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YIELD, MORPHOLOGICAL CHARACTERISTICS AND NUTRITIONAL VALUE OF NEW PSEUDOSTEM – TYPE CULTIVARS OF JAPANESE BUNCHING ONION

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Abstract. In cultivation of Japanese bunching onion as an annual crop harvested for bunches there is required to use pseudostem – type cultivars, with high rate of growth, rich in valuable phytochemicals. In a field study there was evaluated the yield potential, quality of the crop and nutritional value of the following pseudostem – type cultivars: Sprintesa, Parade, Performer, Ishikura Long White, Red Toga, Freedy and Totem. Kroll cultivar commonly recommended as a perennial crop grown for the use of cut foliage was recognized as the control. Seedlings produced in multicell trays were transplanted into the field on 19–22 April and harvested on 19–25 June, when majority of plants reached the pseudostem diameter > 10 mm. At harvest there were evaluated the yield size, morphological features of plants and content selected organic and mineral compounds. Most of the exammed cultivars appeared to be suitable for early spring growing for bunches, among which Parade produced the highest marketable yield and beside Sprintesa characterized the longest pseudostem as well as low nitrates content. 'Kroll' grown as annual crop for bunches produced yield similar to 'Red Toga' and 'Freedy', while significantly lower to the other examined cultivars. Its plants characterized by low mean weight and short pseudostem, but high amounts of potassium and low nitrates accumulation.

Key words: *Allium fistulosum* L., crop quality, organic compounds, macronutrients

INTRODUCTION

Japanese bunching onion (*Allium fistolusum* L.) is commonly cultivated in China, Korea, Indonezia and Japan, where both leaves and pseudostems are consumed either cooked or as a fresh vegetable [Grubben 1994, Rubatzky and Yamaguchi 1997, Warade and Shinde 1998, Umehara et.al.2006]. Its economic importance in European countries is still negligible and mainly limited to growing in small gardens. However, in the last time with the popularity of Asian cuisine, bunching onion are being consumed more in Western diets [Kopsell et al. 2010].

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In Poland, Japanese bunching onion is mostly cultivated as a perennial crop out of rotation for the period of 3–4 years. Cut foliage used as edible plant parts is harvested early in the spring season in about one month intervals, when the leaves reach the height of 20–30 cm. The most suitable for such purpose of cultivation are cultivars with a short pseudostem, strong tendency to tillering, abundant foliage production and the fast re-growth after harvest, like Siedmiolatka Czerwona [Tendaj and Mysiak 2010] or the others included in the Polish Register List of Vegetable Crops such as Kroll, Vita or Flamenco.

Bejo Zaden and some other seed companies introduced to the market some new pseudostem – type cultivars which produce little number of tillers [Tendaj and Mysiak 2010, 2011] characterized by the high rate of growth and for this reason suitable for harvest of entire plants for bunching. In contrast to common onion they have more erect foliage habit, produce fewer but longer leaves, longer pseudostem with stronger flavor [Abbey et al. 2002, Lazić et al. 2002, Wang et al. 2005], show higher resistance to pest and diseases [Martinez et al. 2005] as well as longer storage life after harvest [Ibaraki et.al. 1999].

Pseudostem – type cultivars are mostly grown from transplants to reduce the long growth period and to maximize blanched part of pseudostem, because transplants can be placed deeper into soil than seeds [Rubatzky and Yamaguchi 1997]. The leaves and pseudostem may be consumed at the stage of seedling or later when the stem diameter reaches 10–35 mm [Liu et al. 2009, Kołota et al. 2013a]. The blanched portion of pseudostem is an important quality parameter and is recommended to exceed one fourth to one third of the total length.

Like the other *Allium* species, Japanese bunching onion has been valued for its culinary flavour attributes as well as content of antioxidants and anticancerogenic phytochemicals [Kopsell et al. 2010]. Many data from the literature indicate this vegetable crop as a rich source of vitamin C, carotenoids, phenolic compounds and minerals such as potassium and calcium [Horbowicz and Kotlińska 1998, 2000, Kotlińska and Kojima 2000, Kotlińska et al. 2005, Štajner et al. 2006, Higashio et al. 2007, Mysiak and Tendaj 2006, 2008, Aoyama and Yamamoto 2007]. The latest study of Kopsell et al. [2010] demonstrates high concentration of a variety of valuable pigments in leaf tissue of *A. fistulosum*, and among them carotenoids and chlorophyll.

