Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not Bot Horti Agrobo, 2013, 41(2):546-552

AcademicPres

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Effect of Growing Period and Cultivar on the Yield and Biological Value of *Brassica rapa* var. *narinosa*

Andrzej KALISZ*, Agnieszka SĘKARA, Joanna GIL, Aneta GRABOWSKA, Stanisław CEBULA

*University of Agriculture in Krakow, Department of Vegetable and Medicinal Plants, 29 Listopada 54, 31-425 Kraków, Poland; a.kalisz@ur.krakow.pl (*corresponding author)*

Abstract

The aim of the present study was to evaluate the usefulness of *Brassica rapa* var. *narinosa* for field production in Central European climatic zone in order to introduction of this species to large-scale farming. Chinese flat cabbage cultivars, 'Tatsoi' and 'Misome', were the object of the 2-year-long field experiment in south Poland, conducted in 2 terms: plantings in the middle and at the end of August, harvests in the middle of September and on the beginning of October (1st and 2nd growing period, respectively). Plants were evaluated for morphological and chemical variability at the transplant stage. The yield and bioactive compounds content in the leaf petioles of mature plants were also studied. Analyses of juvenile plants, conducted before transplanting, showed that 'Misome' transplants were greater, but they had less leaves then 'Tatsoi'. Transplants of both cultivars from the 2nd growing period had greater fresh weight, but the content of dry matter, soluble sugars and carotenoids was lower. Total and marketable yield, rosette mass, L-ascorbic acid and crude fibre content were greater for both cultivars planted in the middle of August and harvested in the middle of September. Leaf petioles of Chinese flat cabbage from the 2nd growing period were significantly richer in dry matter and soluble sugars. Only the level of carotenoids and chlorophylls was not influenced by the growing period. 'Misome' gave the greater marketable yield of better structure, and had a higher content of biologically active compounds than 'Tatsoi', with the exception of crude fibre. In Central Europe conditions, this cultivar should be recommended for plantings in the middle of August to achieve the best yields of high nutrient content.

Keywords: biological value, Chinese flat cabbage, timing, transplants, yield

Introduction

Brassica rapa var. *narinosa* (L.H. Bailey) Kitam. is a leafy vegetable, cultivated mainly in China, Japan and Korea. It is still hardy known vegetable in Europe. Common names of this Asiatic species are 'Chinese flat cabbage', 'ge cai', 'tatsoi' 'taasai' or 'rosette pakchoi'. As a leaf vegetable, Chinese flat cabbage has short storing life and should be produced near the markets. This species can be probably cultivated in Central Europe climatic zone from spring to winter because of not high thermal needs and short vegetation period (Larkcom, 2007). Leaves of this vegetable crop can be consumed from a stage of transplant, but it is recommended to harvest rosettes after 50-60 days from sowing or 30-40 days from transplanting (Larkcom, 2007). The crisp leaves and thick petioles of bitter taste are excellent for preparation as a boiled vegetable (Opeña *et al.*, 1988). Petioles and leave blades can be prepared separately, in different way. Petioles are often cooked by steaming or in the water; leaves are used fresh in salads or stewed.

The introduction of new vegetables in Europe should be preceded by the evaluation of plant response to local environmental conditions. It could be achieved by differentiation of planting times (timing) which exposes plants to various weather conditions. The advantage of proper selection of production term is yield increase (Cebula and Kalisz, 1997a, 1997b; Kobryń, 2001; Dufault *et al.*, 2006; Kalisz, 2010; Tendaj and Sawicki, 2012) and its biological value (Radovich *et al.*, 2005; Schreiner, 2005; Mirecki, 2006; Acikgoz, 2011). The choice of a cultivar with high acclimatization ability for introduction in new regions is also of a great importance (Schreiner, 2005; Artemyeva *et al.*, 2006; Dufault *et al.*, 2006; Acikgoz, 2011). The initiation of several Asiatic species from *Brassicaceae* family cultivation in Europe was followed by such investigations (Kobryń, 2001; Artemyeva *et al.*, 2006; Kalisz *et al.*, 2006; Acikgoz, 2012).

