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EFFECT OF GROWING DATE AND CULTIVAR ON THE MORPHOLOGICAL PARAMETERS AND YIELD OF *Brassica rapa* var. *japonica*

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Abstract. The *Brassica rapa* var. *japonica* is a valuable plant, commonly cultivated in the Far East. It is still unknown vegetable crop in Poland. It is necessary to assess plant response to field conditions in Polish climatic zone before introducing this species to the large-scale production. The aim of the study was to evaluate the effect of growing date (transplants were planted out to the field in the middle and at the end of August – 1st and 2nd production term, respectively) and cultivar (Mibuna, Mizuna) on morphological parameters, yielding and chemical composition of the plants. Before planting out, transplants of Mibuna have been found to be larger than Mizuna, the differences in the contents of chemical components in these cultivars were statistically insignificant at this time (with the exception of dry matter). The transplants from a later production term were characterized by greater fresh weight and height, longer leaves, and lower content of dry matter, soluble sugars and carotenoids. Based on collected data regression equations were developed to predict the course of growth and development of *Brassica rapa* var. *japonica* during field vegetation with a precision of more than 94%. There were no statistical differences in yields among cultivars, while significant effect of growing date was observed. The total and commercial yield was higher by 3.34 and 3.77 t·ha^{-1}, respectively, in the 2nd production term than in an earlier one. During harvests the content of chlorophylls, carotenoids and L-ascorbic acid was higher in the rosettes of Mibuna cultivar, while Mizuna had more dry matter and soluble sugars. Production of the plants from later plantings resulted in significantly increased soluble sugars content in the rosettes, but the reduction in dry matter and L-ascorbic acid was observed.

Key words: Mibuna, Mizuna, term of production, transplants, yield quantity and quality

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INTRODUCTION

The assortment of vegetables cultivated in Poland is constantly widening. New vegetable species, not known earlier on a large scale, are introduced to the market offer. Headed Chinese cabbage (*Brassica pekinensis*) and still not widely known pak choy (*Brassica chinensis*) are examples of such plants [Kalisz 2010b]. A lot of members of *Brassicacea* family are still not presenton Polish market. Many of them could be cultivated in the climate conditions of Central Europe, for example *Brassica rapa* var. *japonica* (var. *nipposinica*). This vegetable crop is particularly common in Japan, two groups of cultivars are used: Mibunaand Mizuna [Larkcom 2007]. Both create dense leaf rosettes, and the leaves are placed on long, thin petioles. Cultivar Mizuna creates finely dissected leaves, similar to rocket, and Mibuna has leaves tended to be longer and narrower with rounded tips [Rubatzky and Yamaguchi 1997]. In Poland, the vegetable crop may be cultivated in open field, most of all with the assignment for the autumn harvest. In the spring plants often bolt into inflorescenced shoots prematurely [Larkcom 2007]. It is interesting to test what the most profitable term to planting out the plants is – in terms of the quantity and quality of the yield, assuming the late harvest. It seems crucial to develop a precise timing schedule of the field cultivation for *Brassica rapa* var. *japonica*, species, which characterizes with fast growth. The choice of the proper growing term favours the maximal usage of the potential of the vegetable crops or their cultivars and lead to increase of yielding [Cebula and Kalisz 1997a]. It is connected with different weather conditions in different periods of production, which highly influence the plant growth and its market quality [Siomos 1999, Kałużewicz et al. 2010, Rekowska and Jurga-Szlempo 2011]. The weather conditions undoubtedly influence the chemical composition of the harvested crops. They affect the plants in different ways depending on the period of the cultivation [Kobryń 2001, Mirecki 2006, Francke et al. 2008]. The influence of the microclimate may be visible as early as the juvenile stage, while the transplants are being prepared [Kalisz et al. 2006, Kalisz 2010a]. It is an important element of horticultural science to recognize this aspect of production. It is even more important, because the leafy vegetable *Brassica rapa* is considered as a rich source of nutrients and bioactive substances [Artemyeva et al. 2006]. The vegetable crops belonging to *Brassica rapa* are worth introducing onto the Polish market.

