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CONTENT OF MACRO- AND MICRONUTRIENTS IN GREEN AND BLANCHED LEAVES OF GARLIC CHIVES (*ALLIUM TUBEROSUM* ROTTLER EX SPRENGEL)

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Abstract

Despite its numerous advantages, garlic chives *(Allium tuberosum* Rottler ex Sprengel) remains a species that is little known of and therefore underestimated in Poland. Cultivation requirements of garlic chives in the climatic conditions of West Pomerania have long been studied at the Department of Horticulture, West Pomeranian University of Technology in Szczecin. An example of such research is the experiment, conducted in 2007-2009, whose aim was to determine the effect of blanching two-year old garlic chives plants on the yield of dry matter and the macro- and micronutrient content. Control plants were non-blanched, two-year old plants. Each year, on 10th April, the seeds were sown directly in a field, 5 seeds per point, 30 x 20 cm apart. The plants were blanched by being covered with low plastic tunnels coated with one or two layers of black nonwoven polypropylene fabric. Blanched leaves were collected 4 weeks after installing the tunnels. Field experiments were established and carried out at the Vegetable Research Station in Dołuje (near Szczecin), and chemical analyses were performed at the Regional Chemical and Agricultural Station in Szczecin. The highest content of phosphorus and total nitrogen was found in the leaves blanched under a double layer of nonwoven fabric, as compared to non-blanched plants. An opposite trend was observed for potassium and calcium. The highest content of these macronutrients was noticed in non-blanched leaves of garlic chives. No significant effect of blanching was found regarding the leaf content of magnesium and sulphur. The highest level of copper was reported in non-blanched leaves, and the leaves covered with a double layer of nonwoven fabric were the richest in iron. The lowest content of zinc was found in the leaves blanched under one layer and the lowest level of manganese in those blanched under two layers of black nonwoven fabric.

Key words: bleaching plant, dry matter, mineral components.

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INTRODUCTION

Bulb vegetables include 500 to 780 species, both economically important and wild ones (Pino et al. 2001, Guohua et al. 2006, Kołota et al. 2012, Alizadeh et al. 2013). They are a rich source of saponins, alkaloids (Guohua et al. 2009) and sulphur containing compounds (Yabuki et al. 2010). In addition to that, they exhibit antioxidant properties (Yin and Cheng 1998), which is why they are commonly grown and consumed. Their specific taste and possible medicinal use make them an exciting research subject for scientists and researchers in the field of plant physiology, chemistry or nutrition (Graham, Graham 1987). Introducing and selling new, interesting and nutritious vegetable species is a very important aspect of horticultural production. Garlic chives, a valuable vegetable that combines good taste and nutritional values of garlic and chives (Arcichowska et al. 2009), could serve as an example. Its edible parts include young inflorescences and leaves. Garlic chive is used in Chinese medicine (Guohua et al. 2009) as a herbal remedy for stomachache, diarrhoea, snakebites or asthma (Sang et al. 2001). The plant mainly grows in Japan, China, Korea and South Asia (Rodkiewicz 1999), but it can also be found in North America, North Africa and in Europe (Pino et al. 2001, Hanen et al. 2012). In Japan, there are as many as sixteen varieties of this species (Yabuki et al. 2010).

In the Polish climatic conditions, garlic chives overwinters in field without any shelter. It is resistant to diseases and pests attacking bulb vegetables and therefore it does not require chemical protection. It can be successfully grown at organic farms. Edible parts of this species, often used as an excellent seasoning for many dishes, are mostly leaves and less often young flower stalks. Garlic chives leaves are sometimes quite hard, but they can be blanched. Polish and international scientific literature lacks information on the possibility of implementing this procedure in garlic chives cultivation. The aim of this study was to develop a method for blanching leaves of garlic chives in the climatic conditions of West Pomerania, and to compare dry matter as well as the micro- and macronutrient content in leaves of blanched and non-blanched plants.

