ISSN 1644-0692
www.acta.media.pl

Acta Sci. Pol. Hortorum Cultus 14(2), 2015, 75-85

CONTROL OF HEAD SIZE AND NUTRITIONAL VALUE OF CABBAGE BY PLANT POPULATION AND NITROGEN FERTILIZATION

Eugeniusz Kołota, Piotr Chohura
Wrocław University of Environmental and Life Sciences

Abstract. Small size of cabbage heads around 2.0 kg, preferred by the fresh market, may be attained by the choice of cultivar suitable for such purpose of production as well as culture practice, including reasonable rate of fertilization. The aim of the study was to evaluate the impact of increasing plant population combined with differentiated dose of nitrogen on yield of cabbage, its structure and plant composition. White head cabbage 'Kalorama F_1' cv. was planted in rows 45 cm apart and 50, 40, 35 or 30 cm within rows, which assured 44 000, 55 000, 63 000 and 74 000 plants per 1 ha, respectively. Nitrogen at the rates of 150 or 300 kg ha^{-1} was used in 3 equal doses supplied as preplant and top dressing fertilization. Data obtained in the trial indicate that the dose of 150 kg N ha^{-1} was a limiting factor for the increment of crop yield in higher than 44 000 plant population per 1 ha. In the case of application the dose of 300 kg N ha^{-1} plants grown in population 63 000 and 74 000 per hectare produced significantly higher yield of heads if compared to the treatment with 44 000 plants. Taking into account the yield size and its structure it can be assumed that spacing 45 cm between plant rows and 40 cm distance in the row, which assure 55 000 plants per 1 ha is the optimum for production of cabbage heads weighted 1.0–2.0 kg, that meet the consumers expectation in the fresh market. Close plant spacing appeared to be beneficial for dry matter, vitamin C and total sugars contents and for decrease of nitrates accumulation. The enhancement of N dose to 300 kg N ha^{-1} was beneficial for total yield of heads as well those weighted > 1.0 kg. The only change in plant composition under influence of heavy N fertilization was the increment of nitrates accumulation and decrease of Ca content in cabbage heads.

Key words: *Brassica oleracea* var. *capitata*, vitamin C, planting density, nitrates

Corresponding author: Department of Horticulture, Wrocław University of Environmental and Life Sciences, Pl. Grunwaldzki 24a, 50-363 Wrocław, Poland, e-mail: eugeniusz.kolota@up.wroc.pl

INTRODUCTION

Cabbage, beside tomato and onion, is one of the most popular vegetable crop worldwide, with total annual production around 62 million metric tons (FAO STAT, 2012). The major areas of commercial production are located in Asia and Europe in such countries as China, India, Russian Federation, Japan, Korea Republic, Poland and Ukraine. There are large quantity of open pollinated as well as hybrid cultivars which are well adapted to different growing purposes. Cabbage grown for early market should characterize the high rate of growth and is harvested as soon as it attains sufficient size, which meet the consumer's requirements. Delay in harvesting is associated with the risk of heads to crack and rot. Midseason and late cultivars are not harvested until the heads reach the full size and become firm and hard.

Cabbage heads used for processing are larger than those for storage or fresh market, with weight ranging from 5 up to 8 kg and diameter from 20 to 40 cm [Rubatzky and Yamaguchi 1997]. They are frequently mechanically harvested while smaller size heads for long storage purpose weighted within 2–3 kg are recommended to be harvested manually [Krug 1991]. The new trend for many European and United States fresh markets is a preference of head weights of 1–2 kg.

Reduced head size may be achieved mainly by the use of high density planting, cultivar choice and under application some of other factors such as method of cultivation, the rate of water supply, and fertilization level [Illert 2005]. Seed companies offer some new cultivars recommended for growing in high population such as 'Eminenze' (Clause), 'Impala F_1' and 'Coraflex' (Bejo Zaden), 'Kalorama F_1' (Rijk Zwaan) or suitable for cultivation in different spacing, which allow to control the head size e.g. 'Squadron F_1' (Clause) or 'Lion F_1' (Nickerson-Zwaan).

