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CONTENT OF MACRO- AND MICROELEMENTS IN THE YIELD OF GARLIC CHIVES (*ALLIUM TUBEROSUM* ROTTLER EX SPRENG.) ACCORDING TO THE PLANT AGE

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Abstract

The experiments were carried out in 2002-2005, at the Chair of Vegetable Cultivation of the Agricultural University in Szczecin (currently Chair of Horticulture, West Pomeranian University of Technology in Szczecin). The aim of the study was to estimate the effect of age of grown plants on the content of macro- and microelements in leaves of garlic chives. Seeds of chives were sown on 10th April, directly to the soil, at a density of 30×20 cm, 12 seeds per point. The content of macro- and microelements was assessed in the harvested yield. After mineralization of plant dry matter in a mixture of H_2SO_4 and H_2O, the content of total nitrogen, phosphorus, potassium, sodium, calcium, magnesium and sulphur was determined. The content of copper, zinc, manganese and iron was assessed after mineralization of plant dry matter in a mixture of HNO_3 and $HClO_4$. The research material consisted of one-, two- and three-year-old plants.

A significant effect of the age of garlic chives on the content of macro- and microelements in the yield was found. One- and three-year-old garlic chives were characterized by a higher content of nitrogen while two-year-old plants contained less nitrogen. The highest content of phosphorus was determined in three-year-old garlic chives. However, the least amount of this element was found in one-year-old plants. The highest content of sodium was noted in yield of three-year-old plants, while the least Na was in two-year-old plants. Moreover, the highest content of calcium and magnesium was determined in the yield of two-year-old plants, and the lowest – in three-year-old ones.

Three-year-old garlic chives contained less potassium and sulphur. In contrast, the highest content of these elements was determined in one-year-old plants. The highest content of copper was assessed in one-year-old garlic chives, and the lowest – in three-year-old plants. The yield of one-year-old plants contained significantly more zinc in comparison

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with two- and three-year-old ones. However, the highest content of manganese was noted in three-year-old plant leaves and the lowest – in leaves of two-year-old plants. Three-year-old garlic chives were characterized by a significantly higher content of iron in comparison with one- and two-year-old plants.

Key words: garlic chives, dry matter, macroelements, microelements.

ZAWARTOŚĆ MAKRO- I MIKROSKŁADNIKÓW W PLONIE SZCZYPIORKU CZOSNKOWEGO (*ALLIUM TUBEROSUM* ROTTLER EX SPRENG.) W ZALEŻNOŚCI OD WIEKU ROŚLIN

Abstrakt

Doświadczenia przeprowadzono w latach 2002-2005 w Katedrze Warzywnictwa Akademii Rolniczej w Szczecinie (obecnie Katedra Ogrodnictwa, ZUT w Szczecinie). Celem było określenie wpływu wieku uprawianych roślin na zawartość makro- i mikroskładników w liściach szczypiorku czosnkowego. Nasiona szczypiorku wysiewano 10. kwietnia, bezpośrednio na pole, w rozstawie 30x20 cm, gniazdowo po 12 nasion. W plonie określono zawartość makro- i mikroskładników. Po zmineralizowaniu suchej masy w mieszaninie H_2SO_4 i H_2O oznaczono zawartość: azotu ogólnego, fosforu, potasu, sodu, wapnia, magnezu i siarki. Zawartość miedzi, cynku, manganu i żelaza oznaczono po zmineralizowaniu suchej masy w mieszaninie HNO_3 i $HClO_4$. Ocenie poddano rośliny jednoroczne, dwu- i trzyletnie.