MATERIAL AND METHODS

The study was conducted in 2007-2009, at the Department of Horticulture, West Pomeranian University of Technology in Szczecin. Plant material included two-year-old plants of garlic chives. Fertilization was performed based on soil sample analysis carried out each year of the study (Table 1) and consisted in supplementing the mineral components up to 150 mg $N\text{-}NO_3$, 75 mg P, and 175 mg K dm^{-3}.

Seeds were sown in three replicates, on 10th April of 2007 and 2008,

Table 1

Mineral composition of the soil collected from the experimental plot in the consecutive years of the study

Year of study	pH in H_2O	Salinity (g NaCl dm^{-3})	Mineral content (mg dm^{-3} of soil)					
			$N\text{-}NO_3$	P	K	Ca	Mg	Cl
2007	7.9	0.13	12	55	86	4645	94	15
2008	8.1	0.20	26	98	139	2335	80	11
2009	8.0	0.20	8	40	125	4961	108	21

30x20 cm apart, 5 seeds per point, in beds 8.64 m^2 in surface area. The plant density was 75 individuals per 1 m^2. The leaves were harvested in 2008 and 2009, by cutting at 5 cm above the soil. Green leaves were harvested successively, every 3-4 weeks, according to the agronomical practice of growing the species. In half of the beds, the harvest was finished by 10th July. On 30th August, when the plants were 30-40 cm high, half of the beds were covered with low plastic tunnels coated with one or two layers of black nonwoven fabric. Blanched leaves were harvested each year after 4 weeks of blanching. The harvested blanched and non-blanched material was used to determine the content of dry matter and micro- and macronutrients. Chemical analyses included only fully grown leaves, while damaged and yellowing ones were discarded. The final sample comprised leaves collected from 150 plants. The dry matter content was assessed at the Department of Horticulture, West Pomeranian University of Technology in Szczecin, directly after harvest, by drying the leaves to the constant weight at a temperature of 105°C.

After plant dry matter mineralization in a mixture of H_2SO_4 and H_2O, the content of the following elements was determined:

– total nitrogen by the Kjeldahl method,
– potassium, and calcium by flame photometry,
– phosphorus by the colorimetric method,
– magnesium by flame atomic absorption spectrophotometry (AAS),
– sulphur by the turbidimetric method.

Additionally, after mineralization of the plant dry matter in a mixture of HNO_3 and $HClO_4$, the content of copper, zinc, manganese and iron was determined using flame atomic absorption spectrophotometry – AAS (Krełowska-Kułas 1993).

The analyses of micro- and macronutrient content were performed at the Regional Chemical and Agricultural Station in Szczecin.

The results were evaluated by the Tukey's test and the assumed significance level was $\alpha = 0.05$.

RESULTS AND DISCUSSION

The variance analysis of the mean experimental results revealed significant differences in the dry matter content between blanched and non-blanched leaves of garlic chives. According to KOTLIŃSKA et al. (2005), Welsh onion leaves contain 5-13% of dry matter. This information was confirmed in our study, as the average dry matter content in non-blanched leaves of garlic chives was 13.9%. The highest share of dry matter (19.6%) in the aerial part of garlic chives was reported by KHALID et al. (2014). Our study also showed that non-blanched control plants were characterized by the highest dry matter content, whereas those covered with double layer of nonwoven fabric had the lowest dry matter content (Table 2).

Table 2

Dry matter content (%) in green and blanched leaves of garlic chives

Blanching method	Year of study		
	2008	2009	Mean
I	13.20	14.60	13.90
II	6.600	10.20	8.400
III	4.530	7.490	6.010
Mean	8.110	10.763	9.437
$LSD\alpha_{0,05}$	0.650	1.032	0.785

I – non-blanched plants (control)
II – plants covered with one layer of black nonwoven fabric
III – plants covered with two layers of black nonwoven fabric