The efficient way to decrease the mean weight of heads and enhancement of crop yield is the increment of plant population, which was observed in the experiments with different vegetable crops [Rumpel and Felczyński 1997, Knaflewski and Spiżewski 2001, Wlazło et al. 2006, Zhang et al. 2009, Venkata et al. 2013, Żurawik et al. 2013]. In the case of cabbage it was found that generally, the use of low plant population has increased cabbage head size but simultaneously reduced marketable yield per hectare [White and Forbes 1976, Knavel and Herron 1981, Cizinszky and Schuster 1985]. In the study conducted by Stoffella and Fleming [1990] the optimum cabbage yields, head size and head quality characteristics with reduced plant-to-plant variability were achieved with population 61 500 or lower number of plants per hectare. Heads obtained from high plant population had a higher green color of leaves [White and Forbes 1976].

According to the data obtained by White and Forbes [1976] the other factor influencing the crop yield and weight of head is the level of nitrogen fertilization. The increasing amount of this nutrient from 140 to 310 kg N kg^{-1} was favorable for both, yield and mean weight of cabbage heads. They concluded that nitrogen may have been a limiting factor in head weight in cultivation of cabbage in high population exceeding 4.3 plants per 1 m^2. Maximum dose of nitrogen recommended for white head cabbage in Polish conditions is 300 kg N kg N ha^{-1} or the content of mineral N (NH_4^++NO_3^--N) on the level within 105–130 mg dm^{-3}.

The objective of this study was to determine the effect of increasing plant population of late cabbage grown at two rates of nitrogen fertilization on yield of particular size of heads, and their nutritional value at harvest.

MATERIAL AND METHODS

Field experiment was conducted in 2011–2013 at Piastów Horticultural Experimental Station (long. 17º00'E, lat. 51º05'N) on a sandy clay soil with pH 7.25 and organic matter content 1.8%. Soil content of available forms of phosphorus was equal to 55–64 mg dm^{-3}, 50–68 mg dm^{-3} of potassium, 80–96 mg dm^{-3} of magnesium, 1650–1845 mg dm^{-3} of calcium and 20–30 mg dm^{-3} of mineral nitrogen (NH_4-N + NO_3-N), depending on the year of the trial. Content of tested elements in the soil was examined by universal method [Nowosielski 1974] extraction with 0.03 M CH_3COOH.

Cabbage was grown at the recommended standard level of phosphorus and potassium available forms equal to 80 mg P and 200 mg K per 1 dm^3 of the soil. The required doses of these nutrients were established on the basis of annual chemical test of soil samples and applied in the form of triple superphosphate and potassium chloride 3–4 days before planting and mixed with the soil by harrowing. Nitrogen in the form of ammonium nitrate was supplied at the rates of 150 or 300 kg N ha^{-1} divided in 3 equal doses applied as preplant fertilization and two top dressing done in three weeks after planting and at the end of July.

'Kalorama F_1' cultivar a traditional Dutch white cabbage was used in the trial. It has a round dark green head with a short internal core. Long-term cold storage is enhanced by its intermediate disease resistance. It matures in 140–150 days and can be planted in high densities (60 000–80 000 plants per hectare) to produce small dense heads weighted within 1–3 kg.

Seeds of white head cabbage were sown into multicell trays filled with standard peat moss substrate in 23–25 April. Seedlings produced in the greenhouse, during last ten days were hardened in non heated plastic tunnel. Well developed transplants with 3–4 leaves were planted into the open field at the beginning of June, in rows 45 cm apart and 50, 40, 35 or 30 cm within rows, which assured 44 000, 55 000, 63 000 and 74 000 plants per hectare, respectively. Crop management followed the commonly accepted recommendations for this vegetable species cultivated without irrigation. Only small variation in weather conditions were noted in particular years of the trial. Mean air temperature for the whole growing periods varied within 16.1–16.8ºC, while the sum of rainfall from 290 mm to 307 mm.

The experiment was established in two split-plot factorial design with different plant spacing as the first and nitrogen as the second factor, in four replications and plot area 9.72 m^2 (2.7 × 3.6 m).