The introduction of new vegetables on European market can render a profit not only for producers but also for consumers, due to possibility of including to diet new vegetables of high biological value. The crops of genus *Brassica* contain many compounds of health promoting action (Schreiner, 2005; Podsędek, 2007; Cartea and Velasco, 2008). Chinese flat cabbage was not object of investigations in this discipline, and scientific literature is still not numerous not only in Europe but also in other regions of the world (Artemyeva *et al.*, 2006; Larkcom, 2007).

The aim of this study was to evaluate the transplant quality, yield parameters and chosen constituents of Chinese flat cabbage cultivars grown in different periods for summer-autumn harvest. Because of lack of recommendations for Chinese flat cabbage production in Europe, we chose summer-autumn season as typical for related species (*Brassica pekinensis*) in this region.

Materials and methods

Experimental design

A two-factorial field experiment with Chinese flat cabbage (*Brassica rapa* var. *narinosa* (L.H. Bailey) Kitam.) was conducted in summer-autumn term of 2004-2005 in the Vegetable Experimental Station of University of Agriculture in Krakow, south Poland (51°13' N, 22°38' E). The climate is humid continental climate (Dfb) according to Köppen's classification. Transplants were prepared in a greenhouse. Seeds were sown in the middle of July and in the beginning of August in multipot trays VEFI (96 cells per tray, cell volume of 53 cm^3), filled with standard peat substrate. After 3-4 weeks, transplants were planted out to the open field.

Chinese flat cabbage cultivars, 'Misome' and 'Tatsoi' (factor I), presented in Fig. 1, were used in the experiment. Plants were cultivated in 2 terms: plantings were carried out in the middle and at the end of August - 1st and 2nd growing period, respectively (factor II).

Field trial

Experiment was established in 4 replications, 24 plants per replication (experimental plot) with an area of 2.4 m^2. Plants were planted out in spacing 40 × 25 cm. The amount of fertilizers was calculated on the base of soil analyses 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. Nitrogen was applied in a form of nitrochalk before planting (2/3 of a dose) and calcium nitrate during vegetation (1/3 of a dose). The soil was classified as a typical brown type, grey brown subtype of stabilised fluvial alluvium, silt loam laying on medium-heavy soil, underlain by very fine sandy soil. Cultivation procedures (weeding, irrigation, plant protection against pests and diseases) were performed, with use of adapted recommendations for heading Chinese cabbage. Harvest was carried out in a middle of September (1st growing period) and in the first 10-days of October (2nd growing period), after 4.5 and 6 weeks from transplanting, respectively.

Weather conditions

Data concerning the mean air temperature and sum of rainfall during vegetation seasons 2004-2005 are presented in Tab. 1. Temperature was recorded with a use of automatic sensors HOBO Pro RH/Temp. (Onset Computer Corp., USA). The data on sunshine duration, defined as number of hours in which the solar radiation falling on a plane, and rainfall was derived from the station of the Institute of Meteorology and Water Management in Krakow-Balice, located 3 km from the Vegetable Experimental Station. First growing period was characterized by higher mean, minimum, and maximum daily temperatures (by 4.1, 3.4 an 4.6°C, on average) as well as higher sunshine duration (by 1.4 hrs, on average) as compared to the second growing period. In 2004, sum of precipitation in the second growing period was 2-times higher in comparison to the same period of 2005.

Morphological and chemical analyses of transplants

Before planting to the field, 10 transplants were used in each of four replicates per experimental object as material for biometrical measurements and chemical analysis. Plants were randomly selected, ensuring that each plant was surrounded by others to avoid border effects. It was determined the height of transplants (from the base of shoot to the top of the longest leaf); number of leaves (longer than 1 cm), leaf area (with the use of a program KS-RUN 3.0, Carl Zeiss Vision GmbH, Germany), leaf length (from the base of a leaf petiole to the top of a leaf blade, with the use of a program ImageJ, NIH, USA). The above ground part of transplants was weighted with a use of Sartorius A120S (Germany), the fresh weight was assessed. The dry matter content in leaves of transplants was determined by drying sample at 92-95°C until constant weight was obtained, with the use of Sartorius A120S. The total soluble sugars were determined by anthrone method (Yemm and