Bulb vegetables are a valuable source of many mineral salts (KOTLIŃSKA et al. 2005, TENDAJ and MYSIAK 2006). KHALID et al. (2014) compared the mineral composition of garlic and garlic chives plants, concluding that garlic chives contained more Na, Ca, Fe, P, K, Zn, Mn and Mg, by 4.50, 28.66, 4.40, 10.62, 59.00, 0.86, 0.014, and 3.77 mg 100 g^{-1}, respectively. According to WILLS et al. (1984), the content of K, Ca, and Mg is considerably higher, respectively by 341.0, 23.34, and 16.23 mg 100 g^{-1}. ŻURAWIK et al. (2013) reported that two-year old garlic chives plants contain on average more N – 27.5 g kg^{-1} d.m, Ca – 12.9 g kg^{-1} d. m., K – 48.4 g kg^{-1} d.m, Na – 0.2 g kg^{-1} d.m, P – 3.6 g kg^{-1} d.m, Mg – 2.6 g kg^{-1} d.m, and S – 9.1 g kg^{-1} d.m.

The analysis of variance, carried out for the mean results from individual years, revealed that covering the plants with black nonwoven fabric resulted in an increased content of nitrogen as compared to the control leaves (Table 3). The content of this macronutrient rose significantly with each layer of black nonwoven fabric. A similar relationship was observed for phosphorus. However, an opposite trend was noticed for the leaf content of potassium and calcium. The highest content of these macronutrients was noticed in non-blanched leaves of garlic chives. No significant effect of blanching was observed regarding the leaf content of sulphur. As pointed out by GRZEBISZ (2011), magnesium,

which is known to be a very important element for humans, also plays some essential physiological and biochemical functions in plants and therefore affects their yield. In our experiment, the magnesium content in two-year old non-blanched garlic chives plants was 2.03 g kg^{-1} d.m. HACISEFEROGULLARI et al. (2005) claimed that the Mg content in garlic was by 1.03 g kg^{-1} d.m. lower. This study showed no significant effect of blanching on the leaf magnesium content. According to LOPES et al. (1997) and CHOUDHARY (2008), sulphur compounds present in the species of *Allium* genus are beneficial for human health. Their effects are particularly evident in people whose diet contains *Allium sativum* and *Allium tuberosum*. Our study indicated no differences in the sulphur content in all leaves of garlic chives, with the mean level of this element being 10.1 g kg^{-1} d.m., irrespective of blanching. HACISEFEROGULLARI et al. (2005) claimed that the potassium content in garlic was 21.0 g kg^{-1} d.m. Their study revealed that the K concentration in non-blanched two-year old garlic chives was higher by 29.0 g kg^{-1} d.m. A reverse relationship was observed for phosphorus, where the difference was 3.1 g kg^{-1} d.m.

Table 3

The content of macronutrients in edible parts of two-year old garlic chives depending on the degree of blanching (g kg^{-1} d.m.)

Macronutrient	Year of study	Blanching method			Mean	$LSD\alpha_{0,05}$.
		I	II	III		
N-total	2008	38.10	49.10	56.50	47.90	0.240
	2009	32.10	29.20	34.90	32.07	0.833
	mean	35.10	39.15	45.70	39.98	2.066
K	2008	50.40	39.80	42.10	44.10	2.405
	2009	49.60	38.00	40.70	42.77	2.294
	mean	50.00	38.90	41.40	43.43	2.505
Ca	2008	9.800	6.200	4.700	6.900	0.867
	2009	7.300	2.900	0.920	3.707	0.376
	mean	8.550	4.550	2.810	5.303	1.355
P	2008	3.100	4.600	7.900	5.200	0.240
	2009	2.700	5.560	6.530	4.930	0.378
	mean	2.900	5.080	7.215	5.065	0.433
Mg	2008	2.100	2.100	2.300	2.167	n.s.
	2009	1.950	2.040	1.870	1.953	n.s.
	mean	2.025	2.070	2.085	2.060	n.s.
S	2008	10.80	11.00	10.50	10.77	n.s.
	2009	9.600	9.100	8.340	9.013	0.105
	mean	10.20	10.10	9.420	9.890	n.s.

n.s. – non-significant differences
I – non-blanched plants (control)
II – plants covered with one layer of black nonwoven fabric
III – plants covered with two layers of black nonwoven fabric

The study also demonstrated a significant influence of covering the plants with black nonwoven fabric on the content of some micronutrients (Table 4). Żurawik et al. (2013) reported the following mean content of main

Table 4

The content of micronutrients in edible parts of two-year old garlic chives (mg kg^{-1} d.m.)

