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EFFECT OF SUBSTRATUM AND NUTRIENT SOLUTION UPON YIELDING AND CHEMICAL COMPOSITION OF LEAVES AND FRUITS OF GLASSHOUSE TOMATO GROWN IN PROLONGED CYCLE

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Abstract. In the soilless cultivation of tomato under covers the main factors determining the quantity and quality of obtained yield are the kind of substratum used, as well as the content of nutritional solution dosed under plants. Studies conducted in the glasshouse in the years 2005–2007 were aimed at determining the effect of the substratum of rockwool, perlite and expanded clay, as well as two kinds of nutritreint solution of differentiated macroelement concentrations (EC I – 2.4 mS·cm^{-1} and EC II – 3.6 mS·cm^{-1}) upon yielding and chemical composition of leaves and fruits of tomato cv. 'Cunero F$_1$', grown in extended cycle (22 clusters). Cultivation was conducted with the use of dripping fertigation system, with closed nutrient solution circuit, without recirculation. In the conducted studies no significant differences were found in the total and marketable yield of tomato grown in the examined substrata. Kind of substratum did not also have any significant effect upon the mean weight of one fruit and number of fruits from a plant. In objects cultivated with a solution with higher macroelement concentration (EC II) significantly higher marketable yield was reported, as well as higher fruit unit weight and less non-marketable fruits compared to the basic nutrient solution (EC I). In the leaves of plants fertilized with solution containing 25% more macroelements (EC II) significantly more total nitrogen, potassium, calcium and magnesium was reported. The fruits of plants fertilized with solution of higher macronutrients concentration (EC II) contained significantly more dry matter (5.71%), nitrogen (2.41% d.m.), phosphorus (0.32% d.m.), potassium (4.23% d.m.), calcium (1096 mg·kg^{-1} d.w.) and less vitamin C (17.2 mg·100^{-1}g fr.w.) compared to fruit from plants fertilized with basic nutrient solution of EC 2.4 mS·cm^{-1}. In the studies no significant effect of substratum type was found upon the contents of vitamin C, sugars, total nitrogen, phosphorus, calcium and magnesium in tomato fruit.

Key words: rockwool, perlite, expanded clay, EC of nutrient solution, total yield, marketable yield , macroelements, dry matter, vitamin C, sugars

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INTRODUCTION

Using inert substrata in soilless tomato growing under covers guarantees obtaining high and good quality yields [Jarosz and Dzida 2005, Gajc-Wolska et al. 2008]. According to many authors, rockwool, still predominant in soilless cultivations, will be in due course replaced by cheaper substrata, enhancing easy production waste management or utilization [Jarosz 2006, Abukhovich and Kobryń 2010, Komosa et al. 2010]. Numerous studies indicate that perlite and expanded clay can constitute alternatives for rockwool [Pawlińska and Komosa 2004, Jarosz and Dzida 2005, Gajc-Wolska et al. 2008].

A significant factor, determining the yield of tomato grown in inert substrata, is the composition of nutritional solution supplied under plants [Chohura and Komosa 2003, Nurzyński 2005]. According to Komosa et al. [2002] an extremely important role is also played by the correct proportion of particular ions in the nutritional solution, mainly the N:K ratio. When tomatoes are grown in inert substrata, the total concentration of ions in the nutrient solution (EC) is often increased above the recommended values, which is advantageous for the increase of taste value and certain parameters of the fruit biological value [Grava et al. 2001, Hao and Papadopoulos 2004]. Applying the nutrient solution with increased EC favorably affects the increase of soluble solids, sugars and dry matter contents, as well as fruit acidity [Tuzel et al. 2003, Campos et al. 2006, Tantawy et al. 2009]. However, the effect of such procedures can be excessive concentration of certain ions in the rhisosphere, which disturbs the uptake and distribution of elements in the plant [Grava et al. 2001]. The phenomenon of EC excessive growth in the rhisosphere is especially dangerous in prolonged growing.

The undertaken studies were aimed at determining the effect of the kind of substratum (rockwool, perlite and expanded clay), as well as of two nutritional solutions with differentiated macrocomponent concentrations (EC I – 2.4 $mS{\cdot}cm^{-1}$ and EC II – 3.6 $mS{\cdot}cm^{-1}$) upon the yield and chemical composition of leaves and fruits of tomato grown in extended cycle (22 clusters).