Fig. 1. *Brassica rapa* var. *narinosa* cultivars 'Tatsoi' and 'Misome' (from left)

Willis, 1954). Plant material was mixed with 80% ethanol. After addition of anthrone reagent, samples were placed for 30 min in a water bath (100°C), cooled down to room temperature and the absorbance was measured at 625 nm using Helios Beta spectrophotometer (Thermo Fisher Scientific Inc., USA). The total carotenoid content was determined by the modified Lichtenthaler and Wellburn (1983) method after 80% acetone extraction, at 470 nm, with Helios Beta spectrophotometer (Thermo Fisher Scientific Inc., USA).

Yield and chemical analyses of plants in a stage of a harvest maturity

The total and marketable yield was determined. Harvest was performed only once in particular growing periods, specifying the mass of rosettes and their number. The rosettes fully developed, without damages were treated as marketable. The rosettes with deformations or damages, mechanical and biotic origin, on more than 10% of surface were treated as unmarketable. The share of marketable yield in total yield was counted as the number of marketable rosettes in relation to all harvested ones.

The chemical composition of Chinese flat cabbage leaf petioles, which are edible parts of the plants, was analyzed. The dry matter, total soluble sugars and total carotenoids content was determined by the methods described above for the transplants. The chlorophyll "a" and chlorophyll "b" was determined by Lichtenthaler and Wellburn (1983) method, after 80% acetone extraction, at 646 and 663 nm, with Helios Beta spectrophotometer (Thermo Fisher Scientific Inc., USA). The content of L-ascorbic acid was assessed by the Tillmans method. Plant material (50 g) was mixed with 200 mL CH_3COOH, and after 30 min extract was titrated with the reagent 2,6-dichlorophenolindophenol (Tillman's reagent). The crude fibre content was determined according to Yermakov *et al.* (1987), calculating the difference in weight of samples before etching and after etching with a mixture of HNO_3 and CH_3COOH.

Statistical analysis

All data obtained were subjected to two-way analysis of variance. Means were compared by HSD Tukey test at $p < 0.05$ to determine homogenous groups, with the use of STATISTICA 9.0 (StatSoft Inc., USA). Data were presented as means for 2 years to simplify presentation of results, because of their high repeatability in years of the experiment.

Results and discussion

There are no agronomic recommendations for Chinese flat cabbage production in Europe. For this reason we choose summer-autumn season as typical for closely related species which is heading Chinese cabbage. We differentiated time of plantings, assuming that 10-day interval would be sufficient to cause a response of the plants. Results, presented in this paper, proved significant changes in plant growth and yield as well as in content of some constituents of mature rosettes as depends on the growing periods. We also took into account transplant quality assessed on a basis of chosen biometrical and chemical parameters. Some authors stated close relationships between quality of the transplants and subsequent growth and yielding of vegetable crops (Cantliffe, 1993; Kalisz, 2010; Kalisz and Kostrzewa, 2012). Moreover, such analyses allowed to compare chosen chemical parameters of plants in different stages of growth.

Analysis of morphological features of Chinese flat cabbage transplants before planting out showed that 'Misome' was higher (by 2.7 cm, on average), with greater leaf area (by 3.0 cm^2) and leaf length (by 2.9 cm) as compared to 'Tatsoi' (Tab. 2). 'Tatsoi' had significantly more leaves than 'Misome'. The effect of growing period was statistically proved only for transplant leaf length, which was greater for plants transplanted in the 2nd period. 'Tatsoi' cultivar, transplanted in the 2nd period, had greatest height and length of leaves than in earlier production. It is obvious that genetic factor affected morphological features of investigated plants. 'Misome' has an upright growth habit and taller rosettes than 'Tatsoi' (Larkcom, 2007). In the present experiment, this genetic diversity was already observed during production of transplants. Cultivar differences in transplant morphological features were also noted by Kalisz and Kostrzewa (2012) for non-heading Chinese cabbage (*Brassica rapa* var. *chinensis*). Slightly different microclimatic conditions between growing periods, when transplants were produced, affected morphology of juvenile plants. Effect of different sowing dates on transplant characteristics were also found by Siomos (1999) for non-heading Chinese cabbage and by Kalisz *et al.* (2006) and Kalisz (2010) for heading group of Chinese cabbage (*Brassica pekinensis*).

