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CONTENT OF MACROELEMENTS IN EGGPLANT FRUITS DEPENDING ON VARIED POTASSIUM FERTILIZATION

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Abstract

Eggplant fruits are abundant in potassium, the amount of which ranges from 200 to 600 mg K·100 g^{-1} FM, depending on a variety. They are also a rich source of phosphorus, magnesium, calcium, and iron. As there are no fertilization recommendations for eggplant cultivation under cover, this study been undertaken to evaluate the vegetable's requirements. The aim was to test how the type and dose of potassium fertilizer influences nitrogen, phosphorus, calcium, and magnesium levels in eggplant fruits. The experiment on cv. Epic F_1 eggplant was carried out in unheated polyethylene tunnel in 2004-2005. The eggplant was cultivated on peat subsoil in 10 dm^3 capacity cylinders made of rigid plastic. The experiment was set up in a two-factor, completely randomized design. The influence of two factors was examined: I – type of potassium fertilizer (KCl, K_2SO_4, KNO_3), and II – potassium rate (8, 16, 24 g K·$plant^{-1}$). Fruit samples for laboratory determinations were collected in mid-August, in the middle of fruiting stage. Fruits were harvested at the stage of technological maturity and the following were determined: N_{tot}, P, K, Ca, Mg. The results were processed by variance analysis. Significantly higher total nitrogen and potassium concentrations in fruits of plants fertilized with potassium nitrate as compared to the other two fertilizer types were recorded. Increasing potassium doses, regardless the fertilizer type, considerably increased the element content in eggplant fruits and widened the K:Ca ratio value. The diversification of potassium fertilization did not have significant influence on phosphorus and magnesium concentrations in eggplant fruits. No significant changes in calcium content in fruits were observed when applying potassium sulfate or nitrate, while higher potassium chloride rates significantly decreased the concentration of this element in fruits.

Key words: eggplant fruit, potassium fertilizer, K dose, macroelements.

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ZAWARTOŚĆ MAKROELEMENTÓW W OWOCACH OBERŻYNY W ZALEŻNOŚCI OD ZRÓŻNICOWANEGO NAWOŻENIA POTASEM

Abstrakt

Owoce oberżyny należą do warzyw zasobnych w potas. Jego zawartość w zależności od odmiany wynosi od 200 do 600 mg K·100 g^{-1} świeżej masy. Są również źródłem fosforu, magnezu, wapnia i żelaza. Ze względu na brak informacji o zaleceniach nawozowych do uprawy oberżyny pod folią, podjęto badania nad określeniem potrzeb nawożenia tego warzywa. Celem pracy było określenie wpływu rodzaju nawozu potasowego oraz dawki na zawartość azotu, fosforu, potasu, wapnia i magnezu w owocach oberżyny. Badania oberżyny odmiany Epic F_1 wykonano w latach 2004-2005 w nieogrzewanym tunelu foliowym w latach 2004-2005. Oberżynę uprawiano w cylindrach z folii sztywnej o pojemności 10 dm^3, w torfie ogrodniczym. Doświadczenie przeprowadzono w układzie kompletnej randomizacji. Badano wpływ 2 czynników: I – nawozów potasowych (KCl, K_2SO_4, KNO_3), II – dawek potasu (8, 16, 24 g K·roślina^{-1}). Próby owoców do badań laboratoryjnych pobrano w 2. dekadzie sierpnia, w połowie okresu owocowania. Owoce zbierano w fazie dojrzałości użytkowej i oznaczono w nich N-og., P, K, Ca, Mg. Wyniki opracowano metodą analizy wariancji. Wykazano istotnie większą zawartość azotu ogółem i potasu w owocach roślin nawożonych saletrą potasową w porównaniu z roślinami nawożonymi dwoma pozostałymi nawozami. Wzrastające dawki potasu – niezależnie od zastosowanych nawozów potasowych – istotnie zwiększały zawartość tego składnika w owocach oberżyny oraz rozszerzały stosunek K: Ca.