MATERIAL AND METHODS

Studies with 'Cunero F_1' tomato were conducted in the years 2005–2007 in the glasshouse of Department of Soil Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin. The plants were grown in rockwool (Grodan), perlite (Agroperlit) and expanded clay (Optiroc-Gniew). Perlite and expanded clay were placed in foil sleeves, shaping them and establishing the volume corresponding to the rockwool slabs. The cultivation was conducted with the use of dripping fertilization and watering system with closed nutrient solution circuit, without recirculation. Two kinds of nutrient solution were applied in the studies:

a) basic solution (I) with EC 2.4 $mS{\cdot}cm^{-1}$, containing on average ($mg{\cdot}dm^{-3}$): $N\text{-}NH_4$ – 17.0; $N\text{-}NO_3$ – 188; $P\text{-}PO_4$ – 45; K – 280; Ca – 205; Mg – 75; $S\text{-}SO_4$ – 140; Na – 14.7; Cl – 12.3; Fe – 1.25; Mn – 0.55; B – 0.30; Cu – 0.05; Zn – 0.30; Mo – 0.03 and pH_{H2O} –5.60;

b) concentrated solution (II) with EC 3.6 mS·cm^{-1} containing 25% more macrocomponents with averaged composition (mg·dm^{-3}): N-NH_4 – 21.2; N-NO_3 – 235; P-PO_4 – 56.5; K – 350; Ca – 256; Mg – 94; S-SO_4 – 185; Na – 26; Cl – 18.5; Fe – 1.25; Mn – 0.55; B – 0.30; Cu – 0.05; Zn – 0.30; Mo – 0.03 and pH_{H2O} – 5.65.

The concentration and proportions of macrocomponents in the nutrient solution were differentiated according to the requirements of particular developmental phases of plants in accordance with the present recommendations [Adamicki et al. 2005]. The nutritional solution was prepared considering the following chemical composition of water (mg·dm^{-3}): N-NH_4 – 0.02; N-NO_3 – 5.0; P-PO_4 – 4.0; K – 1.4; Ca – 121; Mg – 13.8; S-SO_4 – 32.0; Cl – 9.5; Na – 2.7; Fe – 0.24; Mn – 0.026; Cu – 0.001; Zn – 0.038; pH_{H2O} – 7.44, EC – 0.71 mS·cm^{-1}. The daily solution outflow, depending on plant developmental phase, ranged from 1.8 to 4.2 dm^3·plant^{-1}. The frequency of nutrient solution supply, controlled by „soltimer", depended upon insolation intensity. The two-factor experiment was established in a completely randomized system, in seven replications with two plants in each. The plants were planted into their permanent places in the first decade of February (04.02.2005; 07.02.2006; 09.02.2007) at the density of 2.3 plants per m^2. The cultivation was conducted in prolonged cycle (22 clusters) until mid-October (20.10.2005; 17.10.2006; 12.10.2007). Plant protection and management procedures were performed in accordance with the recommendations in force [Adamicki et al. 2005].

Fruit picking, conducted from 25.04.2005, 28.04.2006 and 24.04.2007, was performed two times a week. The fruits were counted, weighed and sorted, determining total, marketable and unmarketable yield, as well as mean fruit unit weight and the number of fruits from plant, in accordance with the Ordinance of EEC Committee no. 778/83 [1983]. Unmarketable yield was formed by tiny and damaged fruits.

Leaves for analyses (9th leaf from the top) were collected at the beginning, in the middle and at the end of plant fruiting. Fruit was collected for analysis in the harvest maturity phase at the beginning, in the middle and at the end of fruiting (from 6., 12. and 18. clusters). In the fresh material dry matter was determined by means of weight method [PN-90/A-75101/03], vitamin C – using Tillmans's method [PN-A-04019 1998] and total sugars using Schoorl-Rogenbogen method [Rutkowska 1981]. After the material had been dried, (temp. 105°C) total nitrogen was determined in leaves and fruits with the use of Kjeldahl's method [Ostrowska et al. 1991]. After the material had been mineralized in the mixture of nitric and perchloric acids in the proportion of v:v 3:1 [Ostrowska et al. 1991] phosphorus was determined colorimetrically with ammonium vanadomolybdate (Thermo, Evolution 300), potassium, calcium and magnesium using ASA method (Perkin-Elmer, Analyst 300).