Wykazano istotny wpływ wieku roślin szczypiorku czosnkowego na zawartość w plonie analizowanych makro- i mikroskładników. Więcej azotu zawierał jednoroczny i trzyletni szczypiorek czosnkowy, a mniej dwuletni. Istotnie najwięcej fosforu zawierał trzyletni szczypiorek czosnkowy, najmniej tego pierwiastka oznaczono w plonie zebranym z roślin jednorocznych, a sodu – z dwuletnich. Najwięcej wapnia i magnezu zawierał plon z roślin dwuletnich, a najmniej – trzyletnich. W trzyletnim szczypiorku czosnkowym oznaczono także najmniej potasu i siarki, najwięcej tych pierwiastków zawierał plon zebrany z roślin jednorocznych. Najwięcej miedzi zawierał jednoroczny szczypiorek czosnkowy, a najmniej trzyletni. Plon zebrany z roślin jednorocznych, w porównaniu z dwu- i trzyletnimi, zawierał istotnie więcej cynku. Natomiast najwięcej manganu zawierały liście roślin trzyletnich, a najmniej – dwuletnich. W trzyletnim szczypiorku czosnkowym oznaczono istotnie więcej żelaza, w porównaniu z roślinami jednorocznymi i dwuletnimi.

Słowa kluczowe: szczypiorek czosnkowy, sucha masa, makroskładniki, mikroskładniki.

INTRODUCTION

Garlic chives are a valuable vegetable plant, which offer many health and taste benefits, like chives and garlic. Nowadays, it is cultivated mainly in Japan, China, Korea and countries of South Asia. This species is also popular in Great Britain, where it is sold in bunches. Unfortunately, despite its high nutritional value, simple and low-cost cultivation, resistance to diseases and insects and ornametal value, garlic chives are still unknown in Poland.

Alium tuberosum is a perennial plant. Owing to its resistance to onion vegetable diseases and insects, it does not require the use of chemical sub-

stances for plant protection. In the climatic conditions of Poland, it overwinters in open field without use of covers. The whole plant of garlic chives is edible: bulbs with leaves and young flowering stems. It is very often used in the kitchen as an excellent spice in many dishes. Moreover, it can be lyophilized and used in the food processing industry as an additive to meat and dairy products. For consumption as a fresh product, garlic chives are grown and sold in containers or, after leaf cutting, in bunches. It is a very decorative plant, forming a large number of white, beautiful smelling, umbrella-like flower heads, blooming the whole summer.

In national and international literature, there is little information about garlic chives, such as data concerning the macro- and microelement content. The content of micro- and macroelements in plants is affected by the plant species and cultivar, but also by fertilization (Markiewicz, Golcz 2010), use of biostimulators (Majkowska-Gadomska, Wróblewska-Wierzbicka 2013) and harvest date (Kołota et al. 2012). However, no information is available about the influence of the age of plants. According to Żurawik and Jadczak (2008, 2009), garlic chives are a valuable source of sugars and vitamin C. According to Kotlińska et al. (2005), and Tendaj and Mysiak (2006), bulbs and leaves of onion vegetables are rich in many minerals, including calcium and potassium, which are able to neutralize mild metabolic acidosis. In view of the above, we decided to conduct an experiment in order to assess the content of macro- and microelements in the yield of garlic chives depending on the year of its cultivation.

MATERIAL AND METHODS

A field experiment was carried out in 2002-2005, at the Vegetable Experimental Station in Dołuje, near Szczecin. In the experiment, the effect of plant age on the content of macro- and microelements in garlic chives leaves was tested. The experimental material consisted of one-, two- and three-year-old plants.

The experiment was set up in a split-block design with four replications. The harvest plot area was 1.44 m^2 (1.2×1.2 m). Seeds of chives were sown directly on a field on 10^{th} April, at a density of 30×20 cm (12 seeds per point), and in seedbeds in rows spaced by 30 cm. The seedlings produced in seedbeds were transplanted into an open field when they had formed 2-3 leaves. The plants were analysed after one, two and three years of cultivation. Directly after each harvest, the dry matter content was assessed. Moreover, the content of macro- and microelements determined in the plants. For the chemical analyses, aggregated samples were taken from all of the treatments, separately for one-, two- and three-year-old plants.

During the vegetative season, chemical plant protection from diseases and insects of onion vegetables was provided according to the Vegetable Protection Program of the Research Institute of Vegetable Crops in Skierniewice.

The content of dry matter in fresh yield was assessed by the method of drying at 105ºC to constant weight. After mineralization of plant dry matter in a mixture of H_2SO_4 and H_2O, the content of total nitrogen (by the Kjeldahl's method), phosphorus (by the colorimetric method), potassium, sodium, and calcium (by flame photometry), magnesium (by the method of atomic absorption spectrophotometry ASA) and sulphur (by the turbidimetric method) was determined.

