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INFLUENCE OF GROWING DATE AND PLANT DENSITY ON THE YIELD OF ENDIVE (*Cichorium endivia* L.)

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Abstract. The experiment was carried out in the years 2006–2008. The aim of the study was estimation of yielding of Italian cultivar of endive 'Blonda a cuor pleno' (escarole group) grown in the conditions of Western Pomerania. Seeds of endive were sown on four dates: 10, 20 and 30 June, and 10 July. There were two plant spacing used in the experiment: 40 × 25 and 40 × 35 cm. Significantly the highest yield of leaf rosettes was obtained when seeds were sown on 30 June. However, sowing seeds on 10 June had an effect on obtaining rosettes of the highest weight. This planting date had also an influence on decrease of marketable yield because of premature floral stalks development in long-day conditions. Significantly higher yield of rosettes of the highest weight and diameter was obtained from planting transplants at the spacing of 40 × 25 cm.

Key words: escarole, field cultivation, plant density, yield quantity and quality

INTRODUCTION

Among many horticultural crops, vegetables play a significant role in human nutrition.

Comparing to other European countries there is too little consumption of leafy vegetables in Poland. One of the species is endive which belongs to *Asteraceae* family. In Poland endive is a little known vegetable and it is grown only amateurish. However, in other European countries – mainly in Italy, Spain, France and Greece, endive is a very popular leafy vegetable and it is grown in the open field as well as under covers [Adamczewska-Sowińska and Uklańska 2009].

Edible part of this annual plant is blanched inner part of leaf rosette. The two principal types of endive are curled with fringed and curly leaves and escarole, which has broader, thicker, smooth leaves [Rodkiewicz 2005].

Endive is one of the most nutritious and health benefits leafy vegetables. It contains more of minerals (especially phosphorus, calcium and potassium), pro-vitamin A and

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vitamins B_1, B_2 and C, in comparison with lettuce which is more popular in our country. Because of the high content of bitter compounds endive has properties aiding in digestion [Cieślik et al. 2009].

Endive is also a crop of a little climatic requirements. However, long lasting drought and high air temperatures can cause bolting (premature flowering).

From the point of view of quantity and quality of the yield it seems to be important to specify the best planting date for growing endive in open field conditions. Moreover, one of the most important factor determining productivity of the crop cultivation is plant density.

In present study the effect of planting date and transplant spacing on the quantity and quality of yield of endive – botanical variety of escarole, was estimated.

MATERIAL AND METHODS

The experiment was conducted in the years 2006–2008 in the Horticultural Experimental Station in Dołuje. In the study a suitability of Italian cultivar of endive ('Blonda a cuor pleno') from escarole group for cultivation in the climatic conditions of Western Pomerania was estimated.

The experiment was set in two-factorial, split-block design with four replications. There were four planting dates (from sowing seeds on 10, 20, 30 June and 10 July) compared. Objects of the second experimental factor (transplant spacing) were: 40 × 25 and 40 × 35 cm. Plot area was 2.80 m^2 (1.75 × 1.60 m). Forecrop for the endive was an early head cabbage. Mineral fertilization was quantified according to the results of the chemical analysis of the soil samples and supplemented to recommended for lettuce level (N – 70, P – 60, K – 200 $mg \cdot dm^{-3}$ – Sady 2006). The course of the weather conditions during vegetation period of endive is presented in table 1. Endive was grown from transplants obtained from sowing seeds in the seed-bed. Transplants were planted into the open field at the phase of 4–5 leaves (dates of sowing and transplant planting are presented in table 2), spaced 40 × 25 and 40 × 35 cm.

Table 1. Meteorological data from the period of endive growing in years 2006–2008
Tabela 1. Dane meteorologiczne w okresie uprawy endywii w latach 2006–2008

Specification Wyszczególnienie	Years Lata	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	Oktober Październik
Mean daily air temperature Średnia dobowa temperatura powietrza °C	2006	20	23.9	17.7	16.1	12.8
	2007	18.3	18.2	18.3	13.1	10.5
	2008	17.6	19.2	18.6	13.6	9.8
Total rainfall Suma opadów mm	2006	19.3	5.2	37.2	9.26	3.0
	2007	150.4	158.9	95.3	75.6	96.7
	2008	28.4	59.3	51.5	45.4	68.0

During growing season, the crop management treatments were carried out. These included mainly soil scarification, weeding and in case of need irrigation and leaf rosette blanching (conducted about two weeks before harvest). Plants were blanched by covering rosettes with plastic caps. Just before blanching, in order to protect the plants from fungal diseases they were sprayed with Sumilex 500 S.C. (0.2% solution).