Statistical elaboration of results was conducted using the method of variance analysis on mean values, applying Tukey's test for assessing differences, at significance level of $\alpha = 0.05$. The presented results are mean values from three study years.

RESULTS AND DISCUSSION

The main task of inert substrata is mechanical preservation of rhisosphere and securing the optimal air-water conditions, guaranteeing the appropriate accessibility of nutrients. The correct plant nutrition, securing their appropriate growth, development and optimal yielding depends on precise supply of nutrient solution with appropriate composition [Dyśko and Kowalczyk 2005, Nurzyński 2005].

Table 1. The effect of substratum and nutrient solution on the yielding of tomato (kg·plant^{-1}) grown in prolonged cycle (mean from the years 2005–2007)
Tabela 1. Wpływ podłoża i pożywki na plonowanie pomidora (kg·roślina^{-1}) uprawianego w cyklu wydłużonym (średnia z lat 2005–2007)

Substratum Podłoże	Total yield Plon ogólny			Marketable yield Plon handlowy			Unmarketable yield Plon poza wyborem		
	nutrient solution – pożywka								
	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$
Rockwool – Wełna mineralna	14.24	14.70	14.47	13.26	13.94	13.60	1.02	0.76	0.89
Perlite – Perlit	14.26	15.03	14.64	13.47	14.32	13.89	0.74	0.70	0.72
Expanded clay – Keramzyt	14.13	14.56	14.34	13.07	13.71	13.41	1.05	0.81	0.93
$\bar{x}$	14.21	14.76		13.26	14.01		0.94	0.76	
$LSD_{0,05}$ – $NIR_{0,05}$									
Substratum – podłoże		n.s. – ni.			n.s. – ni.			0.16	
Nutrient solution – pożywka		n.s. – ni.			0,66			0.14	

The statistical analysis of results obtained in the conducted studies did not reveal any significant differences in the total and marketable yield of fruit collected from the examined substrata (tab. 1). These results confirm the previous studies, where no significant differences were found in the yielding of tomato grown in rockwool, perlite and expanded clay [Jarosz and Horodko 2004, Jarosz and Dzida 2005]. Pawlińska and Komosa [2004] in turn, demonstrated a significantly lower yield of tomato fruit grown in expanded clay, compared to rockwool. In the assessment irrespective of the kind of substratum, significantly higher marketable yield (14.01 kg·plant^{-1}) from plants fertilized with the solution containing 25% more macrocomponents (EC II) compared to basic nutrient solution (EC I) was obtained. In most literature sources the predominant view is that the excessive increasing of general ion concentration in nutrient solution dosed under plants causes decrease of tomato yielding [Tuzel et al. 2003, Magan et al. 2008]. According to Hao et al. [2000], if the general concentration of ions in the nutrient solution (EC) does not exceed 40% of the recommended values, a significant yield decrease should not be feared. In the light of other studies, however, these reports are not so unambiguous. In the experiment conducted by Pawlinska and Komosa [2004] a significant decrease was found in the yielding of tomato fertilized with a solution containing 25% more macrocomponents, compared to the basic liquid fed. In the studies by Jarosz and Dzida [2005] in turn, no significant differences were found in the yielding of tomato fertilized with the basic nutrient solution and that containing 25% more macrocomponents. Hao and Papadopoulos [2004] regard daily differentiation of nutrient solution EC in the range from 2.5 to 3.75 $mS \cdot cm^{-1}$ as the best solution improving yielding and biological value of tomato fruit. The results obtained in the presented studies should be referred to the way of increasing the general concentration of ions (EC) in the nutrient solution. In most studies dealing with this issue the increase of general ion concentration (EC) in the nutrient solution was obtained by adding NaCl. The excessive concentration of sodium cations in rhisosphere may be toxic for the roots and may lead to serious disturbances in the uptake of other ions – mainly calcium and magnesium, which is regarded by many authors as the main reason for the decrease of plant yielding [Dyśko and Kowalczyk 2005, Komosa and Kleiber 2007]. The results obtained in the presented studies prove that the proportional increase of the concentrations of all macrocomponents in the medium by 25% may favorably affect the yielding of tomato grown in the selected inert substrata.