The content of copper, zinc, manganese, iron (by atomic absorption spectrophotometry ASA) was assessed after mineralization of plant dry matter in a mixture of HNO_3 and $HClO_4$ (Krełowska-Kułas 1993). The analyses of macro- and microelements were carried out at the Regional Chemical-Agricultural Station in Szczecin.

The results concerning yield quality were subjected to an analysis of variance. The means were separated by Tukey's test at p=0.05.

RESULTS AND DISCUSSION

In the opinion of Kotlińska et al. (2005), leaves of Japanese bunching onion contain 5-13% of dry matter. Similar results were obtained for leaves of garlic chives in our study, which had on average 13.1% of dry matter. However, there were differences in the dry matter content in garlic chive plants correlated to the plants' age. In the first year of the study, a significantly higher content of dry matter was determined in one- and two-year-old plants in comparison with three-year-old ones. However, on the basis of the results in the subsequent year of cultivation and the statistical analysis of means of both years of the study, it was demonstrated that one-year old plants were characterized by the highest amount of dry matter while three-year old plants had the lowest dry matter content (Table 1).

Bulbs and leaves of onion vegetables are a rich source of many minerals, for example calcium and potassium, which are able to neutralize mild metabolic acidosis (Kotlińska et al. 2005, Tendaj, Mysiak 2006). In our experiment, in the plant material (leaves) of garlic chives, the average content of Ca was on average 10.7 g kg^{-1} d.m. and that of K was 47.7 g kg^{-1} d.m. Moreover, there were statistical differences in the content of macroelements between younger and older plants (Table 2). In the first year of chemical analyses, a significantly higher content of nitrogen and sodium was determined in three-year-old plants than in one- and two-year-old ones. The highest content of potassium was in two-year-old plants and the lowest – in one-

Table 1

Content of dry matter in leaves of garlic chives

Garlic chives	Dry matter (%)		
	experiment I	experiment II	mean
One-year-old	14.7	14.0	14.3
Two-year-old	15.0	12.0	13.5
Thrre-year-old	12.6	10.4	11.5
Mean	14.1	12.1	-
LSD α=0.05	1.3	1.3	0.5

Table 2

Macroelements in edible parts of one-, two- and three-year-old plants of garlic chives

Macro-elements	Years of study	Garlic chives (g kg^{-1} d.m.)			Mean	LSD α=0.05
		one-year -old	two-year -old	thrre-year -old		
N	experiment I	33.4	25.9	44.6	34.6	10.6
	experiment II	41.0	29.2	32.4	34.2	7.5
	mean	37.2	27.5	38.5	-	3.6
K	experiment I	41.6	56.5	47.4	48.5	3.5
	experiment II	60.2	40.3	40.3	46.9	0.6
	mean	50.9	48.4	43.8	-	1.0
Ca	experiment I	13.2	7.8	11.4	10.8	1.7
	experiment II	7.2	18.1	6.6	10.6	0.5
	mean	10.2	12.9	9.0	-	0.5
Na	experiment I	0.2	0.1	0.5	0.3	0.2
	experiment II	0.3	0.2	0.2	0.2	n.s.
	mean	0.3	0.2	0.4	-	0.04
P	experiment I	3.3	3.6	4.4	3.8	n.s.
	experiment II	2.6	3.6	5.9	4.0	0.2
	mean	2.9	3.6	5.1	-	0.5
Mg	experiment I	2.7	3.4	1.2	2.4	0.4
	experiment II	1.8	1.9	1.8	1.8	n.s.
	mean	2.2	2.6	1.5	-	0.3
S	experiment I	9.5	10.0	7.9	9.1	1.0
	experiment II	13.7	8.3	7.3	9.8	1.9
	mean	11.6	9.1	7.6	-	0.6

year-old ones. However, one- and two-year-old plants were characterized by a significantly higher content of magnesium and sulphur than three-year-old plants of garlic chives. One-year-old plants contained the highest amount of calcium, while the lowest Ca content was in two-year-old ones.

