ACTA Acta Sci. Pol., Hortorum Cultus 8(4) 2009, 59-67

THE EFFECT OF FOLIAR FEEDING WITH PLONOCHRON FERTILIZERS (K, Mg, Ca) AND DIFFERENTIATED RHIZOSPHERE FERTILIZATION WITH NITROGEN UPON YIELD AND CONTENTS OF SELECTED COMPONENTS IN CUCUMBER LEAVES AND FRUIT

Zbigniew Jarosz, Katarzyna Dzida, Renata Nurzyńska-Wierdak
University of Life Sciences in Lublin

Abstract. The experiment with cucumber of the variety 'Matilde F_1' was conducted in an unheated foil tunnel in the years 2004–2005. The plants were grown in containers of the capacity of 10 dm^3 filled with transitional turf, limed to the pH of 6.0. In our studies we assessed the effect of foliar feeding with Plonochron fertilizers (potassium, magnesium, calcium) and of the differentiated rhizosphere nitrogen fertilization. (1.0 and 1.5 g $N \cdot dm^{-3}$) upon the yield, as well as contents of mineral components in cucumber leaves and fruits. The cucumber fruit yield was found to be significantly greater if the plants underwent foliar feeding with Plonochron fertilizers, as compared to control plants. The greater fruit yield (4.30 $kg \cdot plant^{-1}$) was given by plants fertilized with a higher nitrogen dose (1.5 $g \cdot dm^{-3}$ of substratum). Fruits of cucumber undergoing foliar feeding with Plonochron fertilizers contained significantly more vitamin C, as compared to control plants. The leaves of plants fertilized with a higher nitrogen dose were reported to contain more total nitrogen, potassium and calcium.

Key words: *cucumis sativus*, foliar feeding, nitrogen fertilization, total fruit yield, fruit nutrients

INTRODUCTION

Foliar feeding is the best way of supplying the plants with the nutrients they lack, mainly because of the quickness and effectiveness of action. [Marciniak and Hetman 2008, Kocoń 2009, Kosterna et al. 2009]. Premsekhar and Rajashree [2009] believe that

Corresponding author – Adres do korespondencji: Zbigniew Jarosz, Katarzyna Dzida, Department of Soil Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, Leszczyńskiego 58, 20-068 Lublin, e-mail: kunro@up.lublin.pl; Renata Nurzyńska-Wierdak, Department of Vegetables and Medicinal Plants, University of Life Sciences in Lublin, Leszczyńskiego 58, 20-068 Lublin, e-mail: renata.nurzynska@up.lublin.pl

in intensive plant growing technologies this procedure becomes an indispensable complement to rhizosphere fertilization due to the risk of processes occurring in the root environment that could decrease the accessibility of nutrients. Szewczuk and Michałojć [2003] emphasize that foliar feeding should be applied as a supplement to basic soil fertilization in the periods of increased nutrient requirements or, in the case of problems with their accessibility, in the root environment.

An important parameter, determining the effectiveness of foliar feeding, is the kind of fertilizer used. In this procedure specialized and technologically advanced fertilizers should be used. They should contain nutrients in the forms that could be easily assimilated by aboveground parts of the plants [Vibute 1998].

The aim of the conducted studies was to determine the effects of foliar feeding with three Plonochron fertilizers: potassium, magnesium and calcium, at differentiated levels of rhizosphere nitrogen fertilization (1.0 and 1.5 g N·dm^{-3} of substratum) upon the cropping and chemical composition of 'Matilde F_1' cucumber leaves and fruit.

MATERIAL AND METHODS

The experiment with the cucumber of the variety 'Matilde F_1' was conducted in unheated foil tunnel in the years 2004–2005, in spring-summer period (07.05–09.07.2004 and 16.05–18.07.2005). The plants were grown in transitional peat, limed to pH 6,0, with the use of chalk fertilizer. 10 dm^3 substratum fell upon each plant. The experiment was established in complete randomization system, in 8 repetitions. One plant constituted a repetition.