Table 2. Percentage of marketable yield in total yield, number of fruit per plant (pce) and mean fruit weight of tomato (g) depending on the type of substratum and nutrient solution (mean from the years 2005–2007)

Tabela 2. Procentowy udział plonu handlowego w plonie ogólnym, liczba owoców z rośliny (szt.) oraz średnia masa owocu pomidora (g) w zależności od rodzaju podłoża i pożywki (średnia z lat 2005–2007)

Substratum Podłoże	% of marketable yield in total % udział plonu handlowego w ogólnym			Number of fruits Liczba owoców			Mean fruit weight Średnia masa owocu		
	nutrient solution – pożywka								
	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$
Rockwool Wełna mineralna	92.46	94.67	93.56	110.2	108.8	109.5	128.9	135.1	132.0
Perlite – Perlit	94.37	95.29	94.83	106.4	109.8	108.1	133.9	137.0	135.4
Expanded clay – Keramzyt	92.34	94.52	93.43	108.1	109.2	108.6	130.7	133.3	132.1
$\bar{x}$	93.05	94.83		108.2	109.3		131,2	135,1	
$LSD_{0,05}$ – $NIR_{0,05}$									
Substratum – Podłoże		n.s. – ni			n.s. – ni.			n.s. – ni.	
Nutrient solution – Pożywka		1.14			n.s. – ni.			3.56	

What deserves attention is the high share of marketable yield in the total fruit yield, reported in the studies. It is contained in the range from 92.34% to 95.29% (tab. 2). According to many authors this parameter is a significant determinant of substratum usability in production [Jarosz and Horodko 2004, Jarosz and Dzida 2005]. Komosa et al. [2002] prove that the share of marketable yield in the total fruit yield can be increased through adjusting the N:K ratio to the dynamics of taking these nutrients up during vegetation. In the presented studies a significantly share of marketable yield in the general fruit yield (94.83%) was reported after the application of the nutrient solution containing 25% more macrocomponents compared to the basic solution (EC I). These interesting interdependencies should be referred to the results of mean unit weight of the fruit and unmarketable yield of fruit (tab. 1, 2). In the objects fertilized with concentrated solution (EC II) the tomato fruits had significantly higher unit weight (135.1 g), compared to plants fertilized with basic liquid fed (131.2 g). That is why the unmarketable yield collected from plants fertilized with the solution with higher macroelement concentration was 19% lower and consisted mainly of small fruits (tab. 1). It is worth emphasizing that in most reports the increased general ion concentration in the nutrient solution caused a significant decrease of fruit unit weight [Tuzel et al. 2003, Magan et al. 2008].

In the presented studies the effect of examined factors upon the mean number of fruits from one plant was not statistically confirmed (tab. 2).

According to Chohura and Komosa [2003] the correctly fed tomatoes contain in their leaves 2.8–4.2% of nitrogen and 0.40–0.65% of phosphorus . The contents of total nitrogen (3.94–4.31% d.m.) and phosphorus (0.41–0.51% d.m.) in the leaves of tomato grown in the examined objects were contained in the recommended ranges, which prove appropriate nutrition of plants with these macrocomponents. The contents of potassium (4.27–5.24% d.m.), calcium (2.06–2.99% d.m.) and magnesium (0.25–0.37% d.m.) reported in the leaves of tomato grown in the presented studies were similar to the values quoted by literature sources [Jarosz and Horodło 2004, Nurzyński 2005]. This proves the correct nutrition of plants with these elements [Chohura and Komosa 2003, Jarosz and Horodko 2004].