The chemical analysis of transplants showed, that plants had similar fresh weight, and soluble sugar and carotenoid content (Tab. 3). 'Tatsoi' was characterized by higher dry

Tab. 1. Weather conditions during field production of *Brassica rapa* var. *narinosa*

Year	Growing period	Daily air temperature (°C)			Sunshine duration (hrs)	Rainfall (mm)
		mean	min	max		
2004	1st term	16.1	8.4	24.9	8.3	50.6
	2nd term	12.0	5.3	20.0	6.2	60.2
2005	1st term	17.7	10.7	26.5	7.5	50.0
	2nd term	13.5	7.0	22.2	6.7	28.8

1st and 2nd terms - plantings in the middle and at the end of August, harvests in the middle of September and in the beginning of October, respectively

Tab. 2. Morphological features of *Brassica rapa* var. *narinosa* transplants at time of plantings

Growing period	Cultivar	Height (cm)	Leaf number	Leaf area (cm^2)	Leaf length (cm)
1st term	'Misome'	13.5^{c}	7.9^{a}	15.5^{c}	12.9^{c}
	'Tatsoi'	10.1^{a}	8.9^{b}	11.7^{a}	9.3^{a}
2nd term	'Misome'	13.1^{c}	7.9^{a}	14.8^{bc}	12.5^{c}
	'Tatsoi'	11.1^{b}	9.2^{b}	12.6^{ab}	10.3^{b}
Means for growing period					
1st term		11.8^{A}	8.4^{A}	13.6^{A}	11.1^{A}
2nd term		12.1^{A}	8.6^{A}	13.7^{A}	11.4^{B}
Means for cultivar					
'Misome'		13.3^{B}	7.9^{A}	15.2^{B}	12.7^{B}
'Tatsoi'		10.6^{A}	9.1^{B}	12.2^{A}	9.8^{A}

Mean values within a column, followed by different capital letters for main effects and lower case letter for interaction effects, are significantly different at $p < 0.05$ according to Tukey's HSD test.
1st and 2nd terms - plantings in the middle and at the end of August

Tab. 3. Fresh weight and content of dry matter, soluble sugars and carotenoids of *Brassica rapa* var. *narinosa* transplants

Growing period	Cultivar	Fresh weight (g·plant^{-1})	Dry matter (g·100 g^{-1} FW)	Soluble sugars (g·100 g^{-1} FW)	Carotenoids (mg·100 g^{-1} FW)
1st term	'Misome'	3.37^{ab}	9.81^{c}	0.82^{a}	50.17^{b}
	'Tatsoi'	3.12^{a}	10.07^{d}	0.86^{a}	45.90^{b}
2nd term	'Misome'	3.94^{b}	7.29^{a}	0.70^{a}	33.77^{a}
	'Tatsoi'	3.75^{ab}	7.66^{b}	0.70^{a}	36.08^{a}
Means for growing period					
1st term		3.25^{A}	9.94^{B}	0.84^{B}	48.04^{B}
2nd term		3.85^{B}	7.48^{A}	0.70^{A}	34.93^{A}
Means for cultivar					
'Misome'		3.66^{A}	8.55^{A}	0.76^{A}	41.97^{A}
'Tatsoi'		3.44^{A}	8.87^{B}	0.78^{A}	40.99^{A}