Single plant harvest took place within 5–10 of September, depending of the year of study. The fully developed heads were trimmed from the outer loose leaves, counted and divided into the following grades: > 2.0 kg, 1.5–2.0 kg, 1.0–1.5 kg and < 1.0 kg. Trimmed head weights of particular classes were calculated for a hectare area and those over 1.0 kg of weight were recognized as the marketable yield. At harvest, samples of

25 heads within the grade of 1.5–2.0 kg from each treatment were collected for chemical analysis. The subject of assessment in raw material was the content of dry matter (drying at 105ºC to the constant weight – PN-90/A-7501/11) and nitrates amount expressed as NO_3^- (potentiometric method by using ion-selective electrode Orion). In dry material after extraction by 2% acetic acid [Yash 1998] there was evaluated the content of P, and Mg (colorimetric method), Ca and K (flame photometric method).

The obtained data were subjected to statistical evaluation on the basis of variance analysis for two factorial design, and the least significant differences were calculated using Tukey test at a significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

The effects of tested factors on cabbage yield, its structure and plant composition were similar in the subsequent years of experiment, and for this reason, they are presented as the means for three years. Results of the study shown in Table 1 indicate that the total yield of heads was affected by plant population only at high rate of nitrogen. At 150 kg N ha^{-1} higher plant populations were limited by the amount of nitrogen being to low for maximum yield. Similar effects indicating no response to high plant density at lower N doses were also recorded by White and Forbes [1976]. In the case of use of 300 kg N ha^{-1}, plants grown in population 63 000 or 74 000 per hectare produced significantly higher yield of cabbage if compared to the population 44 000 plants. These results are generally in agreement with those reported by Cebula and Kalisz [2006] who did not observe any clear tendency in yield changes when plant spacing increased from 30 to 50 within the rows and 67.5 cm between rows in treatments with moderate N application equal to 140 kg N ha^{-1}. Beneficial effect of high plant population on marketable yield of cabbage was observed in most of studies conducted by White and Forbes [1976], Knavel and Heron [1981], and Cizinszky and Schuster [1985]. Also Stoffella and Fleming [1990] stated the same linear? relations in the case if plant population increased gradually from 24 000 to 61 500 and in one of two years of the study up to 123 00 per 1 ha.

Table 1. Total yield of cabbage heads influenced by the plant population and N rate (t·ha^{-1})

Plant population per 1 ha	Nitrogen rate (kg·ha^{-1})		
	150	300	mean
44 000	69.15 a	75.66 b	72.41 A
55 000	70.15 a	78.35b c	74.25 AB
63 000	71.07 a	83.29 c	77.18 B
74 000	71.50 a	81.31 c	76.44 B
Mean	70.74 A	79.65 B	

Notes. Within rows the means marked with varied big letters differ significantly. Within columns the means marked with varied big letters differ significantly. Within rows and columns the means marked with varied small letters differ significantly

Data of our study confirm general opinion, that the use of high plant population is associated with the decrement of head size of cabbage. It was expressed by the drastic reduction the yield of large heads of cabbage with mean weight > 2.0 kg along with enhancement of plant population within 44 000 and 74 000 per 1 ha (tab. 2). This trend was especially pronounced in treatments with heavy nitrogen application, where the yield of this class of heads decreased from 37.82 t ha^{-1} to 5.98 t ha^{-1}. Similar effects of different plant density were observed in the yield of 1.5–2.0 kg heads, but only in the case of application 150 N ha^{-1}. In contradiction to these findings, the smaller grade heads with weight 1.0–1.5 kg and especially < 1.0 kg substantially increased with the decreasing plant spacing (tab. 3).

Table 2. Yield of cabbage heads grad > 2 kg and 1.5–2.0 kg ($t \cdot ha^{-1}$) influenced by plant population and N rate

Plant population per 1 ha	Grade > 2.0 kg			Grade 1.5–2.0 kg		
	150 kg $N \cdot ha^{-1}$	300 kg $N \cdot ha^{-1}$	mean	150 kg $N \cdot ha^{-1}$	300 kg $N \cdot ha^{-1}$	mean
44 000	24.80 e	37.82 f	31.31 C	24.96 d	31.22 c	23.09 C
55 000	15.15 c	17.80 d	16.47 B	19.47 b	23.01 c	21.24 B
63 000	11.00 b	13.42 b	12.21 B	18.28 b	20.78 bc	19.53 A
74 000	7.20 a	5.98 a	6.59 A	13.74 a	22.31 c	18.02 A
Mean	14.54 A	18.75 B		19.11 A	21.83 B	

Explanations: see Table 1.

