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EFFECT OF THE CONTROLLED FERTILIZATION ON THE MINERAL COMPONENTS OF CHOSEN VARIETIES OF ONION (*Allium cepa* L.) PART II. MICROELEMENTS AND SODIUM

WPŁYW KONTROLOWANEGO NAWOŻENIA NA ZAWARTOŚĆ SKŁADNIKÓW POKARMOWYCH W WYBRANYCH ODMIANACH CEBULI (*Allium cepa* L.) CZ. II. MIKROSKŁADNIKI I SÓD

Abstract: The paper presents results of studies whose objective was the estimation of the controlled fertilization effect and the bulbs storage – in case of chosen cultivars (21) – on the nutritive value of onion defined on the basis of microelements: iron, manganese, zinc and copper and sodium contained in edible parts of onion. During whole of the vegetative studies there were used controlled fertilization based on the chemical analysis of soil. A significant modifying effect of the cultivar was exerted on the content of the majority of the studied components: manganese, copper and sodium in the dry matter of onion. No effect was found to be exerted by the cultivar on the content of iron and zinc. Storage of onion – similarly as the cultivar – significantly modified the content of manganese and copper, but it did not differentiate the content of sodium, zinc and iron. The determined content of microelements ranged [mg · kg^{-1} d.m.] for: iron 42.6–96.4 mg Fe; manganese 2.6–11.2 mg Mn; zinc 16.9–27.3 mg Zn; copper 4.61–6.85 mg Cu. The determined contents of sodium ranged from 0.16 to 0.40 % Na in onion dry matter. A comparison of the nutritive value of onion with other vegetable species indicated that onion is a comparatively rich source of microelements and sodium in the human diet. Thanks to controlled fertilization based on regular chemical soil analyses is possible to obtain good nutritive value of crops and protect the soil environment against possible contamination with excessive mineral fertilizers.

Keywords: onion, controlled fertilization, nutritive value, microelements, cultivar-induced differentiation, storage

The group of macroelements required daily by human body in an amount exceeding 100 mg per 1 person includes: nitrogen, phosphorus, calcium, magnesium and potassium, sodium and chlorine [1]. On the other hand, microelements whose daily

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demand is below 100 mg · person^{-1} include among others: iron, manganese, zinc, copper and iodine. The basic source of the above-mentioned components in human diet are: meat, dairy produce, fruits and vegetables. Therefore, it is important to diversify the daily diet with the most valuable products.

One of the most frequently consumed vegetables in Poland is onion [2]. The objective of the presented studies was the estimation of the effect of controlled fertilization in case of 21 chosen cultivars of onion and the bulb storage on the nutritive value defined on the basis of the content of microelements (iron, manganese, zinc, copper) and sodium contained in onion bulbs. Furthermore, the nutritive value of onion was evaluated in relation to other vegetables like: red paprica [3], common red cabbage [4], carrot [1], cucumbers [5] and cocktail tomatoes [6].

Material and methods

In the years 2008–2009, field and laboratory experiments were carried out aiming at the estimation of the controlled fertilization and storage of bulbs effect in controlled conditions on the microelement composition and sodium content in onion bulbs (in case of 21 chosen cultivars). Vegetation experiments were carried out in a private horticultural farm growing a collection of 83 onion cultivars. Laboratory experiments were performed in the Experimental Station of the Horticultural Department "Marcelin", University of Life Sciences in Poznan. A detailed description of the applied methods is contained in an earlier paper of the authors [7].

The soil before seeds sowing characterized following of average chemical composition (in mg · dm^{-3}): N-NH_4 12.0, N-NO_3 0.0, P-PO_4 49.0, K 75.1, Ca 720.0, Mg 44.1, S-SO_4 0.1, Cl 13.0, Fe 30.6, Mn 4.1, Zn 5.0, Cu 0.1, pH 7.80, EC 0.20 mS · cm^{-1}. The content of nutritive components was maintained based on the cyclical chemical soil analyses on the standard level (in mg · dm^{-3}): N 90.0, P 70.0, K 225.0, Mg 90.0, Fe 50.0, Mn 15.0, Zn 25.0, Cu 5.0, pH in H_2O 6.0–6.5, EC < 0.6 mS · cm^{-1} [8–10 modified]. It was used fertilizers in following doses (per ha): 180 kg of nitrate ammonium (34 % N), 300 kg of double phosphate (40 % P_2O_5), 200 kg of potassium sulphure (50 % K_2O), 150 kg of magnesium sulphure (16 % MgO), 30 kg manganese sulphure (32.3 % Mn), 30 kg zinc sulphure (22 % Zn), 40 kg copper sulphure (25.6 % Cu), 2 kg of borax (11.3 % B).