Mean values within a column, followed by different capital letters for main effects and lower case letter for interaction effects, are significantly different at $p < 0.05$ according to Tukey's HSD test.
1st and 2nd terms - plantings in the middle and at the end of August

matter than 'Misome', by 0.32 g·100 g^{-1} FW. Growing period significantly affected investigated chemical constituents of transplants. Chinese flat cabbage transplants had higher content of dry matter, soluble sugars and carotenoids in the 1st period than in the 2nd one (by 2.46 g·100 g^{-1} FW; 0.14 g·100 g^{-1} FW and 13.11 mg·100 g^{-1} FW, respectively), only the fresh weight was lower. Genetic factor effects on the content of several nutritive substances in mature leafy crops of *Brassica rapa* was described by Artemyeva *et al.* (2006). In the initial stages of plant growth some differences should also occurred (Kalisz and Kostrzewa, 2012). In a present experiment, more chemical constituents were noted in the transplants of 1st growing period. This was probably caused by differences between growing periods in environmental conditions in the greenhouse. Transplants produced earlier received more light and they grown in higher temperatures before transplanting. It could affect their chemical composition. Effect of planting dates on some compounds in non-heading Chinese cabbage, cultivated in greenhouse, was described by Kobryń (2001). Differentiation in content of some constituents in transplants of heading and non-heading groups of Chinese cabbage as affected by growing period was also noted by Kalisz (2010) and Kalisz and Kostrzewa (2012).

Statistical analysis proved that mean weight of a marketable rosette in a phase of harvest maturity was not influenced by cultivar factor, but on period of growing (Tab. 4). It is interesting result, because visually 'Misome' rosettes were higher and plants had bigger leaves than 'Tatsoi'. However, the latter cultivar created much more leaves of smaller size, which increased mass of a rosette. Marketable yield of 'Misome' was significantly higher of about 6.19 t·ha^{-1}. Yields were affected by growing period. In the 1st growing period, the total and marketable yield were greater (by 6.24 t·ha^{-1} and 5.57 t·ha^{-1}, respectively), as compared to the 2nd growing period. The better yield of 'Misome' rosettes was harvested from plantings in the middle of August. Both cultivars had also greater marketable rosette weight in 1st term of production. For 'Misome', the structure of marketable yield was comparable in both growing periods, while the percentage of marketable rosettes for 'Tatsoi' was higher in the 2nd growing period.

The choice of proper production period has significant effect on yield of vegetables (Dufault *et al.*, 2006).

Tab. 4. Yield characteristics of *Brassica rapa* var. *narinosa*

Growing period	Cultivar	Total yield ($t \cdot ha^{-1}$)	Marketable yield ($t \cdot ha^{-1}$)	Share of marketable yield (%)	Marketable rosette weight (kg)
1st term	'Misome'	45.17^{b}	43.82 b	95.7	0.471^{b}
	'Tatsoi'	38.95^{ab}	35.71^{a}	89.4	0.461^{b}
2nd term	'Misome'	37.33^{a}	36.33^{a}	94.4	0.400^{a}
	'Tatsoi'	34.31^{a}	32.07^{a}	92.3	0.386^{a}
Means for growing period					
1st term		42.06^{B}	39.77^{B}	92.6	0.466^{B}
2nd term		35.82^{A}	34.20^{A}	93.4	0.393^{A}
Means for cultivar					
'Misome'		41.25^{B}	40.08^{B}	95.1	0.436^{A}
'Tatsoi'		36.63^{A}	33.89^{A}	90.9	0.424^{A}

Mean values within a column, followed by different capital letters for main effects and lower case letter for interaction effects, are significantly different at $p < 0.05$ according to Tukey's HSD test.
1st and 2nd terms - plantings in the middle and at the end of August, harvests in the middle of September and in the beginning of October, respectively

In a present experiment, Chinese flat cabbage responded positively to plantings in the middle of August, in the climatic zone of Central Europe. Plants were grown in higher temperatures and more intensive sunlight then in the next growing period, which resulted in higher yields and earliness. Significant effect of growing period on the yield and its quality was stated for many *Brassicaceae* species: leafy cultivars of *Brassica rapa* (Acikgoz, 2012), broccoli (Kałużewicz *et al*., 2009; Acikgoz, 2011), red cabbage (Tendaj and Sawicki, 2012), cauliflower (Cebula and Kalisz, 1997a), Brussels sprouts (Mirecki, 2006) and heading Chinese cabbage (Kalisz, 2010).