MATERIAL AND METHODS

The experiment with the species of *Brassica rapa* var. *japonica* was conducted in the years 2004–2005 in greenhouses of the University of Agriculture in Krakow and in the experimental field in Krakow-Mydlniki (south Poland). The production of transplants was conducted with multi-cells trays VEFI A/S (black multi pallets with 96 cells, cone-shaped with 53 cm^3 capacity of a single cell). The following cultivars of *Brassica rapa* var. *japonica* were used (factor I): Mibuna and Mizuna (fig. 1).

Seeds were sown in two terms (factor II): on 19 July 2004 and 21 July 2005 (1^{st} term); 2August 2004 and 3 August 2005(2^{nd} term). Seedlings production took about 3–4 weeks. The plants were planted out in spacing of 40×25 cm, in the middle and at

the end of August. The experimental objects included 4 replications, on each plot there were 30 plants (with the marginal belts). The plot intended for the yields was 2.4 m^2 and covered 24 plants. The amount of fertilizers was calculated on the base of soil analyzes to achieve the content of nutrients (in 1 dm^3 of soil) on the level of 100 mg N, 80 mg P, 150 mg K and 1500 mg Ca. During harvesting the weight of each single rosette and the number of the plants from the plot were precisely defined. The marketable yield consisted of the rosettes without damages, ripe, healthy. The yield with no market value included the plants with disease symptoms, damages made by insects, deformed. The share of the marketable yield in the total yield was calculated based on the amount of the marketable rosettes vs. all harvested plants. The first harvest took place around the middle of September (1st term) or in the first ten days of October (2nd term). The production of the vegetable crop in the fields condition in the 1st term took about 30 days from planting, whereas in the 2nd term – 42 days.

Fig. 1. Plants of *Brassica rapa* var. *japonica* cv. Mibuna (on the left) and Mizuna (on the right)
Rys. 1. Rośliny *Brassica rapa* var. *japonica* odm. Mibuna (po lewej) oraz Mizuna (po prawej)

During field cultivation the microclimate conditions were automatically registered (air temperature) using the autonomous sensors HOBO Pro RH/Temp. (Onset Computer Corp., USA) with 1-hour intervals. The data was compiled in terms of twenty four hours and used to calculate the average air temperature in the suitable periods of cultivation (tab. 1). The data concerning the rainfalls gained from IMGW (Institute of Meteorology and Water Management) station in Krakow-Balice was also included.

Before the planting out the morphology evaluation of the transplants from each experimental object was conducted. The measurements included: the transplant height, the number of leaves per plant (leaves that were longer than 1 cm), the area of visually

biggest leaf (KSRUN 3.0, Carl Zeiss Vision GmbH program), the leaf length. The plant material was analyzed in a laboratory for fresh matter of the above-ground part (weight method, Sartorius A 120S), the content of the dry matter (dryer method, temp. 92–95°C), soluble sugars (anthrone method) and carotenoids (Lichtenthaler and Wellburn method).

Table 1. Thermal conditions and precipitation during field production of *Brassica rapa* var. *japonica*
Tabela 1. Warunki termiczne i opady podczas polowej produkcji *Brassica rapa* var. *japonica*

Year Rok	Growing date Termin uprawy	Air temperature Temperatura powietrza (°C)			Precipitation Opady (mm)
		mean	min	max	
2004	1st term – 1. termin	16.0	8.3	24.7	50.6
	2st term – 2. termin	12.0	5.3	20.0	60.2
2005	1st term – 1. termin	17.7	10.7	26.5	50.0
	2st term – 2. termin	13.5	7.0	22.2	28.8
Mean for 2004–2005 Średnia dla 2004–2005	1st term – 1. termin	16.9	9.5	25.6	50.3
	2st term – 2. termin	12.8	6.2	21.1	44.5

During vegetation in the field, 3 or 5 measurements of the rosette height and diameter were conducted (respectively in the 1st and the 2nd term) in each experimental object, on 10 precisely marked plants. The measurements were started after 2 weeks from planting and continued with weekly intervals. The data were statistically analyzed (with $p < 0.05$) in order to creating regression equations for the prediction of the growth and development of the plants. In this case the simple regression was used, evaluating the precision of the models based on the correlation coefficient (r) and determination coefficient (R^2).