After the termination of the vegetation period 18–20 onions representative of the given cultivar were collected from the field patches, healthy specimens, without any syndroms of damages or diseases were selected. The collected material was divided into two equal parts. One half of the onions was peeled, sliced, dried at 45–50 ^{o}C and ground. The other half of the collected plant material was transferred for 60 days to a refrigerator (at temperature of 6 ^{o}C and air humidity 50 %) and the further procedure was the same as in case of onion freshly collected.

For the determination of general sodium forms – the plant material was mineralized in concentrated sulfuric acid, while iron, manganese, zinc and copper were mineralized in a mixture of nitric(V) and chloric(VII) acids (3:1 v/v); [11]. After mineralization of the plant material, the following determinations were performed: Fe, Mn, Zn, Cu, Na –

by AAS method (on Carl Zeiss Jena apparatus). Statistical analysis of the results of component contents in onion bulbs was carried out. Conclusions were drawn at significance level of $\alpha = 0.05$.

Results and discussion

Effect of the cultivar on the content of microelements and sodium

A significant influence of the studied cultivar types was found to be exerted on the content of manganese, copper and sodium in the dry matter of onion (Tables 1, 2).

Table 1

Effect of cultivar and of the storage on the content of iron and manganese [mg · kg^{-1} d.m.] and on the coefficient of variation

Variety (A)	Fe			Mn		
	T1(B)	T2(B)	Mean	T1(B)	T2(B)	Mean
'Aurora'	54.6	70.1	62.4	3.4	6.0	4.7
'Bennito'	57.2	59.3	58.2	5.0	8.2	6.6
'Consuelo'	65.3	70.8	68.1	4.5	5.1	4.8
'Cymes'	45.7	61.2	53.4	2.5	4.6	3.6
'Eureka'	54.3	49.9	52.1	4.4	4.9	4.7
'Grabowska'	69.7	73.5	71.6	8.1	14.3	11.2
'Kutnowska'	51.2	53.3	52.2	2.5	5.1	3.8
'Lawica'	59.5	60.2	59.9	4.9	11.8	8.3
'Marbella'	109.0	83.8	96.4	3.4	4.4	3.9
'Mission'	55.9	62.1	59.0	4.2	9.9	7.1
'Napoleon'	65.1	54.6	59.8	2.8	4.1	3.5
'Sherpa'	67.7	70.0	68.9	2.6	4.0	3.3
'Slawa Ozarowa'	59.9	67.9	63.9	2.4	5.9	4.1
'Sochaczewska'	67.8	57.0	62.4	3.4	9.0	6.2
'Stamford'	69.5	74.3	71.9	4.6	5.6	5.1
'Tandem'	73.9	54.6	64.3	2.4	3.5	2.9
'Topolska'	49.6	51.0	50.3	4.4	10.6	7.5
'Wiktoria Skierniewicka'	52.6	64.6	58.6	2.2	3.0	2.6
'Wojka'	38.9	57.8	48.4	2.8	7.5	5.2
'Wola'	53.3	54.4	53.8	3.1	3.3	3.2
'Wolska'	40.7	44.6	42.6	1.8	4.0	2.9
Mean	60.1	61.7	60.9	3.6	6.4	5.0
CV [%]	76.1	28.1	57.7	39.2	47.9	55.5
LSD for A	ns			2.83		
LSD for B	ns			0.46		
LSD for A×B	ns			0.96		

T1 – directly after harvest; T2 – after 60 days of storage; ns – no significant.

However, cultivar did not differentiate significantly the content of iron and zinc. Iron contents determined in the studies ranged from 42.6 mg Fe (cv. 'Wolska') to 96.4 mg Fe · kg^{-1} (cv. 'Marbella'). However, for the majority of cultivars, iron contents ranged from 50 to 60 mg Fe. The mean iron value in onion was 65.2 mg Fe · kg^{-1}. The cv. 'Wiktoria Skierniewicka' was characterized by a significantly smallest content of manganese (2.6 mg Mn · kg^{-1}), while 'Grabowska' cultivar showed the highest value of this component (11.2 mg Mn · kg^{-1}) with a mean content equal to 5.0 mg Mn · kg^{-1}. Content of zinc ranged from 16.9 mg Zn · kg^{-1} (cv. 'Wolska') to 27.3 mg Zn · kg^{-1} (cv. 'Bennito') (Table 2).