In present investigations, 'Misome' leaf petioles were characterized by higher dry matter, soluble sugars and carotenoids content (by 0.17 $g \cdot 100\ g^{-1}$ FW; 0.11 $g \cdot 100\ g^{-1}$ FW and 0.22 $mg \cdot 100\ g^{-1}$ FW, respectively), than 'Tatsoi' (Tab. 5). No significant differences were found between investigated cultivars in crude fibre content. The fact, that genetic factor affects biological value of *Brassicaceae* vegetables was widely described, *inter alia* for Brussels sprouts (Mirecki, 2006), cabbage (Radovich *et al*., 2005), broccoli (Acikgoz, 2011) and leafy cultivars of *Brassica rapa* (Artemyeva *et al*., 2006; Acikgoz, 2012). The dry matter and carotenoids content in leaf petioles of cultivars, investigated in the present study, was lower than determined for whole leaves of Chinese flat cabbage by Artemyeva *et al*. (2006). Significant effect of growing periods on chemical composition of Chinese flat cabbage leaf petioles was noted in the present experiment. The dry matter and soluble sugars content was higher (by 0.35 and 0.15 $g \cdot 100\ g^{-1}$ FW, respectively) in 2nd growing period, but crude fibre content was lower (by 1.14 $g \cdot 100\ g^{-1}$ DM). The carotenoids content was comparable. Exposure to more sunlight and higher temperatures should enhance dry matter, sugars and carotenoids level (Francke and Majkowska-Gadomska, 2008; Kopsell and Kopsell, 2008), but it was not observed in the present study. There is also not a clear explanation for the significantly higher crude fibre content in plants of earlier growing period. Many authors pointed to a different chemical composition of vegetables produced

Tab. 5. Content of dry matter, soluble sugars, crude fibre and carotenoids in leaf petioles of mature *Brassica rapa* var. *narinosa*

Growing period	Cultivar	Dry matter ($g \cdot 100\ g^{-1}$ FW)	Soluble sugars ($g \cdot 100\ g^{-1}$ FW)	Crude fibre ($g \cdot 100\ g^{-1}$ DM)	Carotenoids ($mg \cdot 100\ g^{-1}$ FW)
1st term	'Misome'	4.52^{a}	0.79^{ab}	15.30^{bc}	1.10^{a}
	'Tatsoi'	4.43^{a}	0.74^{a}	15.89^{c}	0.90^{a}
2nd term	'Misome'	4.95^{c}	1.01^{c}	14.80^{ab}	1.08^{a}
	'Tatsoi'	4.70^{b}	0.83^{b}	14.12^{a}	0.83^{a}
Means for growing period					
1st term		4.48^{A}	0.77^{A}	15.60^{B}	1.00^{A}
2nd term		4.83^{B}	0.92^{B}	14.46^{A}	0.96^{A}
Means for cultivar					
'Misome'		4.74^{B}	0.90^{B}	15.05^{A}	1.09^{B}
'Tatsoi'		4.57^{A}	0.79^{A}	15.01^{A}	0.87^{A}

Mean values within a column, followed by different capital letters for main effects and lower case letter for interaction effects, are significantly different at $p < 0.05$ according to Tukey's HSD test.
1st and 2nd terms - plantings in the middle and at the end of August, harvests in the middle of September and in the beginning of October, respectively

Tab. 6. L-ascorbic acid, chlorophyll "a" and "b", and chlorophyll "a" : "b" ratio in leaf petioles of *Brassica rapa* var. *narinosa*