Table 2. Dates of growing on endive types eskarola
Tabela 2. Terminy uprawy endywii odmiany botanicznej eskariola

Growing date Termin uprawy	Sowing – Siew			Planting – Sadzenie			Harvest – Zbiór		
	2006	2007	2008	2006	2007	2008	2006	2007	2008
First Pierwszy	10.60	10.60	10.60	30.06	10.07	12.07	26.08	29.08	28.08
Second Drugi	20.06	20.06	20.06	30.07	19.07	18.07	13.09	04.09	8.09
Third Trzeci	30.06	30.06	30.06	10.08	27.07	24.07	25.09	17.09	30.09
Fourth Czwarty	10.07	10.07	10.07	20.08	20.08	25.08	04.10	10.10	16.10

One-time harvest was carried out on dates presented in table 2. After the harvest the quantity of the total yield of whole rosettes, including the marketable yield of blanched, inner leaves of rosettes, was assessed. Moreover, measurements of the following quality characteristics of the yield were taken: mean weight of leaf rosette including the weight of blanched part of rosette, number of leaves per rosette, and length and width of leaves. The results of endive yielding were subjected to an analysis of variance. The means were separated by the Tukey's test at $p = 0.05$.

RESULTS AND DISCUSSION

In table 3 the results of quantity of leaf rosette yield according to the planting date and plant spacing were presented. In each year of the study, there had been a significant effect of tested in the experiment factors on this yield characteristics proved.

In the first year of the study – the highest total yield of leaf rosettes was obtained from the latest planting date (32.9 $t \cdot ha^{-1}$). Significantly lower yield was collected when seeds were sown on 10 and 20 June (first and second planting date). Planting endive transplants at 40 × 25 cm spacing increased the yield of whole rosettes by 29.6% in comparison with plants grown at spacing of 40 × 35 cm.

In the second year of the study significantly higher leaf rosette yield was obtained when seeds were planted on 20 and 30 June (second and third planting date). Significantly the least yield was noted for the latest planting date.

In the third year of the study – significantly the highest mass of rosettes was collected from the second date of planting. The least yield was obtained from sowing seeds on 10 July (forth planting date). In 2008 as well as in 2007, significantly higher total yield of rosettes was obtained from planting the transplants at 40 × 25 cm spacing.

Table 3. Evaluation of selected features of produce in dependence on growing date and plant density (mean for the years 2006–2008)
Tabela 3. Ocena wybranych cech plonu w zależności od terminu uprawy oraz gęstości sadzenia rozsady (średnio z lat 2006–2008)

Growing date Termin uprawy	Planting density, cm Rozstawa roślin, cm	Weight of leaf rosette ($g \cdot plant^{-1}$) Masa rozety liściowej ($g \cdot roślina^{-1}$)	The mass of blanched part of leaf rosette ($g \cdot plant^{-1}$) Masa wybielonej części rozety ($g \cdot roślina^{-1}$)	Plant diameter Średnica rozety liściowej cm	Lenght of leaves Długość blaszki liściowej cm	Width of leaf Szerokość blaszki liściowej cm
First Pierwszy	40 × 25	667.2	420.3	28.75	16.9	11.0
	40 × 35	646.0	385.8	26.70	15.2	11.3
	mean – średnio	656.6	403.1	27.73	16.1	11.2
Second Drugi	40 × 25	624.1	310.8	32.45	17.9	12.0
	40 × 35	650.1	362.1	30.35	16.3	10.5
	mean – średnio	637.1	336.5	31.40	17.1	11.3
Third Trzeci	40 × 25	661.4	330.7	36.50	18.4	12.8
	40 × 35	676.6	358.6	32.95	16.6	10.9
	mean – średnio	669.0	344.7	34.73	17.5	11.9
Fourth Czwarty	40 × 25	535.7	347.1	32.05	16.7	11.7
	40 × 35	461.8	285.4	30.50	15.7	11.0
	mean – średnio	498.8	316.3	31.28	16.2	11.4
Mean for planting density Średnio dla gęstości sadzenia	40 × 25	622.1	352.2	32.44	17.5	11.9
	40 × 35	608.6	348.0	30.13	16.0	10.9
LSD – $NIR_{\alpha = 0.05}$						
growing date – termin uprawy		18.607	33.24	4.171	n.s.	n.s.
planting density – gęstość sadzenia		11.319	n.s.	1.298	0.271	0.461
interaction – interakcja		26.760	42.536	2.600	2.541	0.992