Table 2

Effect of cultivar type and of the storage on the content of zinc, copper [mg · kg^{-1} d.m.] and sodium [% d.m.] and the coefficient of their variation

Variety (A)	Zn			Cu			Na		
	T1(B)	T2(B)	Mean	T1(B)	T2(B)	Mean	T1(B)	T2(B)	Mean
'Aurora'	19.6	23.4	21.5	7.41	5.79	6.60	0.20	0.26	0.23
'Bennito'	27.2	27.4	27.3	7.62	6.08	6.85	0.30	0.20	0.25
'Consuelo'	23.7	24.1	23.9	5.90	6.18	6.04	0.30	0.26	0.28
'Cymes'	17.8	17.6	17.7	7.51	4.63	6.07	0.20	0.26	0.23
'Eureka'	22.6	23.4	23.0	6.17	5.32	5.75	0.30	0.27	0.29
'Grabowska'	25.7	29.9	27.8	6.37	7.31	6.84	0.20	0.11	0.16
'Kutnowska'	18.1	16.2	17.2	5.34	4.99	5.16	0.20	0.17	0.19
'Lawica'	16.5	20.0	18.3	6.50	5.55	6.02	0.20	0.20	0.20
'Marbella'	20.3	20.5	20.4	6.19	5.80	6.00	0.20	0.20	0.20
'Mission'	23.1	26.1	24.6	5.88	5.75	5.82	0.20	0.19	0.20
'Napoleon'	20.4	20.8	20.6	6.75	5.68	6.22	0.20	0.20	0.20
'Sherpa'	20.4	21.6	21.0	4.93	4.29	4.61	0.30	0.16	0.23
'Slawa Ozarowa'	18.1	22.8	20.5	5.82	4.76	5.29	0.20	0.19	0.20
'Sochaczewska'	22.0	24.6	23.3	5.71	4.65	5.18	0.20	0.26	0.23
'Stamford'	26.2	22.2	24.2	6.29	4.74	5.52	0.20	0.20	0.20
'Tandem'	16.4	20.7	18.6	6.06	5.79	5.93	0.30	0.18	0.24
'Topolska'	19.6	25.4	22.5	5.20	6.15	5.68	0.20	0.26	0.23
'Wiktoria Skierniewicka'	16.5	17.6	17.1	5.88	4.99	5.44	0.30	0.50	0.40
'Wojka'	16.7	20.9	18.8	5.71	6.47	6.09	0.20	0.26	0.23
'Wola'	18.5	20.8	19.7	5.77	5.86	5.82	0.20	0.26	0.23
'Wolska'	15.5	18.2	16.9	5.71	5.54	5.63	0.20	0.26	0.23
Mean	20.2	22.1	21.2	6.13	5.54	5.8	0.23	0.23	0.23
CV [%]	123.7	15.4	91.5	11.9	13.8	13.7	23.0	54.1	105.5
LSD for A	ns			0.59			0.15		
LSD for B	ns			0.60			ns		
LSD for A×B	ns			0.57			0.02		

Descriptions as in Table 1.

Mean value from all studied cultivars was 23.1 mg Zn · kg^{-1}. 'Sherpa' was a cultivar with the significantly smallest content of copper (4.61 mg Cu · kg^{-1}), while 'Bennito' cultivar showed the highest Cu content (6.85 mg Cu · kg^{-1}). The determined contents of sodium ranged from 0.16 % (in case of cv. 'Grabowska') to 0.40 % Na (for cv. 'Wiktoria Skierniewicka'). Cultivar type exerted a significant influence on the content of the studied components. Mean coefficients of variation in the content of the studied components were distinctly higher than in case of macroelements [7], ranging from 13.7 % (in case of copper) to 105.5 % (in case of sodium).

Effect of onion storage on the content of microelements and sodium

Storage exerted a significant effect on the content of manganese and copper in onion bulbs, but it did not differentiate sodium, zinc and iron. In case of manganese, a significant increase of this component was found (from 3.6 mg Mn · kg^{-1} to 6.4 mg Mn · kg^{-1}). In turn, in case of copper, there was a significant decrease of its content (from 6.1 mg Cu · kg^{-1} to 5.5 mg Cu · kg^{-1}).

Nutritive value of onion against other vegetable species

Estimation of the nutritive value of onion as a species regarding its content of microelements and sodium was carried out by the comparison of the contents determined in our own studies with the contents shown by studies referring to carrot [1], red paprica [3], common red cabbage [4], cucumbers [5], cocktail tomato [6], celery [12], as well as with earlier studies referring to onion [13] (Table 3).

