J. Elem. s. 269–276 DOI: 10.5601/jelem.2013.18.2.06

EFFECT OF THE BIOSTIMULATOR ASAHI SL ON THE MINERAL CONTENT OF EGGPLANTS (*SOLANUM MELONGENUM* L.) GROWN IN AN UNHEATED PLASTIC TUNNEL*

Joanna Majkowska-Gadomska, Brygida Wierzbicka

Chair of Horticulture
University of Warmia and Mazury in Olsztyn

Abstract

Eggplants, known for their exceptional taste, are low in calories and constitute a rich source of potassium, phosphorus, magnesium, calcium, iron, manganese, copper and aluminum. They require a long and warm growing season, since adverse environmental conditions lead to growth inhibition, blossom fall and fruit drop. The application of eco-friendly biostimulators, such as Asahi SL, contributes to improving the growth and development of eggplants through increasing their stress tolerance and environmental adaptability, thus resulting in a higher yield.

A two-factorial experiment in a split-plot design with three replications was conducted in 2010-2011. The leaves of two eggplant cultivars, Black Beauty and Violetta Lunga, were sprayed with a 0.1% solution of Asahi SL. Seedlings were grown in a heated greenhouse, in line with the generally observed standards for eggplant cultivation. Eight-week-old seedlings were planted in the ground, at 50x60 cm spacing, in an unheated plastic tunnel. Starting from 30 May, at 10-day-intervals, eggplants were sprayed three times with the biostimulator Asahi SL at a concentration of 0.1%. Plants sprayed with water served as control. The fruits were harvested at the stage of commercial maturity, when normal sized and colored but still unripe.

The objective of this study was to determine the concentrations of macronutrients and micronutrients in fruits of two eggplant cultivars, grown in an unheated plastic tunnel and sprayed with the biostimulator Asahi SL.

Joanna Majkowska-Gadomska, Chair of Horticulture, University of Warmia and Mazury in Olsztyn, Prawocheńskiego 21, 10-957 Olsztyn, e-mail: Majkowska-Gadomska@uwm.edu.pl

*The study was financed as part of research project No. 1014.0804.

The mineral content of eggplants was determined in mid-August, on an average sample of marketable fruit yield collected in each treatment. The application of Asahi SL led to a significant decrease in total nitrogen levels in the fruits of cv. Black Beauty, and a significant increase in potassium concentrations in the fruits of both eggplant cultivars. The biostimulator increased Cu accumulation in fruits of both cultivars, and it significantly decreased Fe accumulation in cv. Violetta Lunga in comparison with the control treatment.

The fruits of cv. Violetta Lunga harvested from control plants were characterized by normal Ca:Mg and Ca:P ratios. The broadest K:Mg ratio was noted in cv. Violetta Lunga in both treatments. The K:(Mg+Ca) ratio was higher in the fruits from control plants of cv. Black Beauty.

Key words: eggplants, Asahi SL, foliar application, macronutrients, micronutrients.

WPŁYW STYMULATORA ASAHI SL NA ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH W OWOCACH OBERŻYNY (*SOLANUM MELONGENUM* L.) Z UPRAWY W NIEOGRZEWANYM TUNELU FOLIOWYM

Abstrakt

Owoce oberżyny oprócz niezwykłego smaku są cennym źródłem składników odżywczych. Są niskokaloryczne, bogate w potas, fosfor, magnez, wapń, żelazo oraz mangan, miedź i glin. Rośliny wymagają długiego i ciepłego okresu wegetacyjnego, a w mniej sprzyjających warunkach środowiskowych następuje zahamowanie wzrostu oraz opadanie kwiatów i zawiązków owoców. Stosowanie biostymulatorów, np. Asahi SL, które są bezpieczne dla środowiska, może być jednym ze sposobów poprawy warunków wzrostu i rozwoju roślin przez zwiększenie odporności oberżyny na czynniki stresowe oraz szybsze przystosowanie się do mniej sprzyjających warunków, a w konsekwencji zwiększone plonowanie.

