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EFFECT OF SOWING DATE ON BIOLOGICAL VALUE OF GARDEN ORACHE

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Abstract. Garden orache (*Atriplex hortensis* L.) belongs to *Chenopodiaceae* family. Usable parts of this species are the young stems and leaves characterized by a high content of protein. The aim of the study was the estimation of the effect of sowing date (2nd and 3rd 10-days' period of April, and 1st 10-days' period of May) on the biological value of garden orache leaves. The experiment was conducted in 2008–2009. Chemical analyses of raw plant material (leaves of garden orache) included determination of the content of dry matter, total sugars, titratable acidity, total ash, crude fibre, total protein, nitrates, L-ascorbic acid, chlorophylls, carotenoids, total polyphenols and antioxidant activity. It was proved that sowing date had a significant effect on the content of dry matter, total ash, total protein, total sugars, L-ascorbic acid and antioxidant activity. On the base of obtained results it was proved that plants of garden orache grown at the latest date of sowing (1st 10-days' period of May) were characterized by the highest biological value.

Key words: *Atriplex hortensis* L., nutritional compounds, biologically active compounds

INTRODUCTION

Over 100 plant species belong to *Atriplex* genus. The common cultivated crop is garden orache (*Atriplex hortensis* L.), named also as mountain spinach, sea purslane or saltbush [Wright et al. 2002]. This species, same as spinach (*Spinacia oleracea*) belongs to *Chenopodiaceae* family. Usable parts of garden orache are the young stems and leaves. In folk medicine this plant was used as tonic for strengthening [Broda and Mowszowicz 1996]. Garden orache is worth recommending plant because of its dietetic and medicinal properties. It helps absorb nutrients from food, stimulates digestion [Sarwa 2001], speeds up metabolism [Bown 1999]. Garden orache herb (*Herba Atriplicis hortensis*) is characterized by a high content of flavonoids, vitamin C [Steinbach

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1996], mineral components [Sarwa 2001] and amino acids [Hegnauer 1989, Nicol 1994, Siddiqui et al. 1994].

Garden orache belongs to a group of plants of leaves being a rich source of protein [Carlsson 1980]. Leaves of orache can be consumed either fresh or boiled, separately or together with other vegetables [Bown 1999]. Data of chemical composition of garden orache plants are still not completed – for example there is still a lack of information about the influence of agrotechnical factors on the nutritional value of obtained yield.

The aim of the presented experiment was to estimate the effect of sowing date on the content of the most important nutritional and biologically active compounds in fresh leaves of garden orache (*Atriplex hortensis* L.).

MATERIAL AND METHODS

The experiment was carried out in 2008–2009 at the Horticultural Experiment Station in Dołuje which belongs to the Department of Vegetable Growing of West Pomeranian University of Technology in Szczecin. The laboratory part of the experiment was conducted in the Department of Processing and Storage of Plant Raw Material of West Pomeranian University of Technology in Szczecin. The research material consisted of plants of garden orache (*Atriplex hortensis* L.).

The experiment was established in randomized blocks with three replications. The experimental plot area was 1.44 m^2 (1.2 m × 1.2 m). Three dates of sowing were examined: 2nd and 3rd 10-days' period of April, and 1st 10-days' period of May.

The field was prepared according to agrotechnique proper for spinach cultivation. Mineral fertilization was quantified according to the results of chemical analysis of the soil. In the first year of the experiment only nitrogen and potassium fertilization was used (respectively: 110 kg N·ha^{-1} and 120 kg K·ha^{-1}), while in the second year – nitrogen fertilization (100 kg N·ha^{-1}), phosphorus (35 kg P·ha^{-1}) and potassium fertilization (120 kg K·ha^{-1}). Phosphorus and potassium fertilizers and half of the nitrogen dose were applied during the field preparation, before seeds sowing. The second half of nitrogen dose was applied after the first harvest.

The seeds of garden orache were sown at a distance of 40 cm between rows. Sowing rate amounted 10 kg·ha^{-1}. During the growing season the crop management was carried out. It included mainly irrigation, weeding, soil cultivation and plant protection (spraying Decis 2.5 EC against aphids).