Zróżnicowane nawożenie potasem nie miało istotnego wpływu na zawartość fosforu i magnezu w owocach oberżyny. Nie wykazano znaczących zmian w zawartości wapnia w owocach po zastosowaniu siarczanu i azotanu potasu, w przypadku zaś większych dawek chlorku potasu zawartość tego składnika była istotnie mniejsza.

Słowa kluczowe: owoce oberżyny, nawozy potasowe, dawki potasu, makroelementy.

INTRODUCTION

Eggplant fruits are attracting a growing interest of consumers and producers on the Polish market of fresh vegetables. Eggplant fruits are valuable dietetically due to their low caloricity along with rich and varied mineral composition. First of all, they are abundant in potassium, calcium, phosphorus, magnesium, and microelements (Kaufmann, Vorwerk 1971, Herrmann 1996, Lawende, Chavan 1998, Kowalski et al. 2003, Golcz et al. 2005, Michałojć, Buczkowska 2007, 2008a).

Vegetables of *Solanaceae* family require much potassium (Kaufmann, Vorwerk 1971, Golcz 2001, Nurzyński et al. 2001). Therefore, this vegetable may be a potassium source in human daily human diet.

The growing interest in eggplant cultivation means that it is necessary to define nutritional and fertilization requirements of this vegetable when grown under cover.

The up-to-date fertilization recommendations for eggplant have referred to tomato's nutritional needs (Uliński, Glapiś, 1998).

The present study has aimed at evaluating the influence of the type and dose of potassium fertilizer on nitrogen, phosphorus, potassium, calcium, and magnesium contents in eggplant fruits grown in transitional peat.

MATERIAL AND METHODS

The study on cv. Epic F_1 eggplant was carried out in unheated polyethylene tunnel in 2004-2005 at the Experimental Farm of the University of Life Sciences in Lublin, Felin. Eggplant seedlings were prepared in a greenhouse, in 8-cm diameter pots on peat subsoil in accordance with the rules approved for this species. In both experimental years, plants were transferred to a tunnel at the beginning of June. The cultivation period, from the seeding until the termination of the experiment, lasted for about 7 months (beginning of March until mid- September).

Eggplants were cultivated in 10 dm^3 capacity cylinders made of rigid plastic, on transitional peat (initial pH 4.6), which was limed using $CaCO_3$ to achieve pH 6.5. The experiment was set up in a two-factor, completely randomized design.

The influence of these two factors was examined:

1) type of potassium fertilizer: KCl, K_2SO_4, KNO_3;
2) potassium rate: 8, 16, 24 g $K \cdot plant^{-1}$.

The experiment included 9 combinations (3 types of potassium fertilizer plus 3 potassium rates). Each combination was represented by 8 experimental units consisting of a cylinder with a single plant.

Fertilization was applied at the amount of (in g $\cdot$ $plant^{-1}$): nitrogen – 11 (as NH_4NO_3 – 34% N, some of the nitrogen was introduced with potassium in combination with KNO_3, while the remaining quantity was added as ammonium nitrate, so that all the plants received the same nitrogen rate); phosphorus – 7.0 in the form of superphosphate ($Ca(H_2PO_4)_2 \cdot H_2O$ – 20.2% P); potassium – 8, 16, and 24 as potassium chloride (KCl – 50% K), potassium sulfate (K_2SO_4 – 41.6% K), or potassium nitrate (KNO_3 – 37.4% K, 15% N); magnesium – 6.0 as magnesium sulfate ($MgSO_4 \cdot H_2O$ – 17.4% Mg). Microelements were applied in following forms: EDTA – Fe, $CuSO_4 \cdot 5H_2O$, $ZnSO_4 \cdot 7H_2O$, $MnSO_4 \cdot H_2O$, H_3BO_3, $(NH_4)_2Mo_7O_{24} \cdot 4H_2O$ at amounts as for peat subsoils. All microelements, half of the phosphorus rate, and 1/7 nitrogen, potassium, and magnesium doses were applied during the subsoil preparation just before plant setting. The remaining nitrogen, potassium, and magnesium amounts were post-crop introduced in six doses every 10 days.