Dwuczynnikowe doświadczenie, w układzie losowanych podbloków w trzech powtórzeniach, przeprowadzono w latach 2010-2011. Do badań wytypowano dwie odmiany oberżyny: Black Beauty oraz Violetta Lunga, w których uprawie stosowano dolistnie 0,1% preparat Asahi SL. Oberżynę uprawiano z rozsady, którą przygotowano w ogrzewanej szklarni na parapetach, wg ogólnie przyjętych zasad dla tego gatunku. Ośmiotygodniową rozsadę wysadzono w gruncie nieogrzewanego tunelu foliowego w rozstawie 50x60 cm. Od 30 maja, w odstępach 10-dniowych, trzykrotnie wykonywano oprysk preparatem Asahi SL w stężeniu 0,1%. W obiekcie kontrolnym rośliny opryskiwano wodą. Zbiór owoców przeprowadzano sukcesywnie, w fazie ich dojrzałości użytkowej, gdy owoce były wyrośnięte i wybarwione, ale niedojrzałe.

Celem badań była ocena zawartości podstawowych makro- i mikroelementów w owocach dwóch odmian oberżyny z uprawy roślin opryskiwanych biostymulatorem Asahi SL w nieogrzewanym tunelu foliowym.

Słowa kluczowe: oberżyna, Asahi SL, aplikacja dolistna, makro- i mikroelementy.

INTRODUCTION

The eggplant (*Solanum melongena* L.), also known as the aubergine, is highly valued for its taste, nutritional and health benefits (Golcz et al. 2005, Adamczewska-Sowińska, Kołota 2010). In additional to their extraordinary taste, eggplants are low in calories and constitute a rich source of essential nutri-

ents that should be included in a balanced diet, as well as potassium, phosphorus, magnesium, calcium, iron (Michałojć, Buczkowska 2008, Markiewicz et al. 2011), manganese, copper and aluminum (Raigón et al. 2008). Until quite recently, eggplants were not grown in backyard gardens in Poland (Sękara et al. 2007, Sękara 2010), mostly due to their higher temperature requirements compared with tomatoes and peppers (Gajewski et al. 2006). Under unfavorable environmental conditions, warm-climate plants are exposed to stress which adversely affects their growth and development, reducing the yield and quality of fruit. In Poland, eggplants can be grown in unheated greenhouses (Sękara 2010), but ground frost in the fall can pose a threat to developing fruit (Kowalska, Buczkowska 2004).

Eco-friendly biostimulators, such as Asahi SL whose active ingredients (nitrophenols) occur naturally in plants, may be applied to improve the growth and development of crops. Biostimulators increase plant resistance to stress factors (heat, drought, disease, mechanical injury) and their environmental adaptability, thus contributing to a higher fruit yield (Czeczko, Mikos-Bielak 2004, Słowiński 2004).

The aim of this study was to determine the concentrations of selected macronutrients and micronutrients in the fruits of two eggplant cultivars, grown in an unheated plastic tunnel and sprayed with the biostimulator Asahi SL.

MATERIAL AND METHODS

A two-factorial experiment was conducted in 2010-2011 in the garden of the Research and Experimental Station of the University of Warmia and Mazury in Olsztyn. Eggplants were grown in an unheated plastic tunnel in a split-plot design with three replications. The leaves of two eggplant cultivars, Black Beauty and Violetta Lunga, were sprayed with a 0.1% solution of Asahi SL.

Seedlings were grown in a heated greenhouse, in line with the generally observed standards for eggplant cultivation and Polish Standard BN-88/9125-08 – Vegetable Seedlings. Each year, on 22 March, seeds were sown in boxes for seedlings, filled with substrate. On 6 April, seedlings were planted out in pots 10 cm in diameter, filled with peat substrate of the following chemical composition: $N–NO_3$ – 100, P – 80, K – 215, Ca – 1240, Mg – 121 mg dm^{-3}, pH in H_2O – 5.9, salt concentration – 1.5 g dm^{-3}. Eight-week-old, hardened off seedlings were planted in the ground, at 50x60 cm spacing, 24 plants per pot. Starting from 30 May, at 10-day-intervals, eggplants were sprayed three times with the biostimulator Asahi SL at a concentration of 0.1%. Plants sprayed with water served as control. The fruits were harvested at the stage of commercial maturity, when normal sized and color-