During harvesting the plant material was collected in order to perform analysis for dry matter and soluble sugars content (methods as described above). The content of L-ascorbic acid (Tillmans method), crude fibre [Jermakov 1972], chlorophyll "a" and "b" and carotenoids (Lichtenthaler and Wellburn method) were marked as well. Chlorophyll "a" to chlorophyll "b" ratio (ChlA : ChlB ratio) was also calculated.

In order to present the data in the synthetic way, the averages of 2 years of the experiments were prepared. The results were evaluated statistically based on the analysis of ANOVA variance in STATISTICA program (StatSoft Inc., USA) with the usage of HSD Tukey's test with $p < 0.05$.

RESULTS

The morphological characteristics of *Brassica rapa* var. *japonica* transplants is presented in the table 2. The bigger plants were observed for Mibuna cultivar, only when it

comes to the length of leaves the differences were not statistically significant. The height of transplants and the length of leaves turned out to be bigger in the 2nd term of production. The leaf area and leaf number were similar and did not depend on this experimental factor. In the case of these parameters the increasing trend in the 2nd term of production may be discussed, however, it was not confirmed statistically.

Table 2. Morphological parameters of *Brassica rapa* var. *japonica* transplants before planting out

Tabela 2. Parametry morfologiczne rozsady *Brassica rapa* var. *japonica* przed sadzeniem

Growing date Termin uprawy	Cultivar Odmiana	Height Wysokość cm	Leaf number Liczba liści	Leaf area Powierzchnia liści cm^2	Leaf length Długość liści cm
1st term – 1. termin	Mibuna	20.1 a	12.3 b	20.1 b	20.5 b
	Mizuna	19.9 a	10.2 a	16.3 a	19.3 a
2nd term – 2. termin	Mibuna	22.1 b	12.6 b	20.9 b	21.7 c
	Mizuna	21.7 b	10.4 a	18.2 ab	22.1 c
Mean for growing date Średnia dla terminu uprawy	1st term 1. termin	20.0 A	11.3 A	18.2 A	19.9 A
	2nd term 2. termin	21.9 B	11.5 A	19.6 A	21.9 B
Mean for cultivar Średnia dla odmiany	Mibuna	21.1 B	12.5 B	20.5 B	21.1 A
	Mizuna	20.8 A	10.3 A	17.3 A	20.7 A

Mean values within a column, followed by different letters are significantly different at $p < 0.05$ (Tukey's HSD test)

Średnie w obrębie kolumn oznaczone różnymi literami różnią się istotnie przy $p < 0,05$ (test HSD Tukeya)

The transplants produced in the 2nd term had significantly greater fresh matter (tab. 3), whereas dry matter, soluble sugar and carotenoid contents were statistically greater in the earlier period. Mizuna cultivar consisted greater amount of the dry matter in comparison to the Mibuna–these averages differed significantly. The level of the fresh matter, sugars and carotenoids do not indicate any changes depending on the genetic factor. Interaction between the experimental factors was observed. Except for the fresh matter, in the case of both cultivars the decrease of the dry matter, soluble sugars and carotenoids contents was observed in the 2nd term of production. The highest decrease of the dry matter and soluble sugar contents was noted for Mizuna cultivar, whereas in the case of carotenoids for Mibuna.

The simple regression for the changes in the height of the plants during vegetation in the field is presented in figure 2. It is clear that the faster increase of height was observed in the case of plants in the 1st term of cultivation, which achieved full ripeness earlier. The longer period of vegetation of the plants in the 2nd term allowed a greater number of conducted measurements. The regression equations, appointed to prediction changes in the rosette height(y) versus time, took the following form (DAT – the number of days from planting): 1st term $y = -947.69 + 9.55 * DAT$ ($r = 0.99$, $R^2 = 0.98$) and 2nd term $y = -804.21 + 8.10 * DAT$ ($r = 0.99$, $R^2 = 0.97$). The high values of the R^2 (determination coefficients) are noticeable. These values explain more than 97% of changes of the dependent variable.

