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THE EFFECT OF CULTIVATION METHOD ON THE MACRONUTRIENTS CONTENT OF SHALLOT BULBS (*ALLIUM ASCALONICUM* L.)

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Summary

A field experiments were carried out in 2005-2007 at the Experimental Station of the University of Warmia and Mazury in Olsztyn. The experiments were set up in a split-plot design, in four replications. Plants were grown in typical black earth soil of quality class IIIb, cereal-fodder strong complex. The first experimental factor was the cultivation method. In the first year of the study, shallot were grown by direct seeding and from seedlings, while small bulbs (Ø 16-20 mm) were additionally introduced in the second year of the experiment. Cultivars were the second experimental factor. The analyzed material consisted of two hybrid shallot cultivars: Bonilla F_1 and Matador F_1. A total of 100 plants were grown in experimental plots with an area of 3 m^2, with 30 x 10 cm spacing.

Shallots were harvested when the foliage on approximately 60 to 70% of plants have collapsed. Plant material (bulbs) was assayed for nitrogen, phosphorus, potassium, calcium and magnesium concentrations. The highest total nitrogen levels were determined in shallot bulbs grown from seedlings, while shallots bulbs grown from seeds were most abundant in phosphorus, potassium, calcium and magnesium. Significantly higher nitrogen and phosphorus concentrations were observed in the bulbs of cv. Matador F_1, while Bonilla F_1 bulbs showed significantly higher levels of potassium, calcium and magnesium.

Favorable Ca:Mg ratios, narrow Ca:P ratios and wide K:Mg, K:(Ca+Mg) and K:Ca ratios were noted in all experimental variants.

key words: shallot, cultivation method, cultivar, macronutrients

INTRODUCTION

The shallot (*Allium ascalonicum* L.) is a relative to the onion that propagates by offsets and has a unique growth and development pattern. Shallot is

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grown in various climate zones ranging from Asia and Africa to northern Europe and North America. It is especially popular in regions where onion is difficult to cultivate by direct seeding. Due to the widespread popularity of onion in Poland, shallot is still grown on a small scale only. Nevertheless, recent years have witnessed a growing interest in the mass production of shallot owing to their versatile applications, taste and high nutritive value (Tendaj 2005).

Plants and animals are made up in nearly 99.8% of macronutrients (C, H, O, N, P, K, Ca, Mg, Na, S and Cl), the main building blocks required for their normal growth and development. The bioavailability of macronutrients supports the healthy function of the human body. The dietary intake of nutrients does not always meet the body's physiological requirements and the resulting deficiency, in particular of magnesium and calcium, can have serious health implications for humans and animals (Jędrzejczak *et al*. 1999, Synowiecki 2002).

As a chlorophyll component and an activator of many enzymes, magnesium has a number of important functions that support the growth and development of plants. According to Jędrzejczak *et al.* (1999), vegetables are not a particularly abundant source of this nutrient, in comparison with other edible plants. However, as reported by Messiaen & Rouamba (2004), and Orłowski & Kołota (1999), they are a rich source of calcium and potassium.

The aim of this study was to determine the effect of cultivation method on the macronutrients content of two shallot cultivars and their nutrient ratios.

MATERIALS AND METHODS

A two-factorial field experiments were carried out in a split-plot design, in four replications, during the years 2005-2007, at the Experimental Station of the University of Warmia and Mazury in Olsztyn. Field treatments were set up on typical black earth soil of quality class IIIb, cereal-fodder strong complex with pH_{H2O} of 7.5 (Systematyka gleb Polski 1989, Bieniek 1994). Soil analysis was performed each year before seeding, seedling transplanting and planting small bulbs. In all years of the study, the average mineral content of soil was as follows: $N\text{-}NO_3$ - 30, P - 120, K - 98, Ca - 2480, Mg - 169 and Cl - 10 ($mg \cdot dm^{-3}$). Mineral deficiencies were supplemented to the optimal levels for onions, i.e. $N\text{-}NO_3$ to 80 and K to 200 $mg \cdot dm^{-3}$. The quantities of P, Ca and Mg in the soil were sufficient for shallot growing.