The aim of the present study was to evaluate the yield potential and nutritional value of new pseudostem – type cultivars of *Allium fistulosum* grown for early harvest in bunches. It was a part of complex project which with the object had to elaborate different aspects of Japanese bunching onion production grown as annual crop, including the response to nitrogen fertilization, the use of flat covers and timing the cultivation all round the vegetation period [Kołota et al. 2012, 2013a, 2013b].

MATERIALS AND METHODS

Field experiment which the object was to determine the suitability of *A. fistulosum* cultivars for growing for early spring season harvest was conducted in 2010–2012 at Piastów Horticultural Experimental Station (long. 17º00'E, lat. 51º05'N) on a sandy

clay soil with pH 7.1 and organic matter content 1.8%. The content of available forms of phosphorus was equal to 55–64 mg·dm^{-3}, 50–68 mg·dm^{-3} of potassium, and 20–30 mg·dm^{-3} of mineral nitrogen (NO_3 + NH_4) in the soil, depending on the year of trial.

In the field study there were evaluated the following cultivars of *A. fistulosum*: Parade and Performer (Bejo Zaden), Ishikura Long White (Bakker Brothers), Red Toga and Freedy (Vilmorin), and Totem (Sakata). Yield characteristics and nutritional value of these cultivars were compared with two others present in the Polish Register List of Vegetable Crops: Kroll (PlantiCo) cultivated for the use of cut foliage and Sprintesa (Hortag Seeds), a pseudostem – type cultivar recommended for the consumption of the whole plants in early growth stages. The experiment was established in one factorial design in four replications, and plot area amounted 6m^2 (1.5 × 4m).

Seeds of all evaluated cultivars were sown into multicell trays filled with standard peat moss substrate, where pot volume ranged to 54 cm^3. Three to four seeds were sown into each pot in 23–25 of February and at the stage of first true leaves, the number of seedlings was reduced to two. Seedlings produced in the greenhouse, during last ten days before planting were hardened in non heated plastic tunnel. Well developed transplants with 2–3 leaves were planted into the open field on 19–22 of April in spacing 30 × 15 cm, which assured the population of 44 plants per 1 m^2.

Japanese bunching onion was cultivated at the 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 an annual chemical analysis 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 ammorium nitrate was used as a single preplant dose in the amount of 150 kg N·ha^{-1}. Crop management followed the commonly accepted recommendations for this vegetable species, including hand weed control.

Single plant harvest took place on 19–25 June, when the majority of plants had a pseudostem diameter greater than 10 mm. The marketable yield consisted of entire plants with a diameter > 10mm, after removing roots and yellowing leaves. Plants of a smaller size were included in total yield. At harvest, samples of 15 plants from each plot were collected for phytometric measurements and chemical analysis. There were evaluated such morphological features as height of plant, number of leaves, length of psedostem and its blanched part, bulb diameter and mean weight of plant. The subject of assessment in chemical analysis was the content of dry mater (draying at 105ºC to constant weight – PN- 90/A-7501/03), total and reducing sugars (Loof-Schoorl method – PN 90/A-7501/07), vitamin C (Tillman's method – PN 90/A-7501/11), total chlorophyll (spectrophotometric method), carotenoids (colorimetric method) according to Lichtenthaller and Welburn [1983], nitrates expressed by the amount of NO_3-N in f.w. (ion--selective method), P and Mg (colorimetric method), Ca and K (photometric method).