Table 3. Plant fresh matter and content of dry matter, soluble sugars and carotenoids in *Brassica rapa* var. *japonica* transplants before planting out

Tabela 3. Świeża masa roślin oraz zawartość suchej masy, cukrów rozpuszczalnych i karotenoidów w rozsadzie *Brassica rapa* var. *japonica* przed sadzeniem

Growing date Termin uprawy	Cultivar Odmiana	Fresh matter g·plant^{-1} Świeża masa g·roślinę$^{-1}$	Dry matter % f.m. Sucha masa % św.m.	Soluble sugars % f.m. Cukry rozp. % św.m.	Carotenoids mg·100 g^{-1} f.m. Karotenoidy mg·100 g^{-1} św.m.
1st term – 1. termin	Mibuna	5.20 ab	8.73 c	1.40 b	32.71 b
	Mizuna	4.98 a	9.30 d	1.44 b	31.18 b
2nd term – 2. termin	Mibuna	6.70 c	6.54 a	0.81 a	24.88 a
	Mizuna	6.19 bc	6.76 b	0.79 a	26.44 a
Mean for growing date Średnia dla terminu uprawy	1st term 1. termin	5.09 A	9.02 B	1.42 B	31.95 B
	2nd term 2. termin	6.45 B	6.65 A	0.80 A	25.66 A
Mean for cultivar Średnia dla odmiany	Mibuna	5.95 A	7.64 A	1.11 A	28.80 A
	Mizuna	5.59 A	8.03 B	1.12 A	28.81 A

Mean values within a column, followed by different letters are significantly different at $p < 0.05$ (Tukey's HSD test)

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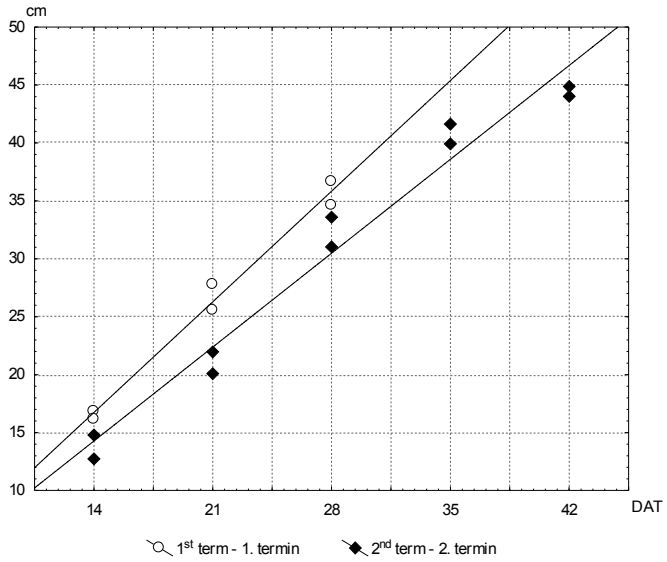

Fig. 2. Prediction of *Brassica rapa* var. *japonica* height over time (DAT – days after transplanting) during vegetation in the field as dependent on term of production

Rys. 2. Przewidywanie wysokości *Brassica rapa* var. *japonica* w czasie (DAT – liczba dni od posadzenia) podczas wegetacji w polu w zależności od terminu uprawy

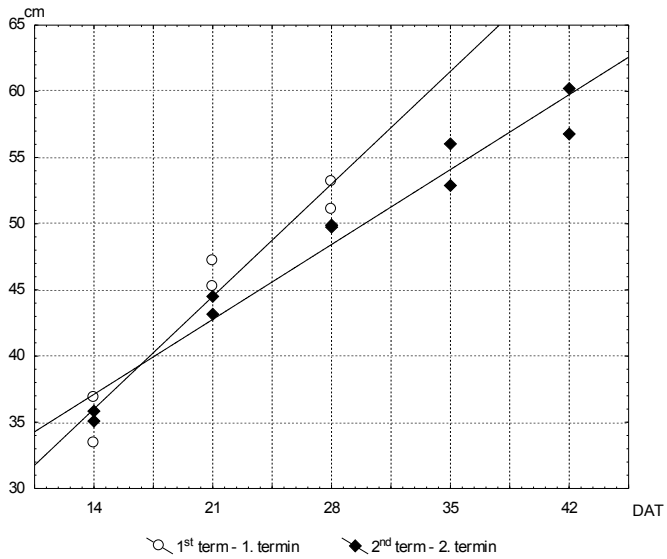

Fig. 3. Prediction of *Brassica rapa* var. *japonica* rosette diameter over time (DAT – days after transplanting) during vegetation in the field as dependent on term of production
Rys. 3. Przewidywanie rozpiętości rozet *Brassica rapa* var. *japonica* w czasie (DAT – liczba dni od posadzenia) podczas wegetacji w polu w zależności od terminu uprawy