Differentiated nitrogen doses were applied in our studies – 1.0 and 1.5 g·dm^{-3} of substratum, as well as foliar feeding with potassium, magnesium and calcium Plonochron. Foliar feeding of plants with Plonochron fertilizers was performed 8 times, every seven days, starting from the third week after planting (27.05.2004 and 03.06.2005), applying 2% solution of operating liquid. The composition of Plonochron fertilizers is contained in table 1. The controls were plants sprayed with water.

Table 1. Composition of Plonochron fertilizers used for foliar feeding of cucumber plants
Tabela 1. Skład nawozów Plonochron stosowanych do dokarmiania pozakorzeniowego ogórka

Plonochron	Part of nutrients in the fertilizer, % Udział składników pokarmowych w nawozie, %										
	N	P	K	Ca	Mg	B	Zn	Mo	Cu	Mn	Fe
Potassium Potasowy	10	-	30	-	2	0.03	0.01	0.006	0.02	-	-
Magnesium Magnezowy	7	-	-	-	12	0.01	0.03	0.001	0.02	-	-
Calcium Wapniowy	-	-	-	9	2	0.01	0.01	0.001	0.005	0.01	0.02

In the experiment, the following rhizosphere fertilization was applied (g·dm^{-3} substratum): 1.0 or 1.5 g N (ammonium nitrate 34% N), 0.6 g P (superphosphate 20% P), 2.6 g K (potassium sulphate 41.5 % K), 0.6 g Mg (magnesium sulphate 9.6% Mg). Microelements were applied once before planting, in the doses of (mg·dm^{-3} substratum): Fe – 8.0 mg (ferrum citrate), Zn – 0.80 mg ($ZnSO_4 \times 7H_2O$). Mn – 3.64 mg ($MnSO_4 \times 5H_2O$), Mo – 0.52 mg ($(NH_4)_6Mo_7O_{24} \times 4H_2O$), B – 2.42 mg ($H_3BO_3$), Cu – 13 mg ($CuSO_4 \times 5H_2O$). During the experiment the contents of nutrients in plant root environment was maintained within ranges recommended for cucumber growing in peat substratum [Dobrzańska 2003].

The plants were managed in conductor system. Fruit picking was performed twice a week, determining total yield (kg·plant^{-1}) and mean fruit weight of (g). All the maintenance works were conducted in accordance with recommendations in force.

Leaves for the analyses were collected in the middle (21.06.2004 and 27.06.2005), as well as at the end of fructification (09.07.2004 and 18.07.2005). The youngest, fully grown leaf with petiole was designed for analysis. Total nitrogen was determined in leaves (by means of Kjeldahl's method), and after mineralization by means of "dry" method (temp. 550°C), phosphorus (by means of colorimetric method with ammonium vanado-molibdate), as well as potassium, calcium and magnesium, using ASA method (Perkin Elmer, Analyst 300).

The fruit for analysis was collected in the middle of fructification (01.07.2004 and 07.07.2005). In the fresh material dry matter was determined with the use of drier method, vitamin C with the use of Tillmans's method (PN-A-04019 1998), and total sugars – with the use of Schoorl-Regenbogen method [Rutkowska 1981]. Having dried the fruit, we determined total nitrogen (by means of Kjeldahl's method), phosphorus, potassium, calcium and magnesium – using the same methods as in leaf analysis.

The statistical workout of the results was conducted with the use of variance analysis method on mean values, using Tukey's test for difference assessment, at significance level of $\alpha = 0.05$. The results contained herein are mean values from two years of studies.

RESULTS AND DISCUSSION

Undoubtedly, the advantages of foliar feeding, compared to typical rhizosphere fertilization, include high effectiveness of the procedure, quick responses of the fed plants and high degree of contributed nutrient utilization [Premsekhar and Rajashree 2009]. Among many factors determining the yield-creating effect of this procedure, the most important ones seem to be the composition and properties of the applied fertilizer [Jaskólski 2007].