The statistical analysis of results obtained in the conducted studies demonstrated a significant effect of the substratum type and differentiated macroelement concentrations in the nutrient solution upon the dry matter contents in tomato fruits (tab. 4). Fruits collected from plants grown in expanded clay contained significantly more dry matter (5.74%) compared to those grown in rockwool (5.39%). A similar tendency was demonstrated in previous studies, comparing growing tomatoes in rockwool and expanded clay, but these results have not been statistically confirmed [Jarosz and Dzida 2005]. In the presented studies a significant increase was reported in dry matter contents in fruit of plants fertilized with a nutrient solution with higher ion concentration (5.71%) compared to the basic solution (5.41%). These results are consistent with numerous reports, where the increase of general ion concentration in a nutrient solution (EC) caused a significant increase of dry matter contents in tomato fruit [Tuzel et al. 2003, Gautier et al. 2010].

According to Gautier et al. [2010] the effect of applying a nutrient solution with increased ion concentration (EC) upon vitamin C biosynthesis in tomato fruit is not so explicit as in the case of dry matter content. In certain studies an increased vitamin C in fruit was reported, as an effect of increase ion concentration in the nutrient solution, while in others no such relationship was reported. In the presented studies significantly less vitamin C was found in the fruits of plants fertilized with a nutrient solution with higher EC (17.2 mg$\cdot$100^{-1} g) compared to the basic solution (18.8 mg$\cdot$100^{-1} g).

Table. 3. The effect of substratum and nutrient solution on the chemical composition of tomato leaves (% d.m) grown in prolonged cycle (mean from the years 2005–2007)

Tabela 3. Wpływ podłoża i pożywki na skład chemiczny liści pomidora odmiany (% s.m.) uprawianego w cyklu wydłużonym (średnia z lat 2005–2007)

Substratum Podłoże	N Total N ogółem			P			K			Ca			Mg		
	nutrient solution – pożywka														
	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$
Rockwool – Wełna mineralna	3.97	4.27	4.12	0.47	0.51	0.49	4.43	5.11	4.77	2.12	2.98	2.55	0.27	0.36	0.32
Perlite – Perlit	3.94	4.31	4.13	0.46	0.50	0.48	4.43	5.24	4.83	2.06	2.95	2.51	0.26	0.36	0.31
Expanded clay – Keramzyt	3.98	4.27	4.13	0.41	0.47	0.44	4.27	5.04	4.65	2.13	2.99	2.56	0.25	0..37	0.31
$\bar{x}$	3.97	4.28		0.45	0.49		4.37	5.12		2.11	2.97		0.26	0.36	
$LSD_{0,05}$ – $NIR_{0,05}$															
Substratum – Podłoże	n.s. – ni.			n.s. – ni.			n.s. – ni.			n.s. – ni.			n.s. – ni.		
Nutrient solution – Pożywka	0.11			n.s. – ni.			0.24			0.21			0.03		

In numerous reports authors demonstrate a significant increase of sugar contents in tomato fruit when the nutrient solution of increased ion concentration is applied [Campos et al. 2006, Gautier et al. 2010]. In the presented studies no significant differences were demonstrated in the contents of total sugars in tomato fruit, depending on the kind of substratum and macrocomponent concentration in the dosed nutrient solution.

Table 4. The effect of substratum and nutrient solution on the composition of fruit of tomato grown in prolonged cycle (mean from the years 2005–2007)
Tabela 4. Wpływ podłoża i pożywki na skład owoców pomidora uprawianego w cyklu wydłużonym (średnia z lat 2005–2007)

Substratum Podłoże	Dry matter (%) Sucha masa (%)			Vitamin C (mg·100 g^{1} fr.w.) Witamina C (mg·100 g^{-1} św.m.)			Total sugars (% fr. w.) Cukry ogółem (% św.m.)		
	nutrient solution – pożywka								
	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$
Rockwool – Wełna mineralna	5.31	5.48	5.39	19.0	17.4	18.2	2.53	2.71	2.62
Perlite – Perlit	5.35	5.54	5.54	18.7	17.6	18.1	2.69	2.85	2.77
Expanded clay – Keramzyt	5.57	5.91	5.74	18.9	16.7	17.8	2.75	2.98	2.87
$\bar{x}$	5.41	5.71		18.8	17.2		2.66	2.85	
$LSD_{0,05}$ – $NIR_{0,05}$									
Substratum – Podłoże		0.32			n.s. – ni.			n.s. – ni.	
Nutrient solution – Pożywka		0.22			0.97			n.s. – ni.	