Table 4. Influence of growing date and cultivar on the yielding of *Brassica rapa* var. *japonica*
Tabela 4. Wpływ terminu uprawy oraz odmiany na plonowanie *Brassica rapa* var. *japonica*

Growing date Termin uprawy	Cultivar Odmiana	Total yield Plon ogólny t·ha^{-1}	Marketable yield Plon handlowy t·ha^{-1}	Share of marketable yield in total yield Udział plonu handlowego w plonie ogólnym %	Marketable rosette weight Średnia masa rozety handlowej kg
1st term – 1. termin	Mibuna	54.55 a	52.23 a	91.9	0.59 a
	Mizuna	59.10 ab	57.94 b	95.2	0.62 ab
2nd term – 2. termin	Mibuna	61.78 b	60.87 b	95.3	0.65 b
	Mizuna	58.56 ab	56.85 ab	94.2	0.62 ab
Mean for growing date Średnia dla terminu uprawy	1st term 1. termin	56.83 A	55.09 A	93.6	0.61 A
	2nd term 2. termin	60.17 B	58.86 B	94.8	0.64 B
Mean for cultivar Średnia dla odmiany	Mibuna	58.17 A	56.55 A	93.6	0.62 A
	Mizuna	58.83 A	57.40 A	94.7	0.62 A

Mean values within a column, followed by different letters are significantly different at $p < 0.05$ (Tukey's HSD test)
Średnie w obrębie kolumn oznaczone różnymi literami różnią się istotnie przy $p < 0,05$ (test HSD Tukeya)

The simple regression lines, which explain the changes in the diameter of analyzed rosettes during field cultivation, took quite similar shape (fig. 3). And in that case the rosette diameter increased more in the earlier cultivation. The conditions during the 2nd term caused slower growth of the plants. To describe the changes in this growth parameter the following regression equations may be used (y – rosette diameter, DAT – days after planting): 1st term $y = -822.50 + 8.50 * DAT$ ($r = 0.97$, $R^2 = 0.94$) and 2nd term $y = -534.53 + 5.66 * DAT$ ($r = 0.98$, $R^2 = 0.96$). The determination coefficients turned out to be very high, however lower in comparison to obtained for rosette height.

No significant differences in the yield of the two tested cultivars of *Brassica rapa* var. *japonica* and in their average rosette weight were observed (tab. 4). The share of the marketable yield in the total yield was aligned. On the other hand the influence of the cultivation term on the yield of the tested species was observed. Greater yield (total and marketable) and greater average rosette weight were obtained from the cultivation conducted in the 2nd term. Share of marketable rosettes in the total yield was also higher at that time in comparison to the earlier production. Interaction of the experimental factors was significant especially for Mibuna cultivar. It gave higher yield and formed greater rosettes during the production from later planting. The structure of Mibuna total yield was also improved. For Mizuna cultivar the effect of interaction turned out not to be statistically significant.

Table 5. Content of dry matter, soluble sugars, crude fibre and carotenoids of *Brassica rapa* var. *japonica* rosettes during harvest

Tabela 5. Zawartość suchej masy, cukrów rozpuszczalnych, błonnika surowego i karotenoidów w rozetach *Brassica rapa* var. *japonica* podczas zbioru