Plants grew naturally with no cutting. Fruits were harvested at the stage of technological maturity, which was indicated by the purple color and characteristic metallic glow (weight of harvested fruits ranged from 250 to

300 grams). Harvests were made every 7-10 days from the end of July to mid-September.

Fruit samples for laboratory determinations were collected in mid-August, in the middle of fruiting stage. Following items were determined in fruits: total N – by means of Kjeldahl's method after wet digestion (Klej-Foss) and after combustion at 550°C: P – colorimetrically using ammonium molybdate, and K, Ca, Mg – applying the AAS technique (Perkin – Elmer). All determinations were performed in three replications.

The results were statistically processed by means of variance analysis. The difference significance was estimated on the basis of Tukey's multiple confidence intersections at the error probability level of 5%.

RESULTS AND DISCUSSION

The results related to total nitrogen, phosphorus, potassium, calcium, and magnesium achieved in 2004 and 2005 are presented in Table 1 as means due to the similar values attained.

Total nitrogen content in eggplant fruits was from 19.1 to 22.2 g $N_{tot} \cdot kg^{-1}$ d.m. Type and rate of the applied potassium fertilizer significantly affected its content in plants. Higher level of this element was found in fruits of plants fertilized with potassium nitrate as compared to the other two fertilizers. Moreover, increasing potassium rates applied in the form of sulfate and nitrate caused considerable increase in the nitrogen content in eggplant fruits. Such dependence was not recorded when applying potassium chloride. The positive potassium influence on nitrogen content in plants can be explained by the share of K^+ ions in transport of NO_3^- through a plant (Nowotny-mieczyńska 1976). Lower nitrogen concentration in fruits of plants fertilized with various potassium doses (KCl) results probably from a high concentration of chlorides in subsoil (Michałojć, Buczkowska 2008b). Literature data report lower nitrate uptake by plants, which is the consequence of antagonism between NO_3^- and Cl^- ions (Nurzyński et al. 2001, Starck 2003).

Phosphorus concentration in eggplant fruits ranged from 2.5 to 3.0 g $P \cdot kg^{-1}$ d.m. No significant influence of the experimental factors on the content of this element in fruits was revealed. Abdel Hafeez and Cornillon (1976) as well as Sewiader and Morse (1982) found similar phosphorus levels in eggplant fruits in their studies on phosphorus fertilization. Golcz et al. (2005) reported twice as much phosphorus in fruits of eggplant cultivated on organic subsoils (peat, bark).

Potassium content ranged from 23.4 to 35.1 g $K \cdot kg^{-1}$ d.m. and, similarly to nitrogen, its amount was significantly differentiated by the experimental factors. Its highest level was found in fruits of eggplant fertilized with potas-

Table 1

The content of N-total, P, K, Ca, Mg ($g \cdot kg^{-1}$ d.m.) in fruit of eggplant depending on type and dose of potassium fertilizer

Type of potassium fertilizer	Dose ($g\ K \cdot plant^{-1}$)	N-total	P	K	Ca	Mg
KCl	8	20.0	2.5	24.5	1.9	1.0
	16	20.0	2.7	28.5	1.4	1.2
	24	20.3	2.8	29.9	1.3	1.3
Average for KCl		20.1	2.7	27.6	1.5	1.2
K_2SO_4	8	19.5	2.9	24.2	1.5	1.2
	16	19.1	2.6	23.7	1.2	1.2
	24	20.5	3.0	29.6	1.4	1.2
Average for K_2SO_4		19.7	2.8	25.8	1.4	1.2
KNO_3	8	20.4	2.7	23.4	1.6	1.0
	16	22.2	2.6	28.2	1.4	1.3
	24	22.2	2.7	35.1	1.6	1.4
Average for KNO_3		21.6	2.7	28.9	1.5	1.2
Average for dose K	8	19.9	2.8	24.1	1.6	1.0
	16	20.5	2.6	26.8	1.3	1.2
	24	21.0	2.8	31.5	1.5	1.3
Average		20.5	2.7	27.5	1.5	1.2
$LSD_{p=0.05}$						
for type of potassium fertilizer		0.27	n.s.	0.58	n.s.	n.s.
for dose of potassium fertilizer		0.27	n.s.	0.58	n.s.	n.s.
for interaction		0.63	0.33	1.36	0.24	0.24