Micronutrient	Year of study	Blanching method			Mean	$LSD\alpha_{0.05}$
		I	II	III		
Cu	2008	20.20	12.00	13.10	15.10	2.645
	2009	28.10	8.040	11.20	15.78	0.546
	mean	24.15	10.02	12.15	15.44	2.506
Zn	2008	70.60	71.00	74.00	71.87	0.636
	2009	78.40	58.00	73.20	69.87	1.734
	mean	74.50	64.50	73.60	70.87	5.349
Mn	2008	18.60	17.50	14.20	16.77	0.833
	2009	15.30	11.50	12.20	13.00	0.962
	mean	16.95	14.50	13.20	14.88	2.542
Fe	2008	128.6	157.0	130.0	138.5	3.639
	2009	142.5	111.5	212.6	155.5	2.369
	mean	135.5	134.3	171.3	147.1	15.47

I – non-blanched plants (control)
II – plants covered with one layer of black nonwoven fabric
III – plants covered with two layers of black nonwoven fabric

micronutrients in two-year old garlic chives plants: Mn – 17.4 g kg^{-1} d.m., Cu – 19.5 g kg^{-1} d.m., Zn – 55.8 g kg^{-1} d.m., and Fe – 136.2 g kg^{-1} d.m. Our study confirmed the above data regarding manganese and iron, whose content in non-blanched leaves of garlic chives was 17.0 g kg^{-1} d.m. and 135.5 g kg^{-1} d.m., respectively. The mean iron content in garlic chives plants examined in our study was higher than reported by Moreau et al. (1996) and Hanen et al. (2012) for *A. roseum* – by 54.0 and 34.0 mg kg^{-1}, respectively. In comparison with *A. sativum* (Haciseferogullari et al. 2005), this difference was even-more distinct, reaching 82.59 mg kg^{-1} d. m. Additionally, it was found that non-blanched leaves contained more copper than blanched ones, and that the copper content in the control leaves was by 142% and 98.4% higher than in leaves of plants covered with one or two layers of black nonwoven fabric, respectively. Tan et al. (2009) claimed that many herbs with antineoplastic properties were characterized by high concentrations of Zn, Mn, Fe and Cu. Mao et al. (2009) pointed out that a higher content of zinc than copper may indicate antineoplastic properties and that such plants are used in traditional Chinese medicine. Our study demonstrated a higher content of zinc (mean 70.9 mg kg^{-1} d.m.) than copper (mean 15.4 mg kg^{-1} d.m.) in leaves of garlic chives. It was also found that covering the plants with a double layer of non-woven fabric significantly affected the iron content. Plants treated in this

way contained a higher level of this micronutrient, as compared to the control ones and the plants covered with a single layer of nonwoven fabric. Blanching caused a significant reduction in the manganese content. The highest level of this macronutrient was found in the control leaves, where it was higher by 75.8% and 28.8% than in the plants covered with one or two layers of nonwoven fabric, respectively.

CONCLUSIONS

1. Blanching garlic chive plants in the second year of cultivation affects the content of leaf dry matter and micro- and macronutrients.

2. The content of dry matter is reduced proportionally to the degree of blanching and it is the highest in the control plants and the lowest in the plants blanched under a double layer of black nonwoven fabric.

3. Blanching in the second year of cultivation increases the content of nitrogen and phosphorus but decreases the level of potassium, calcium, copper and manganese in garlic chives plants.

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