amaranthus retroflexus, Stellaria media*. The same weed species were found to be dominated in our experiments in each year. Because of the similar response of cabbage yield and plant composition to weed infestation and nitrogen doses, the results of the study are presented as the means for three years.

As it is shown in table 1, nitrogen fertilization in the amount of 250 kg $N \cdot ha^{-1}$ caused a significant increase in marketable yield as compared to the dose of 150 kg $N \cdot ha^{-1}$. However, this result highly depended on the term in which weed control was started. Yields of cabbage supplied with both tested N rates were similar to each other on plots, where the first weed removal took place in 3rd week after transplanting. If the period of weed presence in early growth stages was prolonged to 6, 9 or 12 weeks, the use of 250 kg $N \cdot ha^{-1}$ was more preferable for cabbage yield. This dose provided the increase of marketable yield by 7.2%, 13.0% and 36.3% respectively, in comparison to 150 kg $N \cdot ha^{-1}$. Like in our study Evans et al. [2002] concluded that reductions in nitrogen use may create the need for more intensive weed management for corn. They found that addition of 120 kg $N \cdot ha^{-1}$ delayed beginning of the critical period for weed control when compared with 0 $N \cdot ha^{-1}$ and 60 $N \cdot ha^{-1}$ rate.

In the control treatment with the presence of weeds for the whole growing period the suppression of the yield was equal to 68.0%. It was much higher than reported by Chroboczek [1957] and Heemst [1985], who observed reduction of the yield within 24.8–57.8%. According to Dobrzański [1998] cabbage grown from transplants is quite resistant to weeds, but heavy weed infestation lasted for the period of 30 days or more may account the yield reduction by 30–40%. It is also underlined that moderate weed population during first 3–5 weeks after planting may not adversely affect the crop yield if in the later growth stages the plots will be kept weed free [Weaver 1984]. The response to weed infestation was also depended on plant population. Normally, a single weeding approved to be sufficient to prevent yield losses of cabbage [Weaver 1984].

Positive effect of application of high nitrogen dose observed at longer period of weed presence in the field was also expressed by the decrement of unmarketable yield as well as higher mean weight of cabbage heads. Irrespective of the delay of weeds removal the increment of nitrogen dose from 150 to 250 kg $N \cdot ha^{-1}$ provided the enhancement of mean weight of cabbage heads from 1.77 to 1.94 kg. Considerably higher effects were observed under influence of the weed infestation. Delay start of weed removal from 3rd to 12th week after transplanting reduced the mean weight of marketable heads from 2.62 to 1.50 kg and in unweeded control to 1.10 kg. Similar effect of was observed by Weaver [1984] and Lawson [1972]. In early cabbage production the increasingly severe competition adversely affected the internal head quality and reduced the number of plants with developed heads [Lawson 1972].

Increased nitrogen fertilization applied in the dose of 250 kg $N \cdot ha^{-1}$ contributed to a slight and not significantly decrease of dry matter, total and reducing sugars in cabbage, with simultaneous enhancement of nitrates accumulation from 164.1 to 214.4 $mg \cdot kg^{-1}$ f.w. (tab. 2). In reverse to the data presented by Dobrzański [1991] with

Table 1. The effect of nitrogen fertilization and term of weed removal on yielding and mean weight of white head cabbage cultivar Menza F_1 (mean for 2001–2003)

Tabela 1. Wpływ nawożenia azotowego i terminu rozpoczęcia odchwaszczania na plonowanie i średnią masę główek kapusty białej odmiany Menza F_1 (średnio z lat 2001–2003)

Term of first weeding (in weeks after planting) Termin odchwaszczania (w tygodniach po posadzeniu)	Marketable yield Plon handlowy t·ha^{-1}			Unmarketable yield Plon niehandlowy t·ha^{-1}			Mean weight of head Średnia masa głowy kg		
	dose of nitrogen – dawka azotu, kg·ha^{-1}								
	150	250	mean średnio	150	250	mean średnio	150	250	mean średnio
3	99.22	101.05	100.14	4.19	4.81	4.50	2.59	2.65	2.62
6	81.15	86.99	84.07	5.12	4.74	4.93	2.16	2.29	2.23
9	62.69	71.34	67.02	5.97	5.88	5.93	1.72	1.93	1.82
12	43.77	59.66	51.72	10.71	5.68	8.20	1.36	1.63	1.50
Unweeded control Kontrola bez odchwaszczania	29.91	34.25	32.08	11.23	12.84	12.04	1.03	1.18	1.10
Mean – Średnio	63.35	70.66	67.00	7.44	6.79	7.12	1.77	1.94	1.86
$LSD_{0.05}$ for – $NIR_{0.05}$ dla:									
Fertilization – Nawożenia (I)		5.86			n.s.			0.14	
Term of weeding – Termin odchwaszczania (II)		9.27			0.96			0.18	
Interaction – Interakcja (I×II)		16.45			1.76			0.29	

n.s. – differences not significant – różnice nieistotne

Table 2. The effect of nitrogen fertilization and term of weed removal on content of dry matter, total and reducing sugars, vitamin C and nitrates in white head cabbage heads cultivar Menza F_1 (mean for 2001–2003)