In the conducted studies we found significantly higher total fruit yield of cucumber that had undergone foliar feeding with Plonochron fertilizers (4.11–4.31 kg·plant^{-1}), compared to control plants, sprayed with water (3.60 kg·plant^{-1}). These results are concurrent with numerous studies confirming the growth of plant yield after the application of foliar feeding procedure [Dzida and Jarosz 2005, Mengel 2002, Szewczuk and Michałojć 2003]. According to Batra et al. [2002], the yield-creating effect of foliar feeding should be explained with greater effectiveness of photosynthesis. The nutrients supplied to above-ground parts of the plants easily and quickly penetrate into their cells, simultaneously activating the processes related to the production and transport of assimilates. These authors emphasize that the increased cropping of foliarly fed plants takes place as a result of increased number of fruits or unit weight of the usable part. In the authors' studies tendencies were reported to the increase of mean weight of one fruit in plants, which underwent foliar feeding with Plonochron fertilizers, however, these results were not statistically confirmed (tab. 2).

It is worth paying attention to the statistically significant growth of total fruit yield of the cucumber that underwent rhizosphere nitrogen fertilization in the dose of 1.5 g·dm^{-3} substratum (4.30 kg·plant^{-1}), as compared to fertilization with this component in the dose of 1.0 g·dm^{-3} substratum (3.78 kg·plant^{-1}). This result should be referred to the total nitrogen content in plant leaves (tab. 3), which significantly increases from 3.33% d. m. to 4.32% d. m., together with the increased rhizosphere dose of this component from 1.0 to 1.5 g·dm^{-3} substratum. The significantly increased plant yield, as well as the increasing nitrogen content in cucumber leaves, influenced by increasing rhizosphere fertilization, confirm the thesis that foliar feeding is necessary only in combination with full basic fertilization [Michałojć and Szewczuk 2003, Premsekhar and Rajashree 2009]. Foliar feeding should be applied preventively, as a procedure eliminating hidden nutrient insufficiencies, often occurring in intensive growing technologies [Kocoń 2009].

The statistical analysis of results obtained in the conducted studies, revealed significantly higher dry matter contents in fruit collected from plants fed with calcium and magnesium Plonochron (tab. 2). In the available literature reports on the effect of foliar feeding upon the participation of dry matter in usable parts are divergent and the conclusions on lack of significant influence of this procedure upon the examined parameter predominate [Biesiada et al. 2000, Dzida and Jarosz 2005, Michałojć and Konopińska 2009].

The conducted studies revealed significantly higher contents of vitamin C in the fruit of cucumber that underwent foliar feeding with Plonochron fertilizers (10.47–10.62 mg·100 g f. w.$^{-1}$), as compared to control plants, sprayed with water (9.42 mg·100 g f.w.$^{-1}$). This is concurrent with the results of other studies, which revealed the advantageous influence of foliar feeding upon vitamin C contents in usable parts of the plants [Biesiada et al. 2000, Michałojć and Konopińska 2009, smoleń and Sady 2009]. Wierzbicka and Kuskowska [2002] emphasize that the contents of this important antioxidant in edible parts is a significant parameter of the values of fruit and vegetables designed for direct consumption. With reference to the data from literature, the results obtained in the authors' own studies prove the correct biosynthesis of vitamin C in the fruits of cucumber growing in particular objects [Biesiada et al. 2000, Wierzbicka and Kuskowska 2002]. According to many authors, a factor that significantly decreased the contents of vitamin C in usable parts of the plants may be increasing the doses of mineral, and especially nitrogen, fertilizers [Biesiada et al. 2000, Wierzbicka and Kuskowska 2002]. The statistical analysis of results obtained in the presented studies did not reveal significant differences in vitamin C contents in cucumber fruits, depending on nitrogen dose (1.0 or 1.5 mg·dm^{-3}).

The contents of nitrogen, phosphorus, potassium, calcium and magnesium in the leaves of cucumbers growing in particular study objects (tab. 3) indicates correct nutrition of the plants with these components [Babik et al. 2005, Bergman 1992, Manolov et al. 2005]. Significantly more total nitrogen (4.32% d.m.), potassium (2.83% d.m.) and calcium (4.59 % d.m.) were found in the leaves of cucumbers fertilized with a higher nitrogen dose (1.5 g·dm^{-3}).