In the following year of the study, a higher content of nitrogen, potassium and sulphur was found in one-year old plants in comparison with two- and three-year-old ones. The highest content of calcium (18.1 g kg^{-1} d.m.) was determined in two-year-old plants while the least Ca (6.6 g kg^{-1} d.m.) was found in three-year-old ones. However, the highest content of phosphorus was assessed in three-year-old plants, while the lowest was in one-year-old garlic chives. On the basis of the statistical analysis of two-year means, it was proven that three-year-old plants were characterized by the highest content of phosphorus while the least of this element was noted in one-year-old plants. The highest content of sodium was determined in the yield of three-year-old plants, while the lowest was found in two-year-old plants. One- and three-year-old plants contained higher amounts of nitrogen than with two-year-old ones. Moreover, the highest content of magnesium and calcium (respectively 2.6 and 12.9 g kg^{-1} d.m.) was determined in two-year-old plants while the lowest concentrations of the two elements were determined in three-year-old garlic chives. The three-year-old plants were also characterized by the smallest concentrations of potassium and sulphur, while the highest content of these compounds was detected in one-year-old plants.

In the first year of the study, there was a significant effect of the plant age on the microelement content (Table 3). A significantly higher content of zinc was determined in one- and two-year-old plants than in three-year-old ones. However, the highest concentration of copper was found in one-year-old plants (20.5 mg kg^{-1} d.m.) and the lowest – in three-year-old ones (10.4 mg kg^{-1} d.m.). The highest content of manganese and iron was assayed in the yield collected from three-year-old plants. Two-year-old plants were characterized by the smallest content of manganese, and one-year-old plants had the lowest of content of iron. In the following year of the study, one-year-old plants were characterized by a higher content of iron in comparison with two- and three-year-old plants. The highest content of copper (61.8 mg kg^{-1} d.m.) was assessed in one-year-old plants, while the least copper (19.4 mg kg^{-1} d.m.) was in three-year-old garlic chives. Significantly higher amounts of manganese were determined in two-year-old plants in comparison with one- and three-year-old ones. However, one-year-old plants were characterized by the highest content of zinc (89.7 mg kg^{-1} d.m.). The least of this compound (60.3 mg kg^{-1} d.m.) was determined in two-year-old plants. On the basis of two-year means, it was evidenced that one-year-old plants contained the highest amount of copper, while the least copper was in three-year-old plants. Moreover, one-year-old plants of garlic chives were characterized by a higher amount of zinc than two- and three-year-old plants. However, three-year-old plants were characterized by the highest content

Table 3

Microelements in edible parts of one-, two- and three-year-old plants of garlic chives

Macroelements	Years of study	Garlic chives (mg kg^{-1} d.m.)			Mean	LSD α=0.05
		one-year old	two-year old	thrre-year old		
Mn	experiment I	31.3	15.9	34.6	27.3	1.7
	experiment II	15.5	19.0	16.0	16.8	2.4
	mean	23.4	17.4	25.3	-	0.9
Cu	experiment I	20.5	14.2	10.4	15.0	1.9
	experiment II	61.8	24.8	19.4	35.3	1.4
	mean	41.1	19.5	14.9	-	0.7
Zn	experiment I	49.8	51.4	43.5	48.2	4.6
	experiment II	89.7	60.3	65.7	71.9	1.7
	mean	69.7	55.8	54.6	-	1.5
Fe	experiment I	100.0	150.5	197.0	149.2	5.4
	experiment II	148.0	122.0	119.0	130.0	8.7
	mean	124.0	136.2	158.0	-	3.1

of manganese (25.3 mg kg^{-1} d.m.) while two-year-old plants had the least of this element (17.4 mg kg^{-1} d.m.). Moreover, three-year-old plants contained more iron than one- and two-year-old plants.

CONCLUSIONS

1. The plant age had a significant effect on the content of dry matter. The highest amount of dry matter was assessed in leaves of one-year-old plants, while the least dry matter was contained in three-year-old plants.

2. It has been demonstrated that the plant age has a significant effect on the content of macro- and microelements. Leaves of one-year-old plants contained the highest amounts of potassium, sulphur, copper and zinc. Two-year-old plants were characterized by a high content of magnesium and calcium, while three-year-old plants contained the highest amounts of phosphorus and manganese.

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