Each year the yield was harvested three times (2nd and 3rd 10-days' period of June, and 1st 10-days' period of July). The crop was collected when the shoots reached about 25 cm in length. At each harvest time shoots from all of the plots were collected. After the second harvest in both years of the study the chemical analyses of raw plant material (leaves of garden orache) were done. They included determination of the content of dry matter (drying at 105°C to constant weight), total sugars (by the method of Luff-Schoorl), titratable acidity [Krełowska-Kułas 1993], vitamin C as L-ascorbic acid (by the method of Tillmans), total chlorophyll, chlorophyll a and b [Lichtenthaler and Wellburn 1983], total carotenoids [Lichtenthaler and Wellburn 1983], total polyphenols – by spectrophotometer, using gallic acid as reference, and Follin-Ciocalteu reagent [Single-

ton and Rossi 1965], nitrates (by the colorimetric method; Zalewski 1971), total protein (using factor 6.25 for determined amount of nitrogen – by the method of Kjeldahl), crude fibre [Klepacka 1996] and total ash (by incineration of samples in 500°C). Scavening effect of orache leaves on DPPH-radical was determined according to the method of Yen and Chen [1995]. Raw homogenised material was diluted 100 times in 100% methanol. DPPH percent inhibition was calculated according to Rossi et al. [2003]. All of the mentioned above analyses were done in the fresh plant material.

The results of each year of the study were subjected to an analysis of variance which was performed with Program AWAR [Filipiak and Wilkos 1995], made by Department of Applied Informatics, Institute of Soil Science and Plant Cultivation in Puławy. The means of two years were separated by the Tukey's test at $p = 0.05$.

RESULTS AND DISCUSSION

There was a significant effect of sowing date on the biological value of garden orache leaves found in the experiment.

Significantly higher amount of dry matter, total protein and total sugars was noted for leaves obtained from plants grown at the latest date of sowing (tab. 1 and 2). In the content of protein there were no significant differences found between first and second date of sowing. However, the amount of dry matter and total sugars determined in the material obtained from the second date of sowing was significantly lower in comparison with the third sowing date (respectively by 0.53% and 0.27%) and significantly lower comparing with the first date of sowing (respectively by 0.26% and 0.07%). The opposite relation was found according to the results of determination of ash content. Significantly higher amount of this compound was determined for the first two sowing dates, between which there were no significant differences noted.

Table 1. The effect of sowing date on the content of dry matter, total ash, total protein and nitrates in garden orache leaves (mean values from years 2008–2009)

Tabela 1. Wpływ terminu siewu na zawartość w liściach łobody ogrodowej suchej masy, popiołu ogólnego, białka ogółem i azotanów (wartości średnie z lat 2008–2009)

Sowing date Termin siewu	Dry matter Sucha masa	Total ash Popiół ogólny	Total protein Białko ogółem	Nitrates Azotany
		%		$mgNaNO_3 \cdot kg^{-1}$
2nd 10-days' period of April 2. dekada kwietnia	12.00	2.58	3.50	436.40
3rd 10-days' period of April 3. dekada kwietnia	11.74	2.64	3.66	765.90
1st 10-days' period of May 1. dekada maja	12.27	2.25	4.03	687.50
Mean – Średnia	12.00	2.49	3.73	629.90
$LSD_{0.05}$ – $NIR_{0,05}$	0.214	0.271	0.250	n.s.

Table 2. The effect of sowing date on the content of crude fibre, total sugars and titratable acidity in garden orache leaves (mean values from years 2008–2009)

Tabela 2. Wpływ terminu siewu na zawartość w liściach łobody ogrodowej błonnika surowego, cukrów ogółem i kwasowość ogólną (wartości średnie z lat 2008–2009)

Sowing date Termin siewu	Crude fibre Błonnik surowy	Total sugars Cukry ogółem	Titratable acidity % oxalic acid Kwasowość ogólna % kwasu szczawiowego
	%		
2nd 10-days' period of April 2. dekada kwietnia	1.14	0.27	0.12
3rd 10-days' period of April 3. dekada kwietnia	1.06	0.20	0.12
1st 10-days' period of May 1. dekada maja	1.19	0.47	0.12
Mean – Średnia	1.13	0.31	0.12
$LSD_{0.05}$ – $NIR_{0,05}$	n.s.	0.024	n.s.