Growing period	Cultivar	L-ascorbic acid (mg·100 g^{-1} FW)	Chlorophyll "a" (mg·100 g^{-1} FW)	Chlorophyll "b" (mg·100 g^{-1} FW)	Chlorophyll "a" : "b" ratio
1st term	'Misome'	28.17^{c}	2.70^{bc}	1.38^{b}	1.96^{a}
	'Tatsoi'	24.95^{b}	2.18^{ab}	1.05^{a}	2.08^{a}
2nd term	'Misome'	24.65^{b}	2.78c	1.32^{b}	2.11^{a}
	'Tatsoi'	23.62^{a}	2.13^{a}	1.05^{a}	2.03^{a}
Means for growing period					
1st term		26.56^{B}	2.44^{A}	1.22^{A}	2.01^{A}
2nd term		24.14^{A}	2.46^{A}	1.19^{A}	2.07^{A}
Means for cultivar					
'Misome'		26.41^{B}	2.74^{B}	1.35^{B}	2.04^{A}
'Tatsoi'		24.29^{A}	2.16^{A}	1.05^{A}	2.06^{A}

Mean values within a column, followed by different capital letters for main effects and lower case letter for interaction effects, are significantly different at $p < 0.05$ according to Tukey's HSD test.
1st and 2nd terms - plantings in the middle and at the end of August, harvests in the middle of September and in the beginning of October, respectively

at different times of the year, with some opposite results described (Radovich *et al*., 2005; Mirecki, 2006; Kalisz, 2010; Acikgoz, 2011, 2012).

'Misome' leaf petioles contained more L-ascorbic acid, chlorophyll "a" and "b" than 'Tatsoi' by 2.12, 0.58 and 0.30 mg·100 g^{-1} FW, respectively (Tab. 6). Mean L-ascorbic acid content determined in present experiment was lower than gave out by Artemyeva *et al*. (2006) for whole leaves of Chinese flat cabbage, whereas chlorophyll "a" : "b" ratio was similar. Differences in content of ascorbic acid and chlorophylls of various cultivars of *Brassicaceae* species were also observed by Kalisz (2010) for heading Chinese cabbage, Acikgoz (2011) for broccoli, Mirecki (2006) for Brussels sprouts, Artemyeva *et al*. (2006) and Acikgoz (2012) for several leafy Asian greens.

The growing period had a significant effect on L-ascorbic acid content. Leaf petioles of Chinese flat cabbage from the 1st growing period were richer in this compound by 2.42 100 g^{-1} FW, as compared to the 2nd period. Plants of both investigated cultivars from later plantings had less of L-ascorbic acid. It was probably caused by lower sunlight intensity. Positive relationship between light and ascorbic acid level in the plants was also stated by Lee and Kader (2000) and Acikgoz (2012). In a present experiment the content of chlorophylls as well as chlorophyll "a" : "b" ratio was not influenced by growing term.

Conclusions

Two cultivars of *Brassica rapa* var. *narinosa* ('Misome' and 'Tatsoi') were suitable for summer-autumn field cultivation in Central European climatic conditions. Cultivar and growing period affected both biometrical and chemical parameters of transplants, and yield together with biological value of the plants in a stage of harvest maturity. 'Misome' was characterized by better transplant quality, as well as higher yields and amount of investigated constituents in the plants. Transplanting of Chinese flat cabbage in the middle of August as compared to 10 days later time of transplanting caused the advancing of harvest, increase of the total and marketable yields, as well as L-ascorbic acid and crude fibre content. Our research showed that in Central Europe region, later planting of *Brassica rapa* var. *narinosa* is less favorable and the preference of 'Misome' cultivar can be more advantageous.

References

Acikgoz FE (2011). Influence of different sowing times on mineral composition and vitamin C of some broccoli (*Brassica oleracea* var. *italica*) cultivars. Sci Res Essays 6(4):760-765.

Acikgoz FE (2012). Determination of yield and some plant characteristics with vitamin C, protein and mineral material content in mibuna (*Brassica rapa* var. *nipposinica*) and mizuna (*Brassica rapa* var. *japonica*) grown in fall and spring sowing times. J Tekirdag Agr Fac 9(1):64-70.

Artemyeva AM, Solovyeva AE, Vavilov NI (2006). Quality evaluation of some cultivar types of leafy *Brassica rapa*. Acta Hort 706:121-128.

Cantliffe DJ (1993). Pre- and postharvest practices for improved vegetable transplant quality. HortTech 3:415-418.