Tabela 2. Wpływ nawożenia azotowego i terminu rozpoczęcia odchwaszczania na zawartość suchej masy, cukrów ogółem i cukrów prostych, witaminy C i azotanów w główkach kapusty odmiany Menza F_1 (średnio za lata 2001–2003)

Term of first weeding (in weeks after planting) Termin odchwaszczania (w tygodniach po posadzeniu)	Dry matter Sucha masa %			Total sugars Cukry ogółem % f.w. – % św.m.			Reducing sugars Cukry proste % f.w. – % św.m.			Vitamin C Witamina C mg·100g^{-1} f.w. mg·100g^{-1} św.m.			Nitrates Azotany mg·kg^{-1} f.w. mg·kg^{-1} św.m.		
	dose of nitrogen – dawka azotu, kg·ha^{-1}														
	150	250	mean	150	250	mean	150	250	mean	150	250	mean	150	250	Mean
3	7.67	8.12	7.90	4.60	4.98	4.79	3.26	3.06	3.16	63.6	69.4	66.5	146.7	175.2	161.0
6	8.37	7.56	7.97	5.40	4.77	5.09	2.99	2.86	2.93	61.5	59.1	60.3	144.6	219.8	182.2
9	8.75	8.22	8.49	5.02	4.59	4.81	3.45	3.57	3.51	68.2	63.0	65.6	180.1	226.8	203.5
12	8.03	7.34	7.69	4.10	4.32	4.21	2.98	2.87	2.93	57.5	63.9	60.7	176.9	221.0	199.0
Unweeded control Kontrola bez odchwaszczania	7.93	7.89	7.91	4.82	4.80	4.81	3.22	3.27	3.25	60.9	66.8	63.9	172.0	229.2	200.6
Mean – Średnio	8.15	7.83	7.99	4.79	4.69	4.74	3.18	3.13	3.16	62.3	64.4	63.4	164.1	214.4	189.2
$LSD_{0.05}$ for –$NIR_{0.05}$ dla:															
Fertilization – Nawożenia (I)		n.s.			n.s.			n.s.			n.s			14.5	
Term of weeding – Termin odchwaszczania (II)		0.32			0.24			0.18			n.s.			12.2	
Interaction – Interakcja (I×II)		0.36			0.29			0.22			n.s.			18.0	

spinach, the delay of weed removal term resulted in the increase of nitrogen content from 161.0 to 203.5 $mg \cdot kg^{-1}$ f.w. This phenomen may be explained by the poor light conditions on plots heavy infested by weeds which are present in the field for a long period of time. Cabbage grown on plots in which the first weed removal took place of 12 weeks from the date of planting showed some tendency for the lower content of dry matter. Vitamin C content in cabbage head was not dependent on the level of nitrogen fertilization as well as the term in which weed control was started.

CONCLUSIONS

1. Irrespective of N dose the delay of the first weeding to 6, 9, and 12 weeks after transplanting caused the decrease in marketable yield by 16.0%, 33.1% and 48.4%, and the increase of nitrates content, in comparison with the treatment where it was started after period of three weeks.

2. High dose of nitrogen equal to 250 $N \cdot ha^{-1}$ was favorable for the yield and mean weight of cabbage head only in the case of long period of weed infestation.

3. Heavy nitrogen fertilization did not influence the content of dry matter, total and reducing sugars as well as vitamin C content, while caused the enhancement of nitrates accumulation in cabbage heads.

4. Long period of weed infestation lasted for 12 week was disadvantageous for dry matter and sugar contents in comparison to treatment in which weed control started 3 weeks after planting.

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WPŁYW TERMINU ODCHWASZCZENIA I ZRÓŻNICOWANEGO NAWOŻENIA AZOTEM NA PLONOWANIE KAPUSTY GŁOWIASTEJ BIAŁEJ

Streszczenie. W doświadczeniu polowym badano wpływ zróżnicowanego nawożenia azotem w wysokości 150 i 250 kg $N \cdot ha^{-1}$ oraz opóźnienia pierwszego pielenia na plonowanie kapusty głowiastej białej odm. Menza F_1. Kontrolę stanowiły poletka nie odchwaszczane. Opóźnienie pierwszego terminu odchwaszczania do 6, 9 i 12 tygodni po posadzeniu rozsady prowadził do istotnego, sięgającego 16,0%, 33,1% i 48,4% spadku plonu handlowego oraz wzrostu poziomu azotanów w główkach kapusty przy zbiorze. Zwiększenie dawki azotu ze 150 do 250 kg $N \cdot ha^{-1}$ przyczyniało się do uzyskania wyższego i lepszego jakościowo plonu handlowego kapusty, w przypadku opóźnienia pierwszego terminu odchwaszczania do 9 i 12 tygodni po posadzeniu rozsady. Kapusta intensywnie nawożona azotem zawierała nieco mniej suchej masy, cukrów ogółem i cukrów prostych, akumulowała jednak większe ilości azotanów. Opóźniony do 12 tygodni po posadzeniu termin pierwszego odchwaszczania wpłynął niekorzystnie na zawartość suchej masy i cukrów, w porównaniu do obiektu, w którym zabieg ten wykonano po 3 tygodniach uprawy.

Słowa kluczowe: kapusta głowiasta biała, termin odchwaszczania, nawożenie azotowe, plon, skład chemiczny

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