Table 3. Yield of cabbage heads grade 1.0–1.5 kg and < 1.0 kg ($t \cdot ha^{-1}$) influenced by plant population and N rate

Plant population per 1 ha	Grade 1.0–1.5 kg			Grade < 1.0 kg		
	150 kg $N \cdot ha^{-1}$	300 kg $N \cdot ha^{-1}$	mean	150 kg $N \cdot ha^{-1}$	300 kg $N \cdot ha^{-1}$	mean
44 000	15.63 b	13.24 a	14.44 A	3.76 a	3.38 a	3.57 A
55 000	24.75 c	28.82 de	26.79 B	10.78 c	8.72 b	4.75 A
63 000	27.35 d	31.68 f	29.52 C	14.44 d	17.41 e	15.93 B
74 000	29.56 e	32.40 f	30.98 C	21.00 f	20.62 f	20.81 C
Mean	24.32 A	26.54 B		12.50 A	12.53 A	

Explanations: see Table 1.

Nitrogen fertilization appeared to be the other factor influencing the yield and size of trimmed cabbage heads. Application of 300 kg N ha^{-1} resulted in a significant an enhancement of total marketable yield, irrespective of plant population, if compared to half of this dose. This effect was mostly due to increase the heads class > 2.0 kg and to lower degree classes 1.5–2.0 kg and 1.0–1.5 kg. No considerable differences under influence of nitrogen nutrition were noted in the grade of heads < 1.0 kg.

The results of the study revealed that plant spacing highly affected the structure of cabbage yield (fig. 1a–1d). In treatment with the lowest plant population equal to 44 000 per 1 ha the heads weighted > 2.0 kg participated by 43.3% in total marketable yield, while at population 74 000 only in 8.6%. The reverse relations were observed for the class of a very small heads weighted < 1.0 kg, which participated in total yield in 4.9 and 27.2%, respectively. Heads within 1–2 kg, which are considered as the most preferred for fresh market supply constituted 51.8% in treatments of 44 000 plants and increased to 63.7% in the other investigated populations.