Cartea ME, Velasco P (2008). Glucosinolates in *Brassica* foods: bioavailability in food and significance for human health. Phytochem Rev 7:213-229.

Cebula S, Kalisz A (1997a). Value of different cauliflower cultivars for autumn production in a submontane region as depending upon the planting time. I. Yields and pattern of cropping. Folia Hort 9(2):3-12.

Cebula S, Kalisz A. (1997b). Value of different cauliflower cultivars for autumn production in a submontane region as depending upon the planting time. II. Quality of curds. Folia Hort 9(2):13-20.

Dufault RJ, Ward B, Hassell RL (2006). Planting date and Romaine lettuce cultivar affect quality and productivity. HortSci 41(3):640-645.

Francke A, Majkowska-Gadomska J (2008). Effect of planting date and method on the chemical composition of radicchio heads. J Elementol 13(2):199-204.

Kalisz A (2010). Optymalizacja jakości rozsady a plonowanie kapusty pekińskiej (*Brassica pekinensis* Rupr.) oraz wybrane elementy modelowania rozwoju roślin. Zesz Nauk UR w Krakowie 465(342):1-121.

Kalisz A, Kostrzewa J (2012). Modelowanie wzrostu rozsady kapusty chińskiej (*Brassica rapa* var. *chinensis*) oraz ocena zależności między cechami roślin przed sadzeniem do gruntu i podczas zbiorów. Acta Agr 19(2):329-342.

Kalisz A, Siwek P, Cebula S (2006). Ocena wzrostu i składu chemicznego rozsady kapusty pekińskiej (*Brassica pekinensis* Rupr.) w zależności od metody hartowania i terminu produkcji. Folia Hort Supl 1:200-206.

Kałużewicz A, Krzesiński W, Knaflewski M (2009). Effect of temperature on the yield and quality of broccoli heads. Veg Crops Res Bull 71:51-58.

Kobryń J (2001). Effect of planting date on pak choi and butterhead lettuce growth, yield and quality characteristics. Ann Warsaw Univ of Life Sc - SGGW, Horticult and Landsc Architect 22:43-48.

Kopsell DA, Kopsell DE (2008). Genetic and environmental factors affecting plant lutein/zeaxanthin. AgroFOOD Ind Hi-tec 19(2):44-46.

Larkcom J (2007). Oriental vegetables. Frances Lincoln Ltd., London, UK.

Lee SK, Kader AA (2000). Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biol Tec 20:207-220.

Lichtenthaler HK, Wellburn AR (1983). Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. Biochem Soc Trans 603:591-592.

Mirecki N (2006). Influence of the planting dates on chemical composition and yield of Brussels sprouts. Acta Agric Serb XI(21):53-61.

Opeña RT, Kuo CG, Yoon JY (1988). Breeding and seed production of Chinese cabbage in the tropics and subtropics. AVRDC, Shanhua, Tairan, Tech Bull 17:92.

Podsędek A (2007). Natural antioxidants and antioxidant capacity of *Brassica* vegetables: a review. LWT 40:1-11.

Radovich TJK, Kleinhenz MD, Streeter JG, Miller AR, Scheerens JC (2005). Planting date affects total glucosinolate concentrations in six commercial cabbage cultivars. HortSci 40(1):106-110.

Schreiner M (2005). Vegetable crop management strategies to increase the quantity of phytochemicals. Eur J Nutr 44:85-94.

Siomos AS (1999). Planting date and within-row plant sparing effects on pak choi yield and quality characteristics. J Veg Crop Prod 4(2):65-73.

Tendaj M, Sawicki K (2012). The effect of the method and time of seedling production on red cabbage (*Brassica oleracea* L. ssp. *oleracea* convar. *capitata* (L) Alef. var. *capitata* L. f. *rubra* DC.) yield. Acta Agrobot 65(1):115-122.

Yemm EW, Willis AJ (1954). The estimation of carbohydrates in plant extracts by anthrone. Biochem J 57:508-514.

Yermakov AI, Arasimov VV, Yarosh NP (1987). Methods of biochemical analysis of plants Agropromizdat, Leningrad (In Russian).