Growing date Termin uprawy	Cultivar Odmiana	Dry matter % f.m. Suchamasa % św.m.	Soluble sugars % f.m. Cukry rozp. % św.m.	Crude fibre % d.m. Błonnnik surowy % s.m.	Carotenoids mg·100 g^{-1} f.m. Karotenoidy mg·100 g^{-1} św.m.
1st term – 1. termin	Mibuna	4.26 b	0.55 a	17.34 a	1.56 b
	Mizuna	4.47 c	0.63 ab	17.58 ab	0.56 a
2nd term – 2. termin	Mibuna	4.09 a	0.65 b	17.96 b	1.60 b
	Mizuna	4.42 c	0.72 b	17.38 a	0.45 a
Mean for growing date Średnia dla terminu uprawy	1st term 1. termin	4.37 B	0.59 A	17.46 A	1.06 A
	2nd term 2. termin	4.26 A	0.69 B	17.67 A	1.03 A
Mean for cultivar Średnia dla odmiany	Mibuna	4.18 A	0.60 A	17.65 A	1.58 B
	Mizuna	4.45 B	0.68 B	17.48 A	0.51 A

Mean values within a column, followed by different letters are significantly different at $p < 0.05$ (Tukey's HSD test)

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The content of dry matter and soluble sugars was higher in rosettes of Mizuna cultivar, while Mibuna cultivar synthesized more of carotenoids (tab. 5). The influence of cultivar on the level of crude fibre was not significant. The content of crude fibre and carotenoids was not significantly modified by the cultivation period. Whereas more dry

matter was observed in the plants cultivated in the 1st term, and more soluble sugars were observed in rosettes harvested in the 2nd term of the production. The greater decrease of dry matter in the delayed cultivation was observed for cultivar Mibuna in comparison to Mizuna. For Mibuna, significant increase of soluble sugars and crude fibre content was observed in the 2nd term of production. The influence of interaction on carotenoids synthesis by the plants was ambiguous.

Table 6. Content of L-ascorbic acid, chlorophyll "a" (ChlA) and chlorophyll "b" (ChlB), and ChlA : ChlB ratio of *Brassica rapa* var. *japonica* rosettes during harvest

Tabela 6. Zawartość kwasu L-askorbinowego, chlorofilu „a" (ChlA) i chlorofilu „b" (ChlB) oraz stosunek ChlA : ChlB w rozetach *Brassica rapa* var. *japonica* podczas zbioru

Growing date Termin uprawy	Cultivar Odmiana	ChlA mg·100 g^{-1}f.m. mg·100 g^{-1} św.m	ChlB mg·100 g^{-1}f.m. mg·100 g^{-1} św.m	ChlA : ChlB ratio Stosunek ChlA : ChlB	L-ascorbic acid mg% f.m. Kwas L-askorbinowy mg% św.m.
1st term – 1. termin	Mibuna	4.04 b	1.84 b	2.20 b	26.58 d
	Mizuna	1.54 a	0.74 a	2.08 ab	18.55 b
2nd term – 2. termin	Mibuna	4.06 b	1.89 b	2.15 ab	24.24 c
	Mizuna	1.13 a	0.60 a	1.88 a	17.50 a
Mean for growing date Średnia dla terminu uprawy	1st term 1. termin	2.79 A	1.29 A	2.14 A	22.57 B
	2nd term 2. termin	2.60 A	1.25 A	2.02 A	20.87 A
Mean for cultivar Średnia dla odmiany	Mibuna	4.05 B	1.87 B	2.18 B	25.41 B
	Mizuna	1.34 A	0.67 A	1.98 A	18.03 A

Mean values within a column, followed by different letters are significantly different at $p < 0.05$ (Tukey's HSD test)

Średnie w obrębie kolumn oznaczone różnymi literami różnią się istotnie przy $p < 0,05$ (test HSD Tukeya)

The level of chlorophyll pigments ("a" and "b"), ChlA: ChlB ratio and the content of L-ascorbic acid were higher in rosettes of Mibuna cultivar (tab. 6). There was no clearly correlation between pigment and the production term. Significantly higher amount of L-ascorbic acid was observed in the case of plants cultivated from the earlier plantings. Modifying influence of the cultivation term on the level of pigments and ChlA: ChlB ratio was not significant fortested cultivars. There was a decrease of L-ascorbic acid observed in the case of both cultivars as an effect of delayed production, however the decrease was the highest for Mibuna.