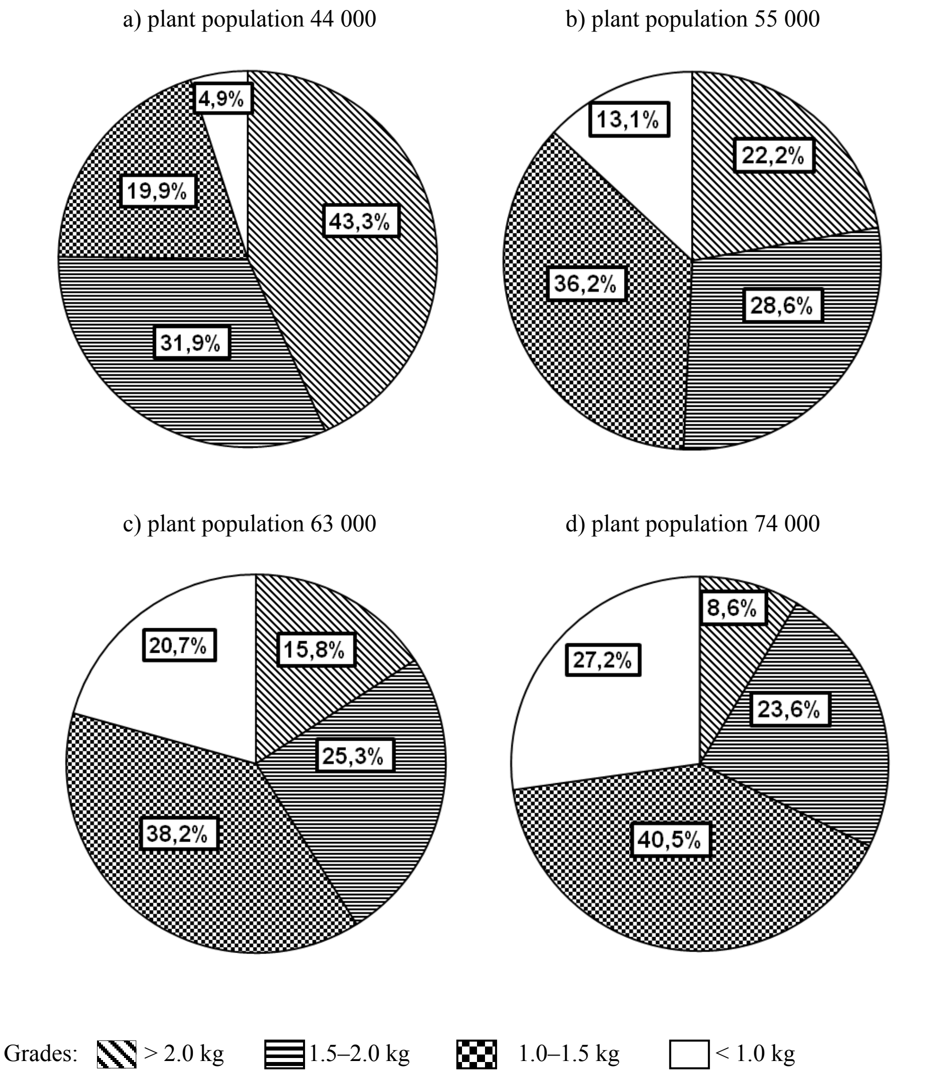

Fig. 1. Structure of cabbage yield (%) depending on plant population

Taking into account the data comprising the yield size as well its structure, it can be assumed that spacing 45 cm between plants rows and 40 cm distance in the row, which assure 55 000 plants per hectare is the optimum for production of cabbage heads weighted 1.0–2.0 kg that meet the consumers expectation in the fresh market. Further increment of plant population which did not provided the significant enhancement of crop yield and share of the heads 1.0–2.0 kg, could not be recommended to the practice because of higher costs of transplant production, crop management as well as labor input for harvest and trimming the heads.

The effect of nitrogen fertilization on the structure of cabbage yield was not so pronounced (fig. 2a and b). Irrespective of the plant population, the application of 300 kg N ha^{-1} was favorable mostly for percentage of heads > 2.0 kg but had no a substantial influence on share of heads classes 1.0–1.5 and 1.5–2.0 kg.

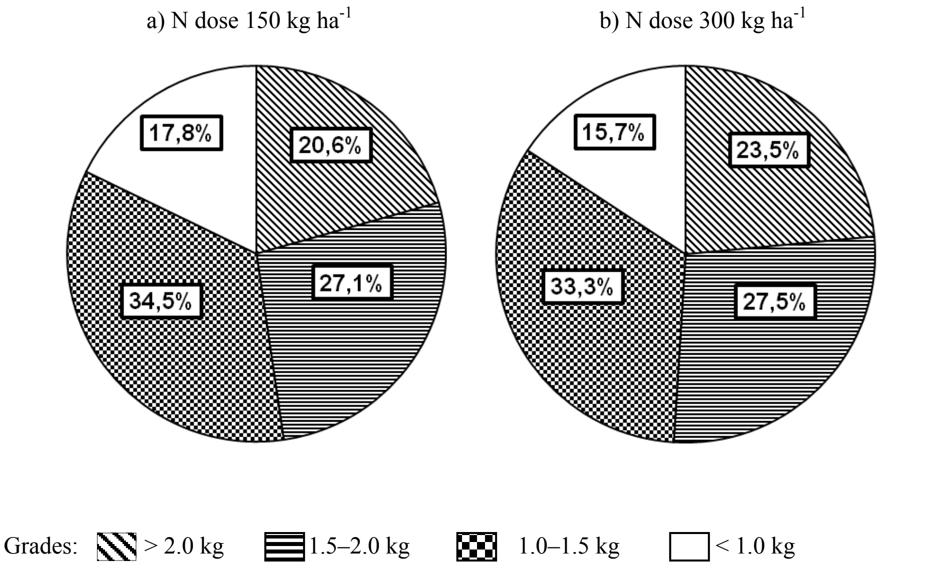

Fig. 2. Structure of cabbage yield (%) depending on nitrogen fertilization

Table 4. Dry matter and total sugars content in cabbage heads influenced by the plant population and N rate