ed but still unripe (30- to 40-day-old buds). They were hard and firm, with the texture of a firm sponge but without developed seed cases. Harvest began towards the end of July and ended in the first week of October. The mineral content of eggplants was determined in mid-August, on a sample of four fruits collected in each treatment, which were comminuted, dried at 65°C to constant weight and ground in an electric grinder. At the laboratory of the Chemical and Agricultural Station in Olsztyn, the plant material was mineralized with concentrated sulfuric acid and assayed for the content of total nitrogen by the potentiometric method, phosphorus by the vanadium-molybdenum method, potassium by flame photometry, magnesium by atomic absorption spectrometry (AAS), calcium by flame photometry, copper and iron by atomic absorption spectrometry (AAS). The study was carried out under Accreditation Certificate no. AB 277 issued by the Polish Center for Accreditation in Warsaw.

The results were processed statistically by analysis of variance. The significance of differences between means was estimated by Tukey's test at α=0.05. All calculations were performed using Statistica software.

RESULTS AND DISCUSSION

Due to their specific taste and flavor, eggplants are becoming increasingly popular among vegetable consumers. Eggplant fruits are rich in organic and mineral compounds, whose concentrations vary depending on the cultivar, growing conditions and the degree of ripeness. Minerals help maintain normal acid-base balance and are stored in the skeletal system (Michałojć, Buczkowska 2008, Markiewicz et al. 2011, Wadas, Mioduszewska 2011).

As demonstrated by Czeczko and Mikos-Bielak (2004), the concentrations of chemical components (dry matter, sugars, vitamin C, protein) in vegetable plants change in response to biostimulators. Crops of the family Solanaceae (tomatoes, potatoes) treated with Asahi SL were characterized by increased saccharose concentrations in fruits and tubers, but the noted changes were statistically non-significant. The macronutrient and micronutrient content of eggplant fruits determined in the present experiment was similar to that reported by Michałojć and Buczkowska (2008). A statistical analysis revealed that neither the cultivar nor the biostimulator had a significant effect on macronutrient concentrations in eggplants (Table 1). The levels of P, Mg and Ca in the fruits of both cultivars were not affected by Asahi SL. The application of Asahi SL led to a significant decrease in total nitrogen levels in the fruits of both eggplant cultivars, which was particularly high in cv. Black Beauty. Potassium is a very important mineral for the proper functioning of cells, tissues and organs in the human body. The potassium content of eggplant fruits ranged from 2.49 to 2.56 g kg^{-1} d.m., and it was higher in plants of both cultivars treated with Asahi SL.

Table 1

Concentrations of selected macronutrients and micronutrients in fruits of eggplants sprayed with Asahi SL (means of 2010-2011)

Cultivar	Biostimulator	Macronutrients (g kg^{-1} d.m.)					Micronutrients (mg kg^{-1} d.m.)	
		total N	P	K	Mg	Ca	Cu	Fe
Black Beauty	control	2.07	0.34	2.49	0.13	0.34	0.16	7.01
	Asahi SL	1.88	0.31	2.56	0.15	0.35	0.22	6.49
	Mean	1.98	0.33	2.53	0.14	0.34	0.20	6.75
Violetta Lunga	control	1.96	0.36	2.49	0.12	0.38	0.29	9.95
	Asahi SL	1.90	0.32	2.51	0.12	0.38	0.39	5.24
	Mean	1.93	0.34	2.50	0.12	0.38	0.34	7.60
Mean	control	2.02	0.35	2.49	0.13	0.36	0.23	8.48
	Asahi SL	1.89	0.32	2.54	0.14	0.37	0.31	5.87
$LSD_{0.05}$								
Cultivar		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	0.13
Biostimulator		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	1.97
Interaction		0.10	n.s.	0.05	n.s.	n.s.	0.22	1.88