n.s. – nonsignificant differences – różnice nieistotne

On average for the years 2006–2008 significantly the highest yield of leaf rosettes was collected from the third planting date (sowing seeds on 30 June). Also, more productive effects were noted when spacing of 40 × 25 cm was used.

Moreover, on the base of data given in table 4, a significant effect of the experimental factors on the marketable yield quantity was proved. In 2006 significantly better effects of yielding were proved in regard to the latest planting dates (third and forth date). The least yield of blanched inner leaves was noted for the earliest sowing date (10 June). For each of the tested in the experiment planting date, significantly higher marketable yield was noted when transplants were planted at spacing of 40 × 25 cm.

Table 4. Influence of growing date and plant density on the marketable yield of endive
Tabela 4. Wpływ terminu uprawy oraz gęstości sadzenia rozsady na wielkość plonu handlowego endywii

Growing date Termin urawy	Planting density Rozstawa roślin cm	Marketable yield Plon handlowy t·ha^{-1}			
		2006	2007	2008	2006–2008
First Pierwszy	40 × 25	16.64	18.3	26.95	20.63
	40 × 35	12.51	15.9	19.52	15.98
	mean – średnio	14.58	17.10	23.24	18.31
Second Drugi	40 × 25	18.90	16.2	17.20	17.43
	40×35	13.30	15.6	14.08	14.33
	mean – średnio	16.10	15.90	15.64	15.88
Third Trzeci	40 × 25	19.33	16.2	24.40	19.98
	40 × 35	15.78	16.8	23.57	18.72
	mean średnio	17.56	16.50	23.99	19.35
Fourth Czwarty	40 × 25	20.62	12.1	15.34	16.02
	40 × 35	16.41	12.7	11.79	12.88
	mean – średnio	18.52	12.40	13.57	14.45
Mean for planting density	40 × 25	18.87	15.70	20.97	18.52
Średnio dla gęstości sadzenia	40 × 35	14.50	15.25	17.24	15.48
LSD – $NIR_{\alpha = 0.05}$					
growing date (I) – termin uprawy		1.062	1.104	0.891	0.752
planting density (II) – gęstość sadzenia		0.335	n.s.	0.779	1.164
interaction – interakcja (I × II)		1.129	n.s.	1.635	2.327

n.s. – nonsignificant differences – różnice nieistotne

In the year 2007 significantly higher marketable yield of rosettes, in comparison with cultivation at the second and the forth planting date, was obtained form the earliest date of planting (sowing seeds on 10 June). However, there were no significant differences of the yielding found according to different plant densities.

In the third year of the experiment significantly higher effects of yielding were noted for the first and third planting date (sowing seeds on 10 and 30 June). The least marketable yield was collected when plants were planted later (sowing on 10 July). Increasing number of plants per row increased the quantity of the yield.

Statistical analysis of the study results proved significance of both of the experimental factors in regard to the quantity of marketable yield of endive. On average for the

three years of the study significantly the highest yield of inner leaves of rosettes was obtained from the third date of planting (sowing seeds on 30 June). Planting endive transplant at 40 × 25 cm spacing had an effect on increase of marketable yield by 22.7% in comparison with spacing of 40 × 35 cm.