Table 2. The yield and the content of some cucumber fruit nutrients depending on foliar feeding and nitrogen fertilizing (mean of 2004 and 2005)

Tabela 2. Plon oraz zawartość wybranych składników odżywczych w owocach ogórka w zależności od dokarmiania pozakorzeniowego i nawożenia azotem (średnio z 2004 i 2005)

Foliar feeding Dokarmianie pozakorzeniowe	Total yield $kg \cdot plant^{-1}$ Plon ogólny $kg \cdot roślina^{-1}$			Mean fruit weight Średnia masa jednego owocu g			Dry matter Sucha masa %			Witamin C $mg \cdot 100\ g^{-1}$ fr.w. Witamina C $mg \cdot 100\ g^{-1}$ św.m.			Total sugars % fr.w. Cukry ogółem % św.m.		
	nitrogen rhizosphere fertilizing, $g \cdot dm^{-3}$ nawożenie dokorzeniowe azotem, $g \cdot dm^{-3}$														
	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$
Control – Kontrola	3.57	3.63	3.60	99.0	109.0	104.0	5.11	4.79	4.95	9.65	9.19	9.42	2.39	2.63	2.51
Plonochron K	3.89	4.74	4.31	113.4	116.5	115.0	5.18	4.83	5.00	10.55	10.70	10.62	2.94	2.50	2.72
Plonochron Mg	3.77	4.49	4.13	116.5	114.5	115.5	5.45	5.40	5.42	11.15	10.10	10.62	2.89	2.58	2.69
Plonochron Ca	3.86	4.35	4.11	111.0	112.0	111.5	5.07	5.78	5.42	10.10	10.85	10.47	2.41	3.02	2.72
$\bar{x}$	3.78	4.30		110.0	113.0		5.20	5.19		10.36	10.21		2.63	2.68	
$LSD_{0.05}$ $NIR_{0,05}$															
Foliar feeding Dokarmianie pozakorzeniowe		0.49			n.s. – r.n.			0.33			0.75			n.s. – r.n.	
Nitrogen dose Dawka azotu		0.37			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.	

n.s. – not significant, r.n. – różnice nieistotne

Table 3. Chemical composition of cucumber leaves depending on foliar feeding and nitrogen fertilizing (mean of 2004 and 2005)
Tabela 3. Skład chemiczny liści ogórka w zależności od dokarmiania pozakorzeniowego i nawożenia azotem (średnio z 2004 i 2005)

Foliar feeding Dokarmianie pozakorzeniowe	N-Total N-ogółem			P			K			Ca			Mg		
	Nitrogen rhizosphere fertilizing, $g \cdot dm^{-3}$ Nawożenie dokorzeniowe azotem, $g \cdot dm^{-3}$														
	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$
Control – Kontrola	3.03	4.21	3.62	0.23	0.23	0.23	2.45	2.75	2.60	3.89	4.97	4.43	0.44	0.49	0.47
Plonochron K	3.31	4.22	3.77	0.22	0.22	0.22	2.53	2.85	2.69	4.23	4.44	4.34	0.49	0.50	0.50
Plonochron Mg	3.47	4.46	3.97	0.22	0.27	0.24	2.58	2.92	2.75	4.12	4.61	4.36	0.49	0.52	0.51
Plonochron Ca	3.52	4.39	3.96	0.21	0.25	0.23	2.50	2.81	2.66	3.88	4.33	4.10	0.44	0.57	0.50
$\bar{x}$	3.33	4.32		0.22	0.24		2.52	2.83		4.03	4.59		0.47	0.52	
$LSD_{0.05}$ $NIR_{0,05}$ Foliar feeding Dokarmianie pozakorzeniowe		n.s. – r.n.			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.	
Nitrogen dose Dawka azotu		0.54			n.s. – r.n.			0.26			0.33			n.s. – r.n.	

n.s. – not significant, r.n. – różnice nieistotne

Table 4. Chemical composition of cucumber fruit depending on foliar feeding and nitrogen fertilizing (mean of 2004 and 2005)
Tabela 4. Skład chemiczny owoców ogórka w zależności od dokarmiania pozakorzeniowego i nawożenia azotem (średnio z 2004 i 2005)