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

RESULTS AND DISCUSSION

Results of the study shown in table 1 indicate that the maximum total and marketable yield of plants harvested for bunches in two out of there years was produced by 'Parade'. Irrespective of the growing conditions in particular years, the yields of this cultivar maintained at the level exceeded 20 $t \cdot ha^{-1}$, with the means of 23.75 $t \cdot ha^{-1}$ and 23.19 $t \cdot ha^{-1}$, which were significantly higher if compared to the other examined cultivars. Another high yielding cultivars appeared to be Sprintesa, Performer, Ishikura Long White and Totem. They showed some variability throughout the years, but in the average did not significantly differ in the yield size. Data obtained in our study are in agreement with the previous statement of Kotlińska et al. [2005] and Tendaj and Mysiak [2011] who also observed outstanding high rate of growth such cultivars as Parade, Performer and Ishikura Long White. Kroll cultivar, having strong tendency for tillering and for this reason widely recommended for cultivation as a perennial crop for harvest of plant tops, like Red Toga and Freedy produced significantly lower, but still around 14.0 $t \cdot ha^{-1}$ yield of bunches. According to the data obtained by Tendaj and Mysiak [2007], as well as results of our own research with Japanese bunching onion grown for bunch harvest in different seasons of the year [Kołota et al. 2012], a marketable yield of that size should be regarded as satisfactory. In the case if the harvest is delayed to 3 months or more after transplanting the yield may be even doubled but it is associated with the decrement of nutritional value, due to the drop of vitamin C, carotenoids, total chlorophyll, nitrogen, potassium and calcium contents in edible parts of plants. Moreover, the foliage of older plants is becoming more tough, which is less accepted by the consumers.

The favorable feature of high yielding cultivars such as Parade and Sprintesa appeared to be a high percentage of marketable yield in total yield of above ground biomass, which expressed as the mean for three years of the study equaled 97.6 and 96.2% respectively. In Kroll Red Topa and Fredy cultivars this share was substantially lower maintaining at the range 92.0–93.3%.

The mean data for the 3 years of study did not show any significant differences among examined cultivars in plant height, number of leaves per plant and bulb diameter at harvest (tab. 2).'Sprintesa' and 'Parade' characterized the highest length of pseudostem, which is an important feature in cultivation of onion for bunches. Together with 'Performer', 'Ishikura Long White' and 'Totem' they produced plants with the substantial higher mean weight ranged within 54.7 to 57.7 g, in comparison to 'Kroll', 'Red Toga' and 'Freedy' which individual weight varied at the level of 45.7–46.0g. The result of the study proved that 'Kroll' appreciated for its abundant tillering and suitability for cultivation as perennial crop for the cut foliage is much less valuable in growing for bunches, not only because of the low yield but also like 'Freddy', the formation of short pseudostem.

Chemical plant analysis demonstrated that the important feature of Kroll cv. was high amount of dry matter, similar to that found in Freedy and Red Toga (tab. 3). Together with 'Ishikura Long White' and 'Red Toga' it contained the highest level of total and reducing sugars.

Table 1. Total, marketable yield and its structure of evaluated cultivars of Japanese bunching onion in 2010–2012 (t ha^{-1})

Cultivar	Total yield				Marketable yield				Share of marketable yield in total yield (%)			
	2010	2011	2012	mean	2010	2011	2012	mean	2010	2011	2012	mean
Kroll	13.99	13.94	16.58	14.84	11.96	12.94	16.08	13.66	85.5	92.8	96.5	92.0
Sprintesa	24.81	17.51	20.42	20.91	24.50	17.10	18.72	20.11	98.8	97.7	91.7	96.2
Parade	23.71	20.86	26.67	23.75	22.68	20.59	26.28	23.19	95.7	98.7	98.5	97.6
Performer	23.29	18.55	22.39	21.41	21.84	18.09	20.17	20.03	93.8	97.5	90.1	93.6
Ishikura Long White	21.92	19.35	21.44	20.91	20.73	18.45	20.81	20.00	94.6	95.3	97.1	95.6
Red Toga	16.64	12.59	17.56	15.60	14.64	11.49	17.19	14.44	89.1	91.3	97.9	92.6
Freedy	13.94	15.44	18.29	15.89	11.89	15.07	17.54	14.83	85.3	97.6	95.9	93.3
Totem	19.32	19.30	25.14	21.25	16.59	18.70	24.69	20.00	85.9	96.9	98.2	94.1
Mean	19.70	17.19	21.06	19.32	18.10	16.55	20.20	18.28	91.9	96.3	95.9	94.6
LSDα = 0.05	6.14	4.30	4.31	2.04	6.98	4.13	4.51	2.15	–	–	–	–

Table 2. Morphological characteristic of evaluated cultivars of Japanese bunching onion, mean for 2010–2012