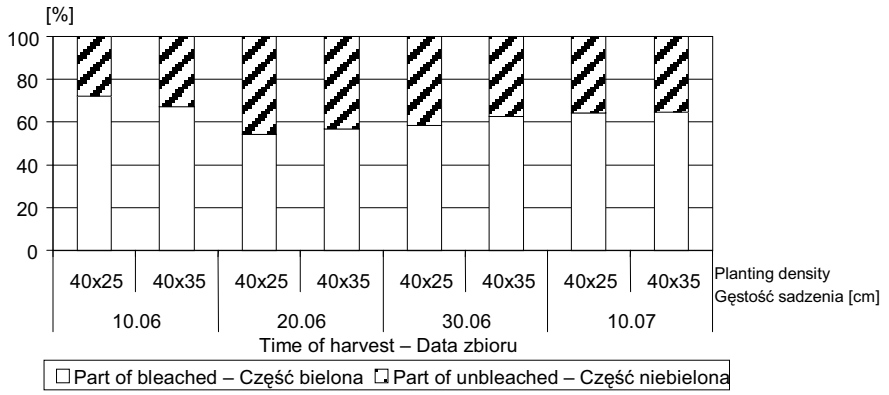

Fig. 1. Participation of marketable yield in total yield of endive (mean for the years 2006–2008)
Ryc. 1. Udział plonu handlowego w plonie całkowitym endywii (średnio z lat 2006–2008)

Statistical analysis of the results of the years 2006–2008 proved a significant effect of used in the experiment planting dates on the mean weight of leaf rosettes of endive (tab. 5). Significantly higher weight of rosettes was assessed when endive was grown in the first and the third date of planting (sowing seeds on 10 and 30 June). According to the mean weight of inner blanched leaves of endive rosettes, the most positive appeared the first date of planting.

Leaf rosettes of the highest weight and diameter were collected when the spacing of 40 × 25 cm was used. However, plant spacing did not have a significant effect on the weight of blanched leaves of rosettes.

Also, there was no significant influence of planting date on the size of leaves found. However, significantly longer and wider leaf blades were noted for plants which were cultivated at the spacing of 40 × 25 cm.

The results of conducted experiment proved that yielding of endive cultivar 'Blonda a cuor pleno' (from escarole group) was strongly affected by the thermal conditions during the vegetation of plants.

On average for the years 2006–2008 significantly the highest marketable yield of inner leaves per rosette was collected from the third planting date. The worst weather conditions were observed in the year 2006. In that year of the study the least marketable yield of endive rosettes was obtained when seed were sown on 10 June (first date of planting). The reason of that decrease were high temperatures of June and July which caused premature flowering in the case of 27% of the plants. This problem was also analysed by Badoux et al. [1990], and Buczkowska and Sałata [1995]. In opinion of Böchmig [1993] seeds of endive should not be sown before middle of June because it

might cause premature flowering of the plants. The experiment considering planting dates of endive was conducted also by Rodkiewicz [2005]. The author proved that in the conditions of the middle part of the Lublin region, it is possible to obtain a marketable yield of endive from sowing seeds from first decade of June till the middle of July. However, when seeds were sown in the first decade of June the yield of endive decreased. The reason of this was a tendency of cultivar 'Bossa' for premature flowering affected by the length of the day.

Table 5. Influence of growing date and plant density on the yield of endive
Tabela 5. Wpływ terminu uprawy oraz gęstości sadzenia rozsady na plonowanie endywii

Growing date Termin uprawy	Planting density Gęstość sadzenia cm	Total yield Plon całkowity t·ha^{-1}			
		2006	2007	2008	2006–2008
First Pierwszy	40 × 25	23.32	27.80	34.38	28.50
	40 × 35	16.08	24.50	30.81	23.80
	mean – średnio	19.70	16.15	32.60	26.15
Second Drugi	40 × 25	20.53	40.10	35.48	32.04
	40 × 35	15.37	35.90	24.39	25.22
	mean – średnio	17.95	38.00	29.94	28.63
Third Trzeci	40 × 25	28.28	40.30	33.57	34.05
	40 × 35	25.85	36.20	32.02	31.36
	mean – średnio	27.07	38.25	32.80	32.71
Fourth Czwarty	40 × 25	38.09	22.90	24.91	28.63
	40 × 35	27.75	20.90	19.52	22.72
	mean – średnio	32.92	21.90	22.22	25.68
Mean for planting density Średnio dla gęstości sadzenia	40 × 25	27.56	30.28	32.09	30.81
	40 × 35	21.26	26.88	26.69	25.78
LSD – $NIR_{\alpha 0.05}$					
growing date – termin uprawy (I)		2.358	1.020	1.872	1.349
planting density – gęstość sadzenia (II)		0.849	0.916	0.746	1.393
interaction – interakcja (I × II)		1.697	1.832	1.492	3.786

One of the most important factors having an effect on the quantity of the yield is a plant spacing. Differentiation of density of plants per unit of area gives possibility of regulation of the size of edible part of such vegetables as e.g. cauliflower [Csizinszky 1996, Wlazło et al. 2006] or broccoli [Knaflewski and Spiżewski 2001; Schellenberg et al. 2009]. The use of proper plant spacing had an effect on obtaining on the one hand florets of a high diameter (aimed for direct consumption) and on the other hand smaller ones – useful for freezing.