The increased ion concentration in nutrient solution causes higher uptake of elements by plants, their distribution, however, to the leaves and fruits, is not even [Grava et al. 2001, Gautier et al. 2010]. The results obtained in the conducted studies confirm these dependencies. The statistical analysis revealed significantly more total nitrogen (2.41% d.m.), phosphorus (0.31% d.m.), potassium (4.23% d.m.) and calcium (1096 mg·kg^{-1} d.m.) in the tomato fruit fertilized with a solution with higher macronutrient concentration. Compared to plants fertilized with basic solution (EC I), the increased contents of these elements in fruit were, respectively: 6.2% total nitrogen, 18.5% phosphorus, 8.3% potassium and 28.9% calcium.

What needs to be emphasized, are the interesting results concerning the effect of nutrient solution with differentiated ion concentration upon the contents of calcium in tomato fruits (tab. 5). Numerous studies revealed a significant decrease in the contents of this element in plants together with the increase of general ion concentration in a nutrient solution [Grava et al. 2001]. This phenomenon is most often explained by slowed down water uptake and thus, decreased uptake of calcium ions by plants grown in the conditions of increased ion concentration in rhisosphere. The decreased calcium contents in fruit increases the risk of blossom-end rot of fruits [Grava et al. 2001, Jarosz

Table. 5. The effect of substratum and nutrient solution on the chemical composition of tomato fruits grown in prolonged cycle (mean from the years 2005–2007)

Tabela 3. Wpływ podłoża i pożywki na skład chemiczny owoców pomidora uprawianego w cyklu wydłużonym (średnia z lat 2005–2007)

Substratum Podłoże	N Total (% d.w.) N ogółem (% s.m.)			P (% d.w.) P (% s.m.)			K (% d.w.) K (% s.m.)			Ca ($mg \cdot kg^{-1}$ d.w) Ca ($mg \cdot kg^{-1}$ s.m.)			Mg ($mg \cdot kg^{-1}$ d.w) Mg ($mg \cdot kg^{-1}$ s.m.)		
	nutrient solution – pożywka														
	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$	EC I	EC II	$\bar{x}$
Rockwool – Wełna mineralna	2.31	2.47	2.39	0.27	0.33	0.30	3.88	4.29	4.08	988	1088	1038	705	875	790
Perlite – Perlit	2.21	2.36	2.29	0.26	0.30	0.28	3.72	4.01	3.86	750	1075	913	663	731	697
Expanded clay – Keramzyt	2.30	2.39	2.34	0.27	0.32	0.29	4.05	4.39	4.22	813	1125	969	638	806	887
$\bar{x}$	2.27	2.41		0.27	0.32		3.88	4.23		850	1096		669	804	
$LSD_{0,05}$ – $NIR_{0,05}$															
Substratum – Podłoże		n.s. – ni.			n.s. – ni.			0.28			n.s. – ni.			n.s. – ni.	
Nutrient solution – Pożywka		0.10			0.03			0.18			175			n.s. – ni.	

and Dzida 2005]. However, the results obtained in the presented studies, where a significant increase of calcium contents was found in the fruits of tomato fertilized with a nutrient solution of increased ion concentration (EC II) reveal the existence of additional relationships determining calcium uptake by plants grown in the conditions of increased rhisosphere EC. The explanation for the obtained results seems to be the composition and proportions of particular elements in the dosed nutrient solution. In most studies on the response of tomato to the increased ion concentration in the rhisosphere, in order to increase the nutrient solution EC, the addition of sodium chloride (NaCl) is applied, or salty water with high content of sodium cations (Na^+). In such conditions in the rhisosphere there occurs excessive accumulation of sodium cations and the Ca:Na proportion becomes narrower, which makes it difficult for plants to take up calcium [Campos et al. 2006]. Campos et al. [2006] argue that the application of nutrient solution containing high sodium concentration requires a simultaneous increase of sodium and potassium contents, which soothes the salt stress symptoms and makes it possible to take these nutrients up on the level favorable to plants grown in normal conditions. Also Cabanero et al. [2004] argue that growing tomatoes in the conditions of high rhisosphere EC requires the increase of calcium concentration that eliminates salt stress and soothes the negative effect of toxic sodium concentration upon plants. According to these authors the increased share of calcium in the conditions of excessive ion concentration (the so-called salinity) also enhances taking up water by plants. The confirmation of these reports are also the results obtained in the presented studies, where the increase of general ion concentration in the nutrient solution was achieved through proportional increase of the contents of all macroelements.