DISCUSSION

The genetic factor influenced significantly most of the morphological parameters of transplants. Mibuna was characterized by greater size of the plants before planting out to the field. The differences in the chemical composition between transplants of investi-

gated cultivars usually were not significant, only the significant difference in the dry matter occurred. The effect of the genetic factor on the morphological characteristics of the plants may be observed not only in the full ripeness stage, but also earlier, in the juvenile stage [Kalisz 2010a]. The cultivar may influence the chemical composition of the transplants [Cebula 2009], more significantly than observed in this experiment. The term of production had stronger influence on themorphological transplant parameters, mainlytheir chemical composition. The transplants grown in a greenhouse are under the controlled conditions. Despite of this, greenhouse microclimate (for example light and temperature) depend on the weather conditions outside [Kobryń 2001]. The slightly different course of climate factors in 1st and 2ndterm of transplant production (data not shown) had an influence on the some morphological parameters of the juvenile plants, as confirmed by a statistical analysis. The relation between the production term and the content of selected chemical components in the transplants and their morphological characteristics were also described for *Brassica pekinensis* species [Kalisz et al. 2006, Kalisz 2010a].

The development of simple regression models for predicting the course of the growth of plants in the field at different terms gave valuable information about the expected time of harvest. Such models can be useful for species not cultivated in Poland previously, such as *Brassica rapa* var. *japonica*. It was shown that rosettes reached larger sizes in shorter time, and therefore harvest began faster for the earlier term of production. Models of growth and development of vegetable crops are being created from the above reasons for the different species, cultivars and growth stages [Wurr et al. 2002]. Such models, based on time relations, were used in the present study. Similar models, showing changes in selected plant parameters (morphological or chemical) over time, were created for some Asian vegetable crops, including Chinese cabbage subsp. *chinensis* and Chinese cabbage subsp. *pekinensis* [Cho and Son 2007, Zhang et al. 2007, Kalisz 2010a].

An interesting result of the experiment was that two tested cultivars of *Brassica rapa* var. *japonica* gave comparable yield. The cultivars of *Brassica* vegetables usually differed in yield in a significant degree [Toth et al. 1998, Cebula 2009, Cebula et al. 2010]. According to Świąder [2005] there were significant differences in the yield of Mibuna Early and Mizuna Early cultivars, but only during spring-summer production. On the other hand, in summer-autumn production the yield was similar for both cultivars. In the present study, the influence of cultivation term on the yield was very clear. It was definitely greater for the 2nd term of cultivation. The effect of the term of production on the yield of different field vegetables was observed by many authors, i.a. for Chinese cabbage (*B. pekinensis*) [Kalisz 2010a], broccoli [Kałużewicz et al. 2010, Acikgoz 2011], cauliflower [Cebula and Kalisz 1997a, 1997b] and Brussels sprouts [Mirecki 2006]. Kobryń [2001] also observed the effect of this factor on the yield of Chinese cabbage (*B. chinensis*), grown in a greenhouse, but in the case of butterhead lettuce it was not significant. Varying the dates of sowing or planting resulted in different climate conditions encountered by plants during their vegetation in the field. It affects plant growth, development, and consequently the level of yield. We can recommend that *Brassica rapa* var. *japonica* should be planted in late August in Polish condi-

tions. However, it must be underlined that earlier planting of the transplants (early August) is associated with a significant shortening of the vegetation period in the field.

The results showed clear differences in the chemical composition of mature rosettes, depending on the cultivar. This kind of relationships is widely described in the literature for many species of vegetables, including white cabbage [Cebula et al. 2010], endive [Adamczewska-Sowińska and Uklańska 2009], Brussels sprouts [Mirecki 2006], broccoli [Acikgoz 2011], Chinese cabbage subsp. *chinensis* and Chinese cabbage subsp. *pekinensis* [Artemyeva et al. 2006] and different other oriental vegetables [Świąder and Radzanowska 2006]. According to Świąder and Radzanowska [2006] the content of carotenoids, chlorophyll "a" and "b" turned out to be higher in Mibuna Early cultivar in comparison to the Mizuna Early, similarly as in the present study. The amounts of dry matter and ascorbic acid marked for the plants of *Brassica rapa* var. *japonica* in the present experiment were lower than the values published by Artemyeva et al. [2006]. The same situation was observed for both chlorophylls and carotenoids, but differences were much greater. The term of cultivation had a significant effect on the level of many nutrients. It was observed for such vegetables like Chinese cabbage subsp. *pekinensis* [Kalisz 2010a], Brussels sprouts [Mirecki 2006], Chinese cabbage subsp. *chinensis* and butterhead lettuce [Kobryń 2001], broccoli [Acikgoz 2011], endive [Adamczewska-Sowinska and Uklańska] or radicchio chicory [Francke and Majkowska-Gadomska 2008]. In present experiment the influence of cultivation term resulted in significant changes in the dry matter, soluble sugar and L-ascorbic acid contents in the rosettes of *Brassica rapa* var. *japonica*. The amount of crude fibre and analyzed pigments was not depended on this factor. The L-ascorbic acid and dry matter content was higher in the earlier period of the production. In opposite, the plants from later cultivation had significantly more soluble sugars. Such differences in the content of these components were probably caused by the weather conditions [Lee and Kader 2000, Mirecki 2006].