In the opinion of Carlsson and Clarke [1983] content of dry matter in garden orache leaves is 12.9%, while protein – 31.8% d.m. In the conducted experiment content of total protein was 31.1% d.m. According to Carlsson and Clarke [1983] among amino acids presented in garden orache leaves the highest concentration was noted for: leucine, lysine, threonine, isoleucine, histidine and methionine.

On the base of obtained results of the study it was proved that the sowing date did not significantly affect the content of nitrates, crude fibre, total carotenoids, chlorophylls, total polyphenols and titratable acidity in garden orache leaves (tab. 1–4). Independently of sowing date, the content of nitrates was on average 629.9 mg $NaNO_3 \cdot kg^{-1}$, crude fibre – 1.13%, total carotenoids – 353.9 $mg \cdot kg^{-1}$, total chlorophyll – 1182.3 $mg \cdot kg^{-1}$, chlorophyll a – 856.1 $mg \cdot kg^{-1}$, chlorophyll b – 189.7 $mg \cdot kg^{-1}$, total polyphenols – 189.2 $mg \cdot 100\ g^{-1}$, and titratable acidity – 0.12%.

Belonging to *Chenopodiaceae* family species like common spinach, New Zealand spinach or tested in the experiment garden orache, as a leafy vegetables show a tendency for nitrate accumulation. In Poland, the regulation issued by the Minister of Health [Dz. U. 2003] permits the content of 2500 mg $NO_3^- \cdot kg^{-1}$ in fresh spinach. In the present study the level of nitrates in leaves of garden orache was assessed as rather low – 459.8 mg $NO_3^- \cdot kg^{-1}$. Jaworska [2005] gave in her report higher amounts of nitrates in New Zealand spinach, even up to 2804 mg $NO_3^- \cdot kg^{-1}$ f.m. In opinion of Jaworska and Słupski [2001], in New Zealand spinach, the level of nitrates may vary from 449 to 3472 mg NO_3^- in 1 kg fresh matter. Jaworska and Kmiecik [1999] recorded in common spinach leaves on average 880 mg $NO_3^- \cdot kg^{-1}$ f.m.

The content of total polyphenols in garden orache leaves was 1577 $mg \cdot 100\ g^{-1}$ of dry matter. Fernández et al. [2007] in leaves of *Atriplex lampa* determined on average 1500 mg of polyphenols in 100 g of dry matter. Bylka et al. [2001] isolated from leaves of *Atriplex hortensis* two flavonoid sulphates: kaempferol 3-*O*-sulphate-7-*O*-*α*-arabinopyranoside and quercetin 3-*O*-sulphate-7-*O*-α-arabinopyranoside.

Table 3. The effect of sowing date on the content of total carotenoids and chlorophylls in garden orache leaves (mean values from years 2008–2009)

Tabela 3. Wpływ terminu siewu na zawartość w liściach łobody ogrodowej karotenoidów ogółem oraz barwników chlorofilowych (wartości średnie z lat 2008–2009)

Sowing date Termin siewu	Total carotenoids Karotenoidy ogółem mg·kg^{-1}	Chlorophyll – Chlorofil mg·kg^{-1}		
		total ogółem	a	b
2nd 10-days' period of April 2. dekada kwietnia	385.4	1237.3	897.3	210.1
3rd 10-days' period of April 3. dekada kwietnia	336.3	1143.6	826.7	161.3
1st 10-days' period of May 1. dekada maja	340.0	1166.0	844.2	197.6
Mean – Średnia	353.9	1182.3	856.1	189.7
$LSD_{0.05}$ – $NIR_{0,05}$	n.s.	n.s.	n.s.	n.s.