The first experimental factor was the cultivation method. In the first year of the study, shallot was grown by seeding and from seedlings, while small bulbs (Ø 16-20 mm) were additionally introduced in the second year of the experiment. Cultivars were the second experimental factor. Experimental material consisted of two hybrid shallot cultivars: Bonilla F_1 and Matador F_1. Plot area was 3 m^2 (1.5 x 2.0 m). A total of 100 plants were grown in experimental plots, with 30 x 10 cm spacing, in five rows of 20 plants each. Seedlings were produced in an unheated greenhouse. Seeds were sown in boxes in the first half of March (9-13 March, depending on the year). Each year, the sowing of seeds and the planting of seedlings and small bulbs took place on the same day in the first

half of April (10-13 April). The recommended cultivation practices for shallot were applied.

Plants were harvested when the foliage an approximately 60 to 70% of plants have collapsed. The time of harvest varied depending on weather conditions. Shallot grown from small bulbs was harvested between 3 and 10 August, shallot grown from seedlings – from 14 to 21 August, while shallot grown from seeds – from 21 to 29 August. Scales bulbs from all experimental treatments were removed, shredded, dried to constant weight at 65ºC and ground. The weight of a single field sample was 2000 g. Plant material was analyzed to determine the content of nitrogen, phosphorus, potassium, calcium, magnesium, cadmium, copper, chromium, zinc and manganese. Total nitrogen levels (determined by the Kjeldahl method), the content of potassium (vanadium-molybdate method), K, Ca (flame photometry, ESA) and Mg (atomic absorption spectroscopy, AAS) were determined after wet mineralization in H_2SO_4+H_2O_2. Quantitative ratios between the following macronutrients were computed: Ca:P, Ca:Mg, K:Mg, K:(Ca+Mg) and K:Ca.

The results of chemical analyses were subjected to an analysis of variance with the use of Statistica 7.0 software. They are presented as mean values for the experimental years.

RESULTS AND DISCUSSION

A statistical analysis revealed that the macronutrient content of shallot bulbs was significantly affected by both experimental factors, i.e. the applied cultivation method and the characteristic features of each shallot cultivar.

The macronutrient levels in the analyzed plant material were similar to those determined by Orłowski *et al*. (2005) in bunch harvested shallot, and by Jadczak (2005) in underground bulbs of *Allium cepa* var. *proliferum*, and remained within the limits set for bulbous vegetables by Kunachowicz *et al*. (2006) (Table 1). Total nitrogen concentrations in shallot bulbs were determined in a relatively wide range of 13.64 to 20.67 g·kg^{-1} d.m. in the following order: Matador F_1 grown from seedlings > Bonilla F_1 grown from seedlings > Matador F_1 grown from seeds > Bonilla F_1 grown from seeds > Bonilla F_1 grown from small bulbs and Matador F_1 grown from small bulbs. Phosphorus levels ranged from 4.45 to 6.04 g·kg^{-1} d.m. The highest quantities of phosphorus were accumulated by shallot grown from seeds. The cultivar most abundant in this macronutrient was Matador F_1. The potassium content of shallot was in the range of 13.82 to 16.85 g·kg^{-1} d.m., and it was determined by both experimental factors. The highest levels of potassium were found in shallot grown from seeds (14.02 g·kg^{-1} d.m.) and in Bonilla F_1 bulbs (15.30 g·kg^{-1} d.m.). Ghoname *et al*. (2007) reported that the potassium content of onion varied from 15.4 to 19.8 g·kg^{-1} d.m., depending on calcium and potassium fertilization levels and the year of study. In the experiment conducted by Jurgiel-Małecka & Suchorska-Orłowska (2004), shallot bulbs accumulated from 0.57 to 0.78 g·kg^{-1} d.m. of magnesium, subject to the type and rate of the applied nitrogen fertilizer and to the year of

study. Similar magnesium levels were reported in this study, in the range of 0.70 to 0.89 g·kg^{-1} d.m., in the following order: Bonilla F_1 grown from seeds > Matador F_1 grown from seeds > Bonilla F_1 grown from seedlings and Matador F_1 grown from seedlings > Bonilla F_1 grown from small bulbs and Matador F_1 grown from small bulbs. The choice of cultivation method had a pronounced effect on magnesium levels. The calcium content of shallot bulbs ranged widely from 1.32 to 1.82 g·kg^{-1} d.m., and it was clearly dependent on the cultivation method and cultivar. Significantly higher quantities of calcium were accumulated by shallot grown from seeds (1.79 g·kg^{-1} d.m.) and by shallot cv. Bonilla F_1 (1.63 g·kg^{-1} d.m.).