CONCLUSIONS

1. Transplants of *Brassica rapa* var. *japonica* Mibuna cultivar before planting were larger than Mizuna. Differences in fresh matter, soluble sugars and carotenoids in the juvenile plants of tested cultivars were statistically insignificant.
2. Development of a simple regression models allowed to provide high precision prediction of growth and development of plants in different periods of field cultivation.
3. The yield of Mizuna and Mibuna was comparable. Later term of planting resulted in a significant increase in total and marketable yield by 5.9% and 6.8%,respectively.
4. The level of chlorophylls, carotenoids and L-ascorbic acid was higher in mature rosettes of Mibuna, while Mizuna had more dry matter and soluble sugars. More vitamin C and dry matter were found in the plants cultivated in the 1st term, while the delayed production resulted in increasing of the soluble sugar content.

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WPŁYW TERMINU UPRAWY I ODMIANY NA PARAMETRY MORFOLOGICZNE I PLON *Brassica rapa* var. *japonica*

Streszczenie. *Brassica rapa* var. *japonica* jest wartościową rośliną, powszechnie uprawianą na Dalekim Wschodzie. Nie jest jednak znana w Polsce. Aby wprowadzić to warzywo do towarowej produkcji, konieczna jest ocena reakcji roślin na warunki polowe, jakie napotkają w polskiej strefie klimatycznej. W badaniach oceniano wpływ terminu uprawy polowej (sadzenie rozsady połowa i koniec sierpnia– odpowiednio 1. i 2. okres produkcji) oraz odmiany (Mibuna, Mizuna) na parametry morfologiczne, plonowanie i skład chemiczny *Brassica rapa* var. *japonica*. Bezpośrednio przed sadzeniem stwierdzono większe rozmiary rozsady odmiany Mibuna niż Mizuna, lecz różnice w zawartości składników chemicznych w tych odmianach były w tym czasie statystycznie nieistotne (z wyjątkiem suchej masy). Rozsada wyprodukowana w terminie późniejszym cechowała się większą świeżą masą oraz wysokością i dłuższymi liśćmi, jednocześnie zawierała mniej suchej masy, cukrów rozpuszczalnych i karotenoidów. Na podstawie zebranych danych opracowano równania regresji prostej, dzięki którym możliwe jest prognozowanie przebiegu wzrostu i rozwoju roślin *Brassica rapa* var. *japonica* podczas wegetacji w polu z precyzją wynoszącą ponad 94%. Nie obserwowano znaczących różnic w plonowaniu w zależności od czynnika odmianowego, zaznaczył się jednak istotny wpływ terminu uprawy. Uzyskany plon ogólny i handlowy w 2. terminie produkcji okazał się wyższy o odpowiednio 3,34 i 3,77 $t \cdot ha^{-1}$ niż w uprawie wcześniejszej. W czasie zbiorów zawartość chlorofilów, karotenoidów i kwasu L-askorbinowego była wyższa w rozetach odmiany Mibuna, podczas gdy Mizuna posiadała więcej suchej masy oraz cukrów rozpuszczalnych. Uprawa roślin z nasadzeń późniejszych przyniosła istotne zwiększenie ilości cukrów rozpuszczalnych w rozetach, lecz obniżenie zawartości suchej masy i kwasu L-askorbinowego.

Słowa kluczowe: Mibuna, Mizuna, termin produkcji, rozsada, wielkość i jakość plonu

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