Plant population per 1 ha	Dry matter (%)			Total sugars (% f.w.)		
	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean
44 000	8.15 b	7.72 a	7.94 A	3.96 ab	3.90 ab	3.93 A
55 000	7.99 ab	7.96 ab	7.97 A	4.23 b	3.80 a	4.01 A
63 000	8.23 b	8.09 b	8.16 A	4.10 b	4.53 c	4.32 B
74 000	8.69 c	8.29 b	8.49 B	4.24 b	4.21 b	4.23 B
Mean	8.26 A	8.02 A		4.13 A	4.11 A	

Explanations: see Table 1.

Table 5. Vitamin C and nitrates content in cabbage heads influenced by the plant population and N rate

Plant population per 1 ha	Vitamin C (mg·100 g^{-1} f.w.)			Nitrates (mg NO_3·kg^{-1} f.w.)		
	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean
44 000	45.7 a	46.9 ab	46.3 A	1249 b	1431 d	1342 B
55 000	44.0 bc	47.6 b	45.8 A	1316 c	1418 d	1369 B
63 000	48.1 b	46.7 ab	47.4 A	1232 b	1391 cd	1311 B
74 000	50.6 c	54.1 d	52.4 B	1240 b	1054 a	1147 A
Mean	47.1 A	48.8 A		1259 A	1323 B	

Explanations: see Table 1.

Table 6. Phosphorus and potassium content in cabbage heads influenced by the plant population and N rate

Plant population per 1 ha	Phosphorus (mg·100 g^{-1} d.m.)			Potassium (% in d.m.)		
	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean
44 000	303 a	323 b	313 A	3.21 b	2.93 a	3.07 A
55 000	323 b	328 b	325 AB	3.45 c	3.25 b	3.35 C
63 000	344 c	322 b	333 B	3.17 b	3.25 b	3.21 B
74 000	315 ab	326 b	321 AB	3.03 a	3.17 b	3.10 A
Mean	321 A	325 A		3.22 A	3.15 A	

Explanations: see Table 1.

Table 7. Calcium and magnesium content in cabbage heads influenced by the plant population and N rate

Plant population per 1 ha	Calcium (mg·100 g^{-1} d.m.)			Magnesium (mg·100 g^{-1} d.m.)		
	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean	150 kg N·ha^{-1}	300 kg N·ha^{-1}	mean
44 000	581 b	566 c	573 C	194 c	193 c	194 B
55 000	563 c	505 ab	534 B	205 d	179 b	192 B
63 000	558 c	518 b	538 B	160 a	177 b	168 A
74 000	510 b	485 a	498 A	166 a	163 a	164 A
Mean	553 B	518 A		181 A	178 A	

Explanations: see Table 1.

Beside of high yield of smaller weight heads, the other benefits of cultivation the cabbage in high density is more uniform head size, which is an important and desired factor for a single plant harvest, and lighter green color outer leaves preferred by the consumers [White and Forbes 1976, Stoffella and Fleming 1990]. Some data obtained in research conducted with cabbage and broccoli indicate the impact of plant spacing and chemical composition of edible parts of these vegetable species [Cebula et al. 2006, Wlazło et al. 2006, Grabowska et al. 2009], especially dry matter, vitamin C and nitrates content. In our study, in reverse to Cebula et al. [2006] findings, the high plant populations equal 74 000 per 1 ha was preferable for dry matter and vitamin C while together with population of 63 000 plants on sugar contents (tab. 4 and 5). All these compounds were not affected by the applied doses of nitrogen. Taking into account all studied treatments, the content of vitamin C varied from 44.0 to 54.1 mg 100 g^{-1} f.w., maintaining within the range of 30 to 65 mg described by Ghosh and Madhavi [1998].