Table 4. The effect of sowing date on the content of total polyphenols, L-ascorbic acid and antioxidant activity in garden orache leaves (mean values from years 2008–2009)

Tabela 4. Wpływ terminu siewu na zawartość w liściach łobody ogrodowej polifenoli ogółem, kwasu L-askorbinowego i aktywność antyoksydacyjną (wartości średnie z lat 2008–2009)

Sowing date Termin siewu	Total polyphenols Polifenole ogółem	L-ascorbic acid Kwas L-askorbinowy	Antioxidant activity Aktywność antyoksydacyjna % DPPH*
	mg·100g^{-1}		
2nd 10-days' period of April 2. dekada kwietnia	194.5	61.74	29.12
3rd 10-days' period of April 3. dekada kwietnia	181.3	71.88	23.61
1st 10-days' period of May 1. dekada maja	191.7	132.25	31.13
Mean – Średnia	189.2	88.62	27.95
$LSD_{0.05}$ – $NIR_{0,05}$	n.s.	n.s.	3.98

*sample diluted 100-times in 100% metanol – 100-krotne rozcieńczenie próbki w 100% metanolu

Leaves of garden orache grown at the third – the last date of sowing were characterized by significantly higher content of L-ascorbic acid in comparison with the first two dates of sowing, on average by 65.44 mg·100 g^{-1}. The mean level of L-ascorbic acid recorded in garden orache leaves (88.62 mg·100 g^{-1}) was higher than that noted by Grzeszczuk et al. [2007] and Jaworska and Słupski [2001] for New Zealand spinach (respectively: 36 and 48 mg·100 g^{-1}), while lower comparing to data presented by Bąkowski et al. [1996] for common spinach (100.55 mg·100 g^{-1}).

Antioxidant activity of leaves obtained from plants grown at the third date of sowing was significantly higher in comparison with the second sowing date. Between the third and the first date of sowing there was no significant difference in the antioxidant activity of the analyzed material found.

CONCLUSIONS

1. There was a significant effect of the sowing date on the content of dry matter, total ash, total protein, total sugars, L-ascorbic acid and antioxidant activity in garden orache leaves found.

2. Among tested in the experiment dates of sowing, the most positive effect on the biological value of garden orache leaves had the third sowing date (1st 10-days' period of May).

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WPŁYW TERMINU SIEWU NA WARTOŚĆ BIOLOGICZNĄ ŁOBODY OGRODOWEJ

Streszczenie. Łoboda ogrodowa (*Atriplex hortensis* L.) należy do rodziny komosowatych (*Chenopodiaceae*). Częścią użytkową tego gatunku są liście i młode pędy charakteryzujące się o wysoką zawartością białka. Celem przeprowadzonego doświadczenia była ocena wpływu terminu siewu (2 dekada kwietnia, 3 dekada kwietnia i 1 dekada maja) na wartość biologiczną liści łobody ogrodowej. Doświadczenie przeprowadzono w latach 2008–2009. Analizy chemiczne w świeżym surowcu (liście łobody ogrodowej) obejmowały oznaczenie zawartości suchej masy, cukrów rozpuszczalnych ogółem, kwasowości ogólnej, popiołu ogólnego, błonnika surowego, białka ogółem, azotanów, kwasu L-askorbinowego, chlorofili, karotenoidów, polifenoli ogółem i aktywności antyoksydacyjnej. Istotny wpływ terminu siewu wykazano w przypadku zawartości suchej masy, popiołu ogólnego, białka ogółem, cukrów ogółem, kwasu L-askorbinowego i aktywności antyoksydacyjnej. Na podstawie otrzymanych wyników badań stwierdzono, że największą wartością biologiczną charakteryzowały się roślin, przy uprawie których zastosowano 3 termin siewu (1 dekada maja).

Słowa kluczowe: *Atriplex hortensis* L., termin siewu, składniki odżywcze, związki biologicznie czynne

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