Cultivar	Height of plant (cm)	Leaves number per plant	Length of pseudostem (cm)	Length of blanched part of pseudo-stem (cm)	Bulb diameter (cm)	Mean weight of plant (g)
Kroll	59.1	5.5.	12.3	4.0	2.0	45.7
Sprintesa	60.6	5.7	16.8	3.9	1.9	57.1
Parade	60.3	5.6	16.2	3.8	2.1	57.7
Performer	54.7	5.5	13.3	3.6	2.2	54.7
Ishikura Long White	58.0	5.8	15.3	4.2	2.0	57.0
Red Toga	58.0	5.0	14.8	4.2	1.8	45.9
Freedy	54.1	5.9	12.1	3.7	2.1	46.0
Totem	53.9	5.4	14.1	3.7	2.1	56.0
Mean	57.3	5.6	14.4	3.9	2.0	52.5
LSDα=0.05	n.s.	n.s.	1.5	0.6	n.s.	8.4

Table 3. Content of dry matter and selected compounds in evaluated cultivars of Japanese bunching onion, mean for 2010–2012

Cultivar	Dry matter (%)	Total sugars (%·f. w.)	Reducing sugars (% f. w.)	Vitamin C ($mg \cdot 100g^{-1}$ f.w.)	Chlorophyll a + b ($mg \cdot 100g^{-1}$ f.w.)	Carotenoids ($mg \cdot 100g^{-1}$ f.w.)
Kroll	12.08	4.99	4.58	34.94	64.8	1.48
Sprintesa	11.61	4.61	4.22	35.32	58.3	1.29
Parade	11.42	4.87	4.40	33.75	58.0	1.35
Performer	11.23	4.52	4.12	34.23	56.1	1.37
Ishikura Long White	11.79	5.09	4.57	30.01	57.3	1.27
Red Toga	12.18	5.21	4.81	35.04	57.6	1.29
Freedy	12.45	4.67	4.30	33.76	57.9	1.38
Totem	11.97	4.35	4.01	32.51	56.1	1.24
Mean	11.84	4.79	4.38	33.70	58.3	1.33
LSDα = 0.05	0.57	0.52	0.34	n.s.	n.s.	n.s.

Japanese bunching onion, especially green tops can be regarded as a rich source of vitamin C [Warade and Shinde 1998], which content in the studies conducted by Lazič et al. [2002] was higher than in young plants of common onion harvested for bunches. In some trials its amount maintained at the level of 40 to over 60 $mg \cdot 100g^{-1}$ f.w. [Higashio et al. 2007] or even 76–95 $mg \cdot 100g^{-1}$ f.w. [Kotlińska and Kojima 2000]. In our study it was lower but still substantial amount equal to 30.01–35.32 $mg \cdot 100g^{-1}$ f.w. and did not show any significant differences among the examined cultivars.

The other valuable phytochemicals comprised in Japanese bunching onion are carotenoids and chlorophyll. There was not considerable differences among the tested cultivars in the content of carotenoids, which was as high as 1.48 mg·100g^{-1} f.w. in Kroll cv., while only 1.24 mg·100g^{-1} f.w. in Totem. The total chlorophyll content varied within 56.1 and 64.8 mg·100g^{-1} f.w. and also was not significantly differentiated. Such high amounts of this constituent can be considered as a great advantage of Japanese bunching onion. Recent studies are shedding new light on a role of chlorophyll in the diet [Feruzzi and Blakeslee 2007] and suggesting that it may possess biological activities associated with cancer prevention and antimutagenic properties [Egner et al. 2003, Balder et al. 2006]. Data of our trial are in agreement with the findings of Kopsell et al. [2010] indicated Japanese bunching onion an abundant source of valuable pigments and showing only small variability of their contents under influence of growing location or by accession.