Mabako and Du Plooy [2009] carried out the experiment aimed to the estimation of plant growth and yield quantity of four cultivars of lettuce according to the plant density: 20 × 10 cm (50 plants per 1 m^2), 25 × 10 cm (40 plants per 1 m^2), 20 × 15 cm (30 plants per 1 m^2), 20 × 20 cm (25 plants per 1 m^2) and 25 × 20 cm (20 plants per 1 m^2). There was a similar reaction of the lettuce cultivars on the changes in plant density proved. The highest yield of the fresh leaves, and the highest size and number of leaves were assessed for the highest plant density amounted to 50 plants per 1 m^2.

In the experiment of Biesiada [2008] higher planting density had an effect on obtaining significantly higher yield of kohlrabi. However, at the same time it has decreased the weight of tubers. This corresponds with investigation of Filho et al. [2007]. The authors found that decrease of distance between rows from 40 to 30 cm had an effect on decrease of mean weight of lettuce head from 460.3 g to 321.1 g. This opinion is not in agreement with the results of the present study. Increase of planting density from 35 cm to 25 cm did not have a significant effect on decrease of mean weight of leaf rosettes.

Also, the results of studies carried out by Uklańska and Adamczewska-Sowińska [2010] confirmed that planting date and cultivar of endive had an effect on quantity and quality of the yield. In their experiment 14 cultivars of endive were grown in two dates: spring and autumn. More profitable was autumn planting (transplant planting on 23 August). The obtained yield was by 58.5% higher in comparison with the spring planting. There were differences between endive cultivars according to the bolting found. Higher tendency for premature flowering was noted for plants grown in spring period (planting on 8 April) what had a strong effect on decrease of their marketable yield.

Similar research at this area was conducted by Francke [2008]. The author investigated the effect of date and method of cultivation on the quantity and quality of the yield of leaf chicory grown in the open field. Chicory was cultivated in two dates: spring (from harvests 14 June – 6 July) and summer-autumn (harvests were on 27 September – 27 October). For this species more profitable date was spring planting – marketable yield was by 19% higher in comparison with summer-autumn planting. However, planting date had no significant effect on such yield characteristics as: weight of plant and number of leaves.

CONCLUSIONS

1. In regard to quantity of the yield of endive cultivar 'Blonda a cuor pleno' the third date of planting (sowing seeds on 30 June) was found as more profitable.

2. The highest participation of marketable yield in the total yield of leaf rosettes was assessed for the earliest sowing date (10 June).

3. Transplant planting at spacing of 40 × 25 cm had an effect on increase of leaf rosette yield on average by 22.7% in comparison with growing endive at 40 × 35cm spacing.

4. Increase of number of plants per row did not had an influence on decrease of weight and diameter of leaf rosette.

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WPŁYW TERMINU UPRAWY ORAZ ROZSAWY ROŚLIN NA PLONOWANIE ENDYWII (*Cichorium endivia* L.)

Streszczenie: W latach 2006–2008 przeprowadzono doświadczenie, w którym oceniono plonowanie endywii włoskiej odmiany 'Blonda a cuor pleno' (z grupy eskariola) uprawianej w warunkach Pomorza Zachodniego. W badaniach porównywano cztery terminy uprawy endywii (z wysiewu nasion 10, 20 i 30.06 oraz 10.07). Stosowano dwie rozstawy roślin: 40 × 25 i 40 × 35 cm. Istotnie największy plon rozet liściowych zebrano z wysiewu nasion 30.06. Stosowanie wysiewu nasion 10.06 przyczyniło się natomiast do uzyskania rozet o największej masie jednostkowej. Z tego terminu uprawy uzyskano jednak mniejszy plon handlowy z powodu przedwczesnego tworzenia organów generatywnych pod wpływem długiego dnia. Wykazano istotnie większy plon rozet o największej masie i średnicy z sadzenia rozsady 40 × 25 cm.

Słowa kluczowe: eskariola, uprawa polowa, zagęszczenie roślin, wielkość i jakość plonu

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