Table 1. Macronutrient content of shallot bulbs as dependent on the cultivation method (mean values of the years 2005-2007)

Cultivar	Cultivation method	Macronutrients (g·kg^{-1} d.m.)				
		N- total	P	K	Mg	Ca
Bonilla F_1	Direct sowing	15.62	5.88	16.85	0.89	1.82
	Seedlings	19.22	4.95	15.21	0.73	1.63
	Small bulbs	13.46	4.45	13.83	0.70	1.44
Mean		16.10	5.10	15.30	0.77	1.63
Matador F_1	Direct sowing	18.50	6.04	13.82	0.86	1.76
	Seedlings	20.67	5.23	14.41	0.73	1.38
	Small bulbs	13.46	4.54	14.21	0.70	1.32
Mean		17.54	5.27	14.15	0.76	1.49
Mean for	Direct sowing	17.06	5.96	15.33	0.87	1.79
cultivation	Seedlings	19.94	5.09	14.81	0.73	1.51
method	Small bulbs	13.46	4.50	14.02	0.70	1.38
$LSD_{0.05}$						
factor I - cultivation method		0.16	0.05	0.08	0.03	0.03
factor II - cultivar		0.13	0.04	0.06	0.02	0.03
I x II		0.23	0.06	0.11	0.04	0.05

The proportions in which macronutrients are found in edible plant parts are also an important determinant of plants' nutritive value (Kotowska & Wybieralski 1999). According to Czapla & Nowak (1995), Czuba & Mazur (1988), Falkowski *et al*. (2000) and Radkowski *et al*. (2005), the optimal macronutrient ratios in the dietary intake of mammals should not exceed: for Ca:P – 2, Ca:Mg – 3, K:(Ca + Mg) – 1.6-2.2, K:Mg – 6, K:Ca – 2. Kotowska & Wybieralski (1999) and Matraszek *et al*. (2002) observed that macronutrient ratios in plant edible parts often diverge from the above reference standards. They are highly diversified and dependent on, among other things, the cultivar, the part of the plant, time of cultivation and fertilization. Wider Ca:Mg and Ca:P ratios than optimal may be indicative of magnesium or phosphorus deficiency. According to Skibniewska *et al*. (2007) and the FAO/WHO (2001) report, excessive phosphorus levels may inhibit calcium absorption, posing a risk of osteoporosis. Ca:P ratios in the investigated shallot were very similar and always too narrow, regardless of the cultivation method and cultivar (Fig. 1). The analyzed bulbs

were marked by satisfactory Ca:Mg ratios. The optimum calcium to magnesium ratio (2.23) was observed in Bonilla F_1 shallot grown from seedlings (Fig. 2). As regards calcium to magnesium weight ratios, satisfactory results were noted in cv. Bonilla F_1 and in shallot bulbs grown from seedlings. The K:Mg quantitative ratios in the analyzed shallot were very wide, ranging from 16.07 to 20.84 (Fig. 3). Those macronutrients were determined in more favorable ratios in the edible parts of Matador F_1 shallot and in shallot bulbs grown from seeds. K:(Ca+Mg) ratios were relatively uniform, ranging from 5.27 in Matador F_1 shallot grown from seeds to 7.03 in Matador F_1 shallot grown from small bulbs. All of the reported ratios were significantly wider than the optimal values (Fig. 4). The obtained ratios were higher than those noted by Jadczak (2005) in underground bulbs of *Allium cepa* var. *proliferum*. These results suggest that the content of calcium and magnesium in shallot bulbs was too low, relative to the concentrations of other macronutrients. Cultivar had no statistically significant effect on the K:(Ca+Mg) ratio which was more influenced by the cultivation method. The most favorable ratio of potassium to the sum of calcium and magnesium was determined for shallot grown from seeds. The highest variability was demonstrated by the K:Ca ratio which ranged from 7.85 in Matador F_1 shallot grown from seeds to 10.77 in Matador F_1 shallot grown from small bulbs (Fig. 5). The choice of cultivation method had a significant effect on K:Ca ratios in the investigated plant material, while cultivar proved to be a relatively insignificant experimental factor.