Table 4. Mineral composition of evaluated cultivars of Japanese bunching onion, mean for 2010–2012

Cultivar	Nitrates (mg·kg^{-1} f.w.)	Phosphorus (% d.m.)	Potassium (% d.m.)	Calcium (% d.m.)	Magnesium (% d.m.)
Kroll	1089	0.24	2.71	1.47	0.18
Sprintesa	1307	0.21	2.09	1.43	0.17
Parade	1035	0.23	2.30	1.59	0.19
Performer	1333	0.20	2.13	1.44	0.20
Ishikura Long White	1093	0.21	2.29	1.24	0.20
Red Toga	1356	0.24	2.29	1.24	0.18
Freedy	1580	0.22	2.26	1.48	0.19
Totem	1321	0.22	2.32	1.68	0.21
Mean	1264	0.22	2.30	1.45	0.19
LSDα = 0.05	118	n.s.	0.21	n.s.	n.s.

Taking into account the mineral composition of edible parts of Japanese bunching onion it was not stated any significant differences among the investigated cultivars in phosphorus, calcium and magnesium contents (tab. 4). Potassium accumulation in plant tissue of ‘Kroll’ was considerable higher if compared to the other cultivars, which did not show any clear differences. Another positive feature of this cultivar, beside ‘Parade’ and ‘Ishikura Long White’, was significantly lower tendency for nitrates accumulation at harvest. The highest level of nitrates were found in ‘Freedy’ followed by ‘Red Toga’, ‘Performer’, ‘Totem’ and ‘Sprintesa’. Generally the obtained data confirm the opinion of Zhu et al. [1998] regarding rather low tendency of this vegetable species to nitrates accumulation.

CONCLUSIONS

1. Upon the data obtained in the study it can be concluded that Japanese bunching onion maybe a good alternative for the young common onion plants harvested for bunches due to high rate of growth and yield potential, abundant source of vitamin C, carotenoids, chlorophyll as well as minerals.

2. 'Parade' producing the highest total and marketable yield of plants, characterizing by the long pseudostem with low tendency for nitrates accumulation may be recognized as the best suitable for early growing for bunches.

3. The other high yielding cultivars appeared to be Sprintesa, Performer, Ishikura Long White and Totem. 'Sprintesa' can be especially appreciated for its long pseudostem, while Ishikura Long White for the low nitrates accumulation.

4. 'Kroll' cultivated mainly as perennial crop, grown as annual for bunches, produced yield similar to 'Red Toga' and 'Freedy', while significantly lower to the other examined cultivars. Its plants characterized by a low mean weight, short pseudostem, high amounts of potassium and low nitrates content.

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PLONOWANIE, CECHY MORFOLOGICZNE ORAZ WARTOŚĆ ODŻYWCZA NOWYCH ODMIAN CEBULI SIEDMIOLATKI O WYDŁUŻONEJ ŁODYDZE RZEKOMEJ

Streszczenie. Cebula siedmiolatka w uprawie jednorocznej na zbiór pęczkowy całych roślin powinna odznaczać się długa łodygą rzekomą, intensywnym wzrostem oraz wysoką wartością biologiczną. W doświadczeniu polowym oceniono plonowanie, jakość plonu oraz wartość odżywczą następujących odmian, charakteryzujących się wydłużoną łodygą rzekomą: Sprintesa, Parade, Performer, Ishikura Long White, Red Toga, Freedy i Totem. Kontrolę stanowiła odmiana Kroll, zalecana do uprawy wieloletniej na zbiór szczypioru. Rozsada produkowana w wielodoniczkach była sadzona na poletkach w dniach 19–22 kwietnia, zbiór zaś przeprowadzono 19–25 czerwca, gdy większość roślin posiadała średnicę łodygi rzekomej > 10 mm. Ocenie poddano wielkość uzyskanego plonu, cechy morfologiczne roślin oraz skład chemiczny. Większość badanych odmian wykazała przydatność do uprawy na zbiór pęczkowy całych roślin. Wyróżniającą się pod względem wielkości uzyskanego plonu, niskiej zawartości azotanów i – obok Sprintesy – długości łodygi rzekomej, okazała się odmiana Parade. Odmiana Kroll w uprawie tego rodzaju plonowała na podobnym poziomie jak Red Toga i Freedy istotnie niższym natomiast w porównaniu z pozostałymi odmianami w doświadczeniu. Rośliny tej odmiany charakteryzowały się krótką łodygą rzekomą, małą masą jednostkową, wysoką zawartością potasu i niską azotanów.

Słowa kluczowe: *Allium fistulosum* L., jakość plonu, składniki organiczne, makroskładniki

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