High density of plants assured the decrease of calcium, magnesium, and at the dose of 300 kg N ha^{-1} also nitrates accumulation. The changes in phosphorus and potassium amounts though often significant did not show any clear tendencies under influence of plant population (tab. 5–7). Heavy nitrogen fertilization did not cause any considerable differences in mineral composition of cabbage heads. The only exception was the decrease of calcium content in treatment with application the dose of 300 kg N ha^{-1}.

CONCLUSION

1. Reduced plant spacing can be considered as an efficient factor to control the head size of cabbage, while to much lower degree the limited rate of nitrogen fertilization.
2. The increment of plant population over 44 000 per 1 ha was favorable for the total yield of trimmed heads, and especially the grade 1–2 kg, the most preferable for the fresh market only in the case of heavy nitrogen fertilization at the rate 300 kg N ha^{-1}.
3. Close spacing, which assured 74 000 plants per hectare appeared to be beneficial for dry matter, vitamin C and total sugar contents while for the decrease of nitrates accumulation. The adverse impact was observed in the case of calcium and magnesium contents.
4. The enhancement of N dose from 150 to 300 kg N ha^{-1} caused a significant increment of the yield of cabbage, and nitrates accumulation while the decrease of Ca content in edible parts.

REFERENCES

Cebula, S., Kalisz, A., Kunicki, E. (2006). Wpływ zagęszczania roślin na wartość odżywczą kilku odmian kapusty głowiastej białej przed i po przechowywaniu. Folia Hort., Supl., 1, 88–93.

Cebula, S., Kalisz, A. (2006). Zależność pomiędzy zagęszczeniem roślin a plonowaniem i jakością handlową kilku odmian kapusty głowiastej białej. Folia Hort. Supl., 1, 82–87.

Cizinszky, A.A., Schuster, D.J. (1985). Response of cabbage to insecticide schedule, plant spacing, and fertilizer rates. J. Amer. Soc. Hort. Sci., 110, 888–893.

FAOSTAT (2012). http://www.fao.org/home/en/.

Ghosh, S.P., Madhavi, R. (1998). Cabbage. In: Handbook of vegetable science and technology. Production, composition, storage and processing, Salunkhe, D.K., Kadam, S.S. (eds). Marcel Dekker INC. New York.

Grabowska, A., Kunicki, E., Libik, A. (2009). The effects of different methods of cultivation and plant spacing on the chemical composition of broccoli heads. Folia Hort, 21/2, 25–34.
Illert, S. (2005). Mini-Gemüse. Gemüse, 12, 66–68.
Knaflewski, M., Spiżewski, T. (1991). Effect of plant density on the yield and quality of broccoli. Veg. Crop Res. Bull., 55, 65–69.
Knavel, D.E., Herron, J.W. (1981). Influence of tillage system, plant spacing, and nitrogen on head weight, yield, and nutrient concentration in cabbage. J. Amer. Soc. Hort. Sci., 106, 540–545.
Krug, H. (1991). Gemüseproduktion. Ein Lehr und Nachschlagewerk für Studium und Praxis. Verlag Paul Parey. Berlin und Hamburg.
Nowosielski, O. (1974). Metody oznaczania potrzeb nawożenia. Wyd. II, PWRiL, Warszawa. Polska Norma. PN-90/A-7501/11.
Rubatzky, V., Yamaguchi, M. (1997). World vegetables. Principles, production, and nutritive value. Chapman & Hall, New York.
Rumpel, J., Felczyński, K. (1997). Effect of plant density and cultivar on yield responses in onions (*Allium cepa*) grown from seeds. Acta Agrobot., 50 (1–2), 221–229.
Stoffellal, P.J., Fleming, M.F. (1990). Plant population influences yield variability of cabbage. J. Amer. Soc. Hrt. Sci., 115(5), 708–711.
United States Standards for Grades of Cabbage (1997). http:/www.ams.usda.gov./AMSv1.0/getfile?dDocName=STELPRDC5050254.
Venkata, R., Subbaiah, G., Veeraraghavaiah, R. (2013). Agronomic responses of maize to plant population and nitrogen availability – a review. Internat. J. Plant Anim. Environ. Sci., 4(1), 107–116.
White, J.M., Forbes, R.B. (1976). Effect of spacing and fertilizer ratio on cabbage yield and head weight. Proc. Fla. State Hort. Soc., 89, 118–120.
Wlazło, A., Kunicki, E., Libik, A. (2006). Effect of growing method and plant density on yield of broccoli. Folia Hort., Supl., 2, 197–202.
Yash, P.K. (1998). Handbook on reference methods for soil analysis. Taylor & Francis, New York.
Zhang, F.L., Yu, Y.J., Zhang, D.S., Xu, J.B., Zhao, X.Y., Yu, S.C., Lu, G.X. (2009). A new mini-type Chinese cabbage F_1 hybrid – 'Jingqiuwawacai' for autumn cultivation. China Veget., 24, 72–73.
Żurawik, A., Jadczak, D., Żurawik, P. (2013). The influence of selected agricultural factors on yield and content of some components of Welsh onion (*Allium fistulosum* L.) 'Sprint'. Acta Agrobot., 66(1), 105–112.