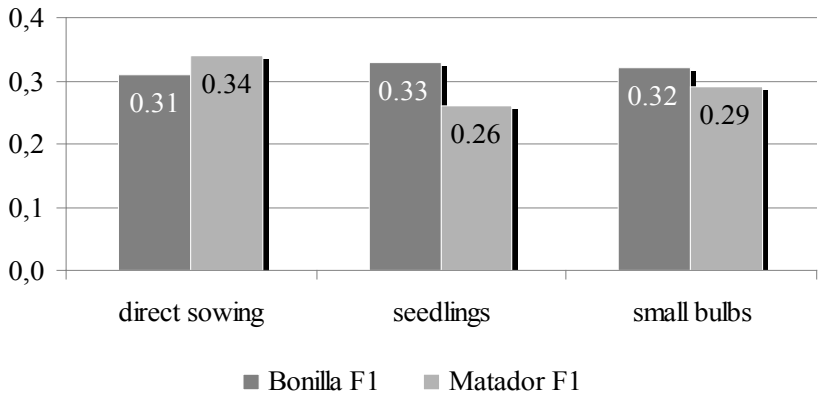


Fig. 1. Ca : P ratio in shallot bulbs (mean values of 2005-2007)

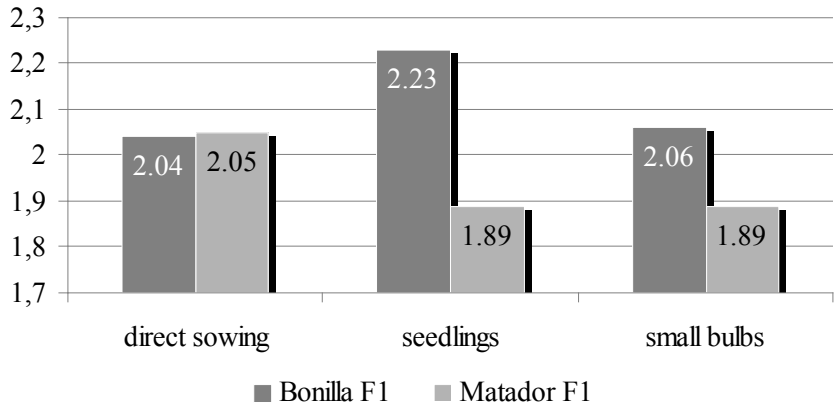


Fig. 2. Ca : Mg ratio in shallot bulbs (mean values of 2005-2007)

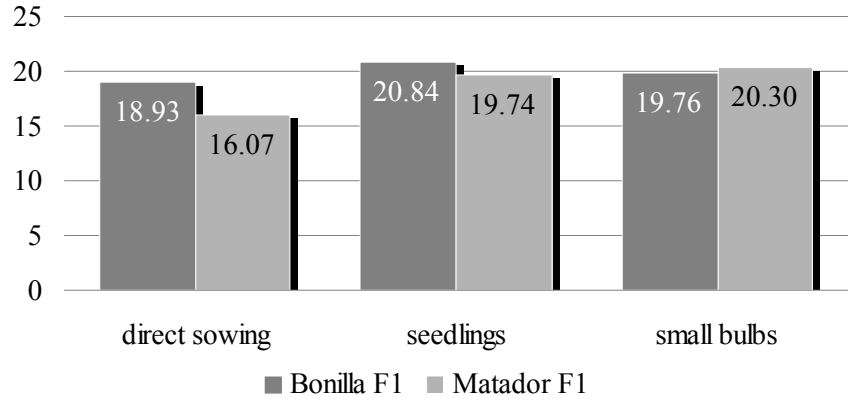


Fig. 3. K : Mg ratio in shallot bulbs (mean values of 2005-2007)

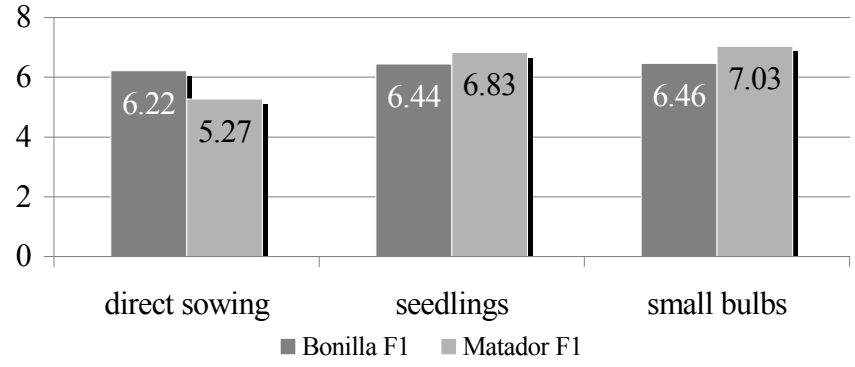


Fig. 4. K : (Ca+Mg) ratio in shallot bulbs (mean values of 2005-2007)