Table 3

Contents of iron, manganese, zinc and copper [mg · kg^{-1} d.m.] and sodium [% d.m.] in the edible part of selected vegetable species (acc. to different authors)

Species	Nutrient				
	Fe	Mn	Zn	Cu	Na
	[mg · kg^{-1} d.m.]				[% d.m.]
Onion – own studies	42.6–96.4	2.6–11.2	16.9–27.3	4.61–6.85	0.16–0.40
Onion	41.8	9.98	26.02	6.02	—
Red paprica	2.2–4.6	0.3–0.8	1.0–2.3	0.3–1.3	—
Common red cabbage	93.4–173.8	25.0–31.4	33.2–39.5	6.4–11.8	—
Carrot	20.0	8.0	23.0	10	0.8
Cucumber	314.03	—	—	23.10	—
Cocktail tomatoes	128.0	—	18.1	—	—
Celery	19.0–105.3	2.1–8.9	12.9–64.6	2.1–8.9	

On the basis of our present studies, one can conclude that onion is a comparatively rich source of microelements and sodium in human diets. The mean value of iron (from the studied cultivars) was similar to the values determined in the earlier studies of this species [13]. Paprica is a less rich source of iron [3]. Celery shows iron value similar to

onion [12]. On the other hand, cucumbers and cocktail tomato are characterized by a distinctly higher iron content [6, 5]. Regarding the content of manganese, onion is placed after common red cabbage and cucumber [4, 5], however, its iron content is richer than that represented by paprica [3], but its iron value is similar to that represented by celery [12]. Our determinations of zinc content are similar to the contents reported earlier for onion [13] and tomato [6]. Red cabbage [4] and celery [12] show more zinc than it was found in onion, but paprica is significantly poorer as far as zinc is concerned [3]. Similarly as in case of the remaining microelements, the richest sources of copper are represented by common red cabbage [4], cucumber [5], celery [12] and carrot [1].

Conclusions

1. The cultivar and storage significantly modified the content of manganese, copper and sodium in the dry matter of onion.
2. The studied factors did not differentiated the contents of iron and zinc.
3. During storage time of bulbs there were analyzed, the increase of the content of manganese and sodium in onion dry matter and a decrease of copper was found.
4. A comparison of the nutritive value of onion with other vegetable species indicated that onion is a comparatively rich source of microelements and sodium in the human diet.
5. The controlled fertilization based on regular chemical soil analyses is useful to obtain good micronutritive value of onion crops and protection the soil environment against possible contamination with excessive mineral fertilizers.

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WPŁYW KONTROLOWANEGO NAWOŻENIA NA ZAWARTOŚĆ SKŁADNIKÓW POKARMOWYCH W WYBRANYCH ODMIANACH CEBULI (*Allium cepa* L.) CZ. II. MIKROSKŁADNIKI I SÓD

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Abstrakt: Przedstawiono wyniki badań, których celem była ocena wpływu kontrolowanego nawożenia i przechowania cebul – w przypadku 21 wybranych odmian – na wartość odżywczą cebuli, określoną na podstawie zawartość w niej mikroelementów: żelaza, manganu, cynku i miedzi oraz sodu zawartych w jadalnych częściach cebuli. W trakcie badań wegetacyjnych stosowano nawożenia kontrolowane za pomocą analiz chemicznych gleby. Wykazano istotny, modyfikujący wpływ odmiany na zawartość większości badanych składników: manganu, miedzi i sodu w suchej masie cebuli. Nie stwierdzono z kolei wpływu odmiany na zawartość żelaza i cynku. Przechowywanie cebuli – podobnie jak odmiana – znacznie modyfikowało zawartość manganu i miedzi – a nie różnicowało z kolei zawartości sodu, cynku i żelaza. Oznaczone w przeprowadzonych badaniach zawartości mikroelementów zmieniały się w zakresie [mg · kg^{-1} s.m.] dla: żelaza 42,6–96,4 mg Fe, manganu 2,6–11,2 mg Mn, cynku 16,9–27,3 mg Zn, miedzi 4,61–6,85 mg Cu. Z kolei oznaczone zawartości sodu mieściły się w zakresie od 0,16 % do 0,40 % suchej masy cebul. Porównanie wartości odżywczej cebuli z innymi gatunkami warzyw wskazuje, że cebula jest bogatym źródłem mikroelementów i sodu w diecie człowieka. Dzięki nawożeniu kontrolowanemu poprzez regularne analizy chemiczne gleby, możliwe jest osiągnięcie plonu o dobrej jakości dietetycznej oraz ochrona środowiska glebowego przed skażeniem nadmiernymi dawkami nawozów mineralnych.

Słowa kluczowe: cebula, kontrolowane nawożenie, wartość odżywcza, mikroelementy, zróżnicowanie odmianowe, przechowywanie