STEROWANIE WIELKOŚCIĄ GŁÓWEK I WARTOŚCIĄ ODŻYWCZĄ KAPUSTY POPRZEZ OBSADĘ ROŚLIN I NAWOŻENIE AZOTEM

Streszczenie. Obecnie najbardziej preferowane na rynku małe główki kapusty (o masie ok. 2,0 kg), można uzyskać poprzez dobór odpowiedniej odmiany, jak również właściwe zabiegi agrotechniczne, w tym umiarkowane nawożenie azotem. Celem przeprowadzonych badań była ocena wpływu zwiększonego zagęszczenia roślin i dawki azotu na plonowanie i strukturę plonu kapusty z uwzględnieniem jej wartości odżywczej. Kapustę głowiastą białą odmiany 'Kalorama F_1' uprawiano w rozstawie międzyrzędzi 45 cm, a w rzędzie, co 50, 40, 35 i 30 cm, co zapewniało obsadę roślin na 1 ha wynoszącą odpowiednio 44 000, 55 000, 63 000 i 74 000 szt. Azot zastosowano w ilościach 150 i 300 kg ha^{-1} podzielonych na 3 równe dawki. Na podstawie przeprowadzonych badań wykazano, że dawka azotu wynosząca 150 kg N ha^{-1} była czynnikiem ograniczającym wzrost plonu kapusty przy obsadzie roślin większej od 44 000 szt. ha^{-1}. Po zastosowaniu azotu w ilości 300 kg N ha^{-1} plon kapusty uprawianej w obsadzie 63 000 i 74 000 szt. ha^{-1} był istotnie większy w porównaniu z obsadą 44 000 szt. Biorąc pod uwagę zarówno wielkość plonu, jak i jego strukturę, można stwierdzić, że rozstawa między rzędami wynosząca 45 cm i 40 cm w rzędzie i dająca obsadę 55 000 szt. roślin na 1 ha jest optymalna do uzyskania wysokiego plonu główek o masie 1,0–2,0 kg. Zwiększanie zagęszczenia roślin wpłynęło również korzystnie na wzrost zawartości suchej masy, witaminy C i cukrów oraz przyczyniło się do ograniczenia akumulacji azotanów w główkach kapusty. Zwiększenie dawki azotu do 300 kg N ha^{-1} wpłynęło korzystnie na plon ogólny główek kapusty oraz frakcji o masie > 1,0 kg. Jedyne spowodowane intensywnym nawożeniem azotem zmiany w składzie chemicznym roślin to wzrost akumulacji azotanów i zmniejszenie zawartości wapnia w częściach jadalnych kapusty.

Słowa kluczowe: *Brassica oleracea* var. *capitata,* witamna C, azotany, struktura plonu

Accepted for print: 13.02.2015

For citation: Kołota, E., Chohura, P. (2015). Control of head size and nutritional value of cabbage by plant population and nitrogen fertilization. Acta Sci. Pol. Hortorum Cultus, 14(2), 75–85.