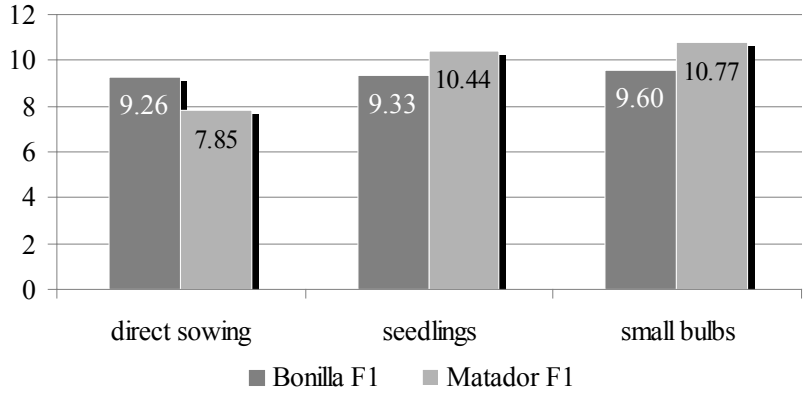


Fig. 5. K : Ca ratio in shallot bulbs (mean values of 2005-2007)

CONCLUSIONS

1. Macronutrient concentrations in shallot bulbs were significantly affected by both experimental factors, i.e. cultivation method and cultivar.
2. The highest total nitrogen levels were determined in shallot grown from seedlings, while shallot grown from seeds were most abundant in phosphorus, potassium, calcium and magnesium.
3. Significantly higher quantities of nitrogen and phosphorus were accumulated by the bulbs of cv. Matador F_1, compared to cv. Bonilla F_1, while higher potassium, calcium and magnesium levels were noted in Bonilla F_1 shallot , in comparison with cv. Matador F_1.
4. Favorable Ca:Mg ratios were observed in all experimental variants.
5. An analysis of plant material showed narrow Ca:P ratios and wide K:Mg, K:(Ca+Mg) and K:Ca ratios.

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ZAWARTOŚĆ MAKROELEMENTÓW W CEBULACH SZALOTKI (*ALLIUM ASCALONICUM* L.) W ZALEŻNOŚCI OD METODY UPRAWY

Streszczenie

Doświadczenie zostało przeprowadzone w latach 2005-2007 na polu Ogrodu Doświadczalnego Uniwersytetu Warmińsko-Mazurskiego w Olsztynie. Założone zostało w układzie split - plot w czterech powtórzeniach na glebie typu czarna ziemia właściwa, zaliczonej do klasy bonitacyjnej IIIb, należącej do kompleksu zbożowo-pastewnego mocnego. Pierwszym czynnikiem doświadczenia była metoda uprawy. W pierwszym roku rośliny uprawiano dwiema metodami – z siewu nasion do gruntu oraz z rozsady, a od drugiego roku także z sadzenia małych cebul (Ø 16-20 mm). Drugi czynnik doświadczenia stanowiły odmiany. Badaniami objęto dwie mieszańcowe odmiany szalotki

– Bonilla F_1 i Matador F_1. Rośliny w ilości 100 szt. na poletku rosły w rozstawie 30 x 10 cm. Powierzchnia poletka wynosiła 3 m^2.

Rośliny zbierano w fazie dojrzałości zbiorczej. W materiale roślinnym oznaczono zawartość azotu, fosforu, potasu, wapnia i magnezu.

Najwięcej azotu ogółem oznaczono w cebulach szalotki uprawianej z rozsady, natomiast fosforu, potasu, wapnia i magnezu w uprawianych z siewu bezpośredniego. Istotnie więcej azotu i fosforu zgromadziły w cebulach rośliny odmiany Matador F_1, natomiast potasu, wapnia i magnezu odmiany Bonilla F_1.

We wszystkich wariantach doświadczenia zanotowano prawidłowy stosunek Ca : Mg, niski między Ca : P oraz wysoki K : Mg, K : (Ca + Mg) oraz K : Ca.