sium nitrate, lower when nourished with potassium chloride, and the lowest when receiving potassium sulfate (Table 1). Regardless the fertilizer type, significant increase of its content in eggplant fruits was recorded (Table 1). Potassium is a nutrient that can be easily taken up and transported through a plant, hence its higher content was also found in generative parts. The following authors also reported similar and higher potassium concentrations in eggplant fruits: Kaufmann and Vorwerk (1971), Savvas and Lenz (1994), Russo (1996), Golcz et al. (2005), as well as Michałojć and Buczkowska (2008a).

Calcium content in eggplant fruits was from 1.2 to 1.9 g $Ca \cdot kg^{-1}$ d.m. The variance analysis revealed no significant influence of the varied potassium fertilization on the element concentration in eggplant fruits when applying potassium sulfate and nitrate, while higher rates of potassium chloride resulted in considerably lower calcium content. Lower calcium concentration in tomato and paprika fruits caused the apical dry-rot (Golcz 2001, NURZYŃSKI et al. 2001). Present study did not reveal any symptoms of this disease in any combination.

Magnesium level in eggplant fruits was also similar to that of calcium and ranged from 1.0 to 1.4 g Mg·kg^{-1} d.m. No significant effects of the varied potassium fertilization on its content in fruits were recorded. A study by GOLCZ et al. (2005) on eggplant cultivated on organic subsoils (peat, bark) revealed similar calcium and magnesium contents.

The potassium to calcium contents ratio in eggplant fruits seems to be interesting. Regardless the potassium fertilizer type, the widening of K:Ca ratio was observed along with the potassium rate increase (Table 2). Such dependence apparently proves the antagonistic action of K^+ ions towards Ca^{2+} intake. Potassium to magnesium did not reveal similar correlation (Table 2). KULCZYCKI (2006), in his studies on corn, found that increasing potassium doses considerably decreased magnesium concentration and widened the K:Mg ratio value.

Table 2

Values of K: Ca and K: Mg ratios in fruit of eggplant depending on type and dose of potassium fertilizer

Type of potassium fertilizer	Dose (g K·plant^{-1})	K: Ca	K: Mg
KCl	8	12.9	24.5
	16	20.4	23.8
	24	23.0	23.0
Average for KCl		18.4	23.0
K_2SO_4	8	16.1	20.2
	16	19.8	19.8
	24	21.1	24.7
Average for K_2SO_4		18.4	21.5
KNO_3	8	14.6	23.4
	16	20.1	21.7
	24	21.9	25.1
Average for KNO_3		19.2	24.1
Average for dose K	8	15.1	24.1
	16	20.6	22.3
	24	21.0	24.2
Average		18.3	22.9

CONCLUSIONS

1. Significantly higher total nitrogen and potassium concentrations in fruits of plants fertilized with potassium nitrate as compared to the other two fertilizer types were recorded.

2. Increasing potassium doses, regardless the fertilizer type, considerably increased the element content in eggplant fruits and widened the K:Ca ratio value.

3. The varied potassium fertilization did not have significant influence on phosphorus and magnesium concentration in eggplant fruits.

4. No significant changes of calcium content in fruits when applying potassium sulfate or nitrate were observed, while higher potassium chloride rates significantly decreased that element concentration in fruits.

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