The copper content of eggplant fruits was significantly affected by the cultivar x biostimulator interaction. Higher copper concentrations were noted in the fruits of cv. Violetta Lunga and cv. Black Beauty sprayed with Asahi SL, and the differences relative to control plants reached 0.10 mg kg^{-1} d.m. and 0.06 mg kg^{-1} d.m., respectively. The iron content of eggplant fruits varied widely, from 5.24 to 9.95 mg kg^{-1} d.m.. Significantly higher iron accumulation was observed in the fruits of cv. Violetta Lunga. Asahi SL decreased iron concentrations by 2.61 mg kg^{-1} d.m., in comparison with the control treatment. The interaction between the experimental factors was significant. Higher iron levels were determined in control plants of both cultivars. Dobrzański et al. (2008) and Łyszkowska et al. (2008) found that the application of various biostimulators contributed to a significant yield increment in vegetable crops and a minor increase in the content of dry matter and nitrates, but further research is needed to confirm the above findings. Very good results were obtained when Asahi SL was applied in combination with herbicides to sugar beets whose roots contained increased concentrations of sugars, nitrogen, potassium and sodium (Kositorna, Smoliński 2008). In contrast to the findings of Kositorna and Smoliński (2008) and analogously to our study, Matysiak et al. (2011) demonstrated that edible parts of plants treated with Asahi SL contained significantly less nitrogen. Asahi SL had varied effects on the potassium content of sugar beet roots, but a significant increase in the concentrations of this macronutrient was observed in only one year of the study.

According to KOTOWSKA and WYBIERALSKI (1999), the quality of edible plant parts is determined by both the concentrations and ratios of macronutrients and micronutrients, in particular the K:Mg, Ca:Mg and K:(Mg+Ca) ratios. In the current study, the ratios between the analyzed elements in eggplant fruits varied between the cultivars and between plants treated and untreated with Asahi SL (Table 2).

Table 2

Ratios of selected elements in edible parts of eggplants sprayed with Asahi SL (means of 2010-2011)

Cultivar	Biostimulator	Ratios			
		Ca:Mg	Ca:P	K:Mg	K:(Ca+Mg)
Black Beauty	control	2.62	1.00	19.15	5.30
	Asahi SL	2.33	1.13	17.07	5.12
Mean		2.43	1.03	18.07	5.27
Violetta unga	control	3.17	1.06	20.75	4.98
	Asahi SL	3.17	1.19	20.75	4.98
Mean		3.17	1.12	20.75	4.98
Mean	control	2.88	1.03	19.92	5.13
	Asahi SL	2.70	1.16	18.70	5.05

As demonstrated by MAJKOWSKA-GADOMSKA and WIERZBICKA (2008), and MAJKOWSKA-GADOMSKA (2006, 2009, 2010), the optimal Ca:Mg ratio in edible parts of vegetables should approximate 3, and the Ca:P ratio should be within the 1.2-2.2 range. The Ca:P ratio is very important in children's nutrition. The fruits of cv. Black Beauty were characterized by lower values of the Ca:Mg and Ca:P ratios (Table 2). The fruits of cv. Violetta Lunga harvested from control plants had normal Ca:Mg and Ca:P ratios. According to RADKOWSKI et al. (1999), the K:Mg and K:(Mg+Ca) ratios should be 6 and 1.6 – 2.2, respectively. The broadest K:Mg ratio was noted in cv. Violetta Lunga in both treatments. The K:(Mg+Ca) ratio was higher in fruits from control plants of cv. Black Beauty.

CONCLUSIONS

1. The application of Asahi SL led to a significant decrease in total nitrogen levels in fruits of cv. Black Beauty, and a significant increase in potassium concentrations in fruits of both studied eggplant cultivars.

2. The biostimulator increased Cu accumulation in fruits of both cultivars, and it significantly decreased Fe accumulation in cv. Violetta Lunga in comparison with the control treatment.

3. The application of Asahi SL had varied effects on the quality of eggplant fruits, which were characterized by similar ratios of the analyzed elements in both treatments, including normal Ca:Mg and Ca:P ratios. The broadest K:Mg ratio was noted in cv. Violetta Lunga in both treatments. The K:(Mg+Ca) ratio was higher in the fruits from control plants of cv. Black Beauty.

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