Foliar feeding Dokarmianie pozakorzeniowe	N-Total N-ogółem			P			K			Ca			Mg		
	Nitrogen rhizosphere fertilizing ($g \cdot dm^{-3}$) Nawożenie dokorzeniowe azotem ($g \cdot dm^{-3}$)														
	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$	1.0	1.5	$\bar{x}$
Control – Kontrola	2.37	2.94	2.65	0.60	0.59	0.59	4.20	4.14	4.17	0.37	0.37	0.37	0.23	0.21	0.22
Plonochron K	2.39	3.11	2.75	0.56	0.59	0.58	4.17	4.70	4.43	0.29	0.37	0.33	0.22	0.24	0.23
Plonochron Mg	2.57	3.06	2.81	0.55	0.60	0.58	4.05	4.22	4.14	0.38	0.31	0.34	0.21	0.21	0.21
Plonochron Ca	2.78	2.95	2.86	0.61	0.36	0.49	4.38	4.02	4.20	0.33	0.51	0.42	0.22	0.20	0.21
$\bar{x}$	2.52	3.01		0.58	0.53		4.20	4.27		0.34	0.39		0.22	0.21	
$LSD_{0.05}$, $NIR_{0,05}$															
Foliar feeding Dokarmianie pozakorzeniowe	n.s. – r.n.			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.		
Nitrogen dose Dawka azotu	0.19			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.			n.s. – r.n.		

n.s. – not significant, r.n. – różnice nieistotne

Except total nitrogen, no significant differences were found in the contents of examined mineral components in cucumber fruits, depending on the studied factors (tab. 4). Similar contents of nitrogen, phosphorus, potassium, calcium and magnesium in cucumber fruits are reported by other literature sources [Górecki and Danielski-Busch 2009]. This proves that there are no abnormalities in the fruit development of plants growing in particular study objects.

The results obtained in the presented studies prove the usefulness of potassium, magnesium and calcium Plonochron fertilizers in growing cucumbers under shields with the use of organic substrate.

CONCLUSIONS

1. Significantly greater yield of fruit was found in cucumber plants, which underwent foliar feeding with Plonochron fertilizers, as compared to control plants, sprayed with water.
2. Significantly greater fruit yield was collected from plants fertilized with a higher nitrogen dose.
3. In the fruits of cucumber, which underwent foliar feeding with Plonochron fertilizers, significantly more vitamin C was found, as compared to control plants.
4. In the leaves of plants fertilized with a higher nitrogen dose, more total nitrogen, potassium and calcium were reported.

REFERENCES

Babik J., Kosson R., Nawrocka B., Ślusarski C., 2005. Metodyka integrowanej produkcji ogórków pod osłonami. Państwowa Inspekcja Ochrony Roślin i Nasiennictwa, Główny Inspektorat Warszawa.

Batra V.K., Singh B., Singh V., 2002. Response of brinjal to foliar feeding of water soluble fertilizers. International conference of vegetable, Bangalore, 11–14.

Bergmann W., 1992. Nutritional disorders of plants- development, visual and analytical diagnosis. Gustav Fisher Verlag, Jena.

Biesiada A., Kołota E., Osińska M., Michalak K., 2000. Wpływ nawożenia dolistnego na wybrane wskaźniki wartości odżywczej warzyw. Zesz. Nauk. Akad. Roln. im. H. Kołłątaja w Krakowie, 364, 53–56.

Dobrzańska J., 2003. Ogórki pod osłonami. Hortpress sp. z o.o., Warszawa.

Dzida K., Jarosz Z., 2005. Wpływ zróżnicowanego nawożenia azotem oraz dokarmiania pozakorzeniowego na plon i zawartość wybranych składników w liściach i owocach pomidora. Annales UMCS, Sectio EEE, LV (2), 51–58.

Górecki R., S., Danielski-Busch W., 2009. Effect of silicate fertilizers on yielding on greenhouse cucumber *(Cucumis sativus L.)* in container cultivation. J. Elementol. 14(1), 71–78.

Jaskólski D., 2007. Porównanie wpływu dolistnego stosowania nawozów na efekty produkcyjne oraz ekonomiczne uprawy niektórych roślin polowych. Fragment. Agronom. XXVI, 1(93), 106–112.

Kocoń A., 2009. Efektywność dolistnego dokarmiania pszenicy i rzepaku ozimego wybranymi nawozami w warunkach optymalnego nawożenia i wilgotności gleby. Annales UMCS, Sectio E, LXIV (2), 23–28.