Many authors emphasize that with the application of technologies creating conditions for very accurate fertilization of plants, that is cultivations in inert substrata, the main factor determining the yield quantity and quality is the appropriately selected nutrient solution, satisfying the specific nutritional requirements of a given cultivar [Nurzyński 2005, Jarosz 2006]. The results obtained in the presented studies seem to confirm these interdependencies.

CONCLUSIONS

1. No significant effects were found in the total yield, marketable yield, mean weight of one fruit and the number of fruits from one plant, depending on the kind of examined substratum.

2. In the objects fertilized with a nutrient solution with higher macrocomponent concentration (EC II) significantly higher marketable yield was obtained, as well as higher fruit unit weight and lower unmarketable yield, compared to the basic solution (EC I).

3. In the leaves of plants fertilized with a solution containing 25% more macroelements (EC II) significantly more total nitrogen, potassium, calcium and magnesium were found.

4. Fruits of plants fertilized with nutrient solution of higher macroelements concentration (EC II) contained significantly more dry matter, total nitrogen, phosphorus, potassium, calcium and less vitamin C, compared to the basic solution (EC I).

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WPŁYW PODŁOŻA I POŻYWKI NA PLONOWANIE ORAZ SKŁAD CHEMICZNY LIŚCI I OWOCÓW POMIDORA SZKLARNIOWEGO UPRAWIANEGO W CYKLU WYDŁUŻONYM

Streszczenie. W bezglebowej uprawie pomidora pod osłonami głównymi czynnikami decydującymi o wysokości i jakości uzyskanego plonu są rodzaj użytego podłoża uprawowego oraz skład pożywki pokarmowej dozowanej pod rośliny. Badania przeprowadzone w szklarni w latach 2005–2007 miały na celu określenie wpływu rodzaju podłoża z wełny mineralnej, perlitu i keramzytu oraz dwu rodzajów pożywki pokarmowej o zróżnicowanej koncentracji makroskładników (EC I – 2.4 $mS \cdot cm^{-1}$ i EC II – 3.6 $mS \cdot cm^{-1}$) na plonowanie oraz skład chemiczny liści i owoców pomidora odmiany 'Cunero F_1' uprawianego w cyklu wydłużonym (22 grona). Uprawę prowadzono z wykorzystaniem kroplowego systemu fertygacji, z zamkniętym obiegiem pożywki, bez recyrkulacji. W przeprowadzonych badaniach nie stwierdzono istotnych różnic w plonie ogólnym oraz handlowym owoców pomidora uprawianego w badanych podłożach. Rodzaj podłoża nie miał również istotnego wpływu na średnią masę jednego owocu i liczbę owoców z rośliny. W obiektach nawożonych pożywką o wyższej koncentracji makroskładników (EC II) odnotowano istotnie większy plon handlowy, większą masę jednostkową owoców oraz mniej owoców niehandlowych w porównaniu z pożywką podstawową (EC I). W liściach roślin nawożonych pożywką zawierającą 25% więcej makroskładników (EC II) odnotowano istotnie więcej azotu ogółem, potasu, wapnia i magnezu. Owoce roślin nawożonych pożywką o wyższej koncentracji makroskładników (EC II) zawierały istotnie więcej suchej masy (5.71%), azotu ogółem (2,41% s.m.), fosforu (0,32% s.m.), potasu (4,23% s.m.), wapnia (1096 $mg \cdot kg^{-1}$s.m.) oraz mniej witaminy C (17.2 $mg \cdot 100^{-1}$ g św.m.) w porównaniu do owoców z roślin nawożonych pożywką podstawową o EC 2.4 $mS \cdot cm^{-1}$. W badaniach nie stwierdzono istotnego wpływu rodzaju podłoża na zawartość witaminy C, cukrów, azotu ogółem, fosforu wapnia i magnezu w owocach pomidora

Słowa kluczowe: wełna, perlit, keramzyt, EC pożywki, plon ogólny, plon handlowy, makroelementy, sucha masa, witamina C, cukry

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