Kosterna E., Zaniewicz-Bajkowska A., Franczuk J., Rosa R., 2009. Effect of foliar feeding on the yield level and quality of six large-fruit melon (*Cucumis melo* L.) cultivars. Acta Sci. Pol., Hortorum Cultus, 8 (3), 13–24.
Manolov I., Antonow D., Stoilov G., Tsareva I., Baev M., 2005. Jordanian zeolitic tuff as a raw material for the preparation of substrates used for plant growth. J. Cent. Eur. Agric., 6(4), 485–494.
Marcinek B., Hetman J., 2008. The effect of foliage feeding on the structure of yield, dry weight content and macroelements in the corms of Sparaxis tricolor Ker-Gawl. Acta Sci. Pol., Hortorum Cultus, 7 (4), 89–99.
Mengel K., 2002. Alternative or Complementary Role of Foliar Supply in Mineral Nutrition. Acta Hort. 594, 33–48.
Michałojć Z., Konopińska J., 2009. Wpływ dokarmiania pozakorzeniowego P i K na plonowanie i skład chemiczny sałaty. Annales UMCS, Agricultura, 64(2), 86–93.
Michałojć Z., Szewczuk C., 2003. Teoretyczne aspekty dolistnego dokarmiania roślin. Acta Agroph. 85, 9–17.
Premshekhar M., Rajashree V., 2009. Performance of hybrid tomato as infuenced by foliar feeding of water soluble fertilizers. Am.-Eurasian J. Sustain. Agric., 3(1), 33–36.
Rutkowska U., 1981. Wybrane metody badań składu i wartości odżywczej żywności. PZWL, Warszawa.
Smoleń S., Sady W. 2009., The effect of foliar nutrition with urea, molybdenum, sucrose and benzyladenine on quantity and quality of radish yield. Acta Sci. Pol., Hortorum Cultus, 8(2), 45–55.
Szewczuk C., Michałojć. Z., 2003. Praktyczne aspekty dolistnego dokarmiania roślin. Acta Agroph. 85, 19–29.
Vibute C. P., 1998. A process for manufacturing complex solid and liquid completely water soluble fertilizer. Fert News, 43(8), 63–65.
Wierzbicka B., Kuskowska M., 2002. Wpływ wybranych czynników na zawartość witaminy C w warzywach. Acta Sci. Pol. Hortorum Cultus 1(2), 49–57.

WPŁYW DOKARMIANIA POZAKORZENIOWEGO NAWOZAMI PLONOCHRON (K, Mg, Ca) ORAZ ZRÓŻNICOWANEGO NAWOŻENIA DOKORZENIOWEGO AZOTEM NA PLON I ZAWARTOŚĆ WYBRANYCH SKŁADNIKÓW W LIŚCIACH I OWOCACH OGÓRKA

Streszczenie. Doświadczenie z ogórkiem odmiany 'Matilde F_1' przeprowadzono w nieogrzewanym tunelu foliowym w latach 2004–2005. Rośliny uprawiano pojemnikach o objętości 10 dm^3 napełnionych torfem przejściowym zwapnowanym do pH 6.0. W badaniach oceniano wpływ dokarmiania pozakorzeniowego nawozami Plonochron (potasowy, magnezowy, wapniowy) oraz zróżnicowanego nawożenia dokorzeniowego azotem (1,0 i 1,5 g $N \cdot dm^{-3}$) na plon oraz zawartość składników mineralnych w liściach i owocach ogórka. Stwierdzono istotnie większy plon owoców ogórka dokarmianego pozakorzeniowo nawozami Plonochron w porównaniu z roślinami kontrolnymi. Większy plon owoców (4,30 kg·roślina^{-1}) wydały rośliny nawożone wyższą dawką azotu (1,5 g·dm^{-3} podłoża). Owoce ogórka dokarmianego pozakorzeniowo nawozami Plonochron zawierały istotnie więcej witaminy C w porównaniu z roślinami kontrolnymi. W liściach roślin nawożonych wyższą dawką azotu odnotowano więcej azotu ogółem, potasu i wapnia.

Słowa kluczowe: *Cucumis sativus*, dokarmianie pozakorzeniowe, nawożenie azotem, plon ogólny owoców, składniki odżywcze owoców

Accepted for print – Zaakceptowano do druku: 21.12.2009