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POSSIBILITY OF REUSING EXPANDED CLAY IN GREENHOUSE TOMATO CULTIVATION. PART I. YIELD AND CHEMICAL COMPOSITION OF FRUITS

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

Abstract. One of the possibility that allow costs of soilless tomato culture to be reduced is to reuse the same growing medium. Expanded clay is classified as an inert medium, that is, chemically and biologically passive, although some studies indicate the possibility of the occurrence of exchange sorption and ion adsorption in this medium during cultivation. The aim of the study, conducted in the period 2007–2008, was to determine the usefulness of expanded clay being post-production waste in soilless tomato culture under extended cycle conditions. The study used new expanded clay (I) as the control and expanded clay being post-production waste from year-round tomato cultivation with the following experimental design: chemically sterilized material (II); material washed in water with the remains of the old root system of plants removed and additionally chemically sterilized (III); and material without any modifying treatments (IV). Expanded clay was placed in 12 dm^3 poly sleeves and formed in the shape of growing slabs. Crops were grown using a drip irrigation and fertilization system with closed nutrient solution circulation, without recirculation. The nutrient solution was supplied to all plants in the same amount and with the same composition. The study found the lowest total fruit yield (15.10 $kg \cdot plant^{-1}$) and marketable fruit yield (14.07 $kg \cdot plant^{-1}$) of tomato grown in reused expanded clay without any modifying treatments (IV), whereas this yield was significantly higher from tomato plants grown in the material washed and additionally chemically sterilized (III). Fruits with the highest unit weight (150.8 g) were picked from plants grown in new expanded clay (I), while fruits with a significantly lower weight (138.6 g) were obtained from the treatments with the reused medium both washed and chemically sterilized (III). Fruits of tomato plants growing in reused expanded clay subjected to washing and chemical sterilization (III) contained the highest amount of dry matter (5.71%) and total sugars (3.08% fr.w.), whereas fruits of tomato grown in the new medium (I) had the highest amount of vitamin C (21.96 $mg \cdot 100\ g^{-1}$ FW), zinc (25.86 $mg \cdot kg^{-1}$ d.w) and copper (6.10 $mg \cdot kg^{-1}$ d.w).

Key words: soilless culture, reused medium, vitamin C, total sugars, fruit nutrient content

Corresponding author – Adres do korespondencji: Zbigniew Jarosz, Department of Soil Cultivation and Fertilization of Horticultural Plants, University of Life Sciences in Lublin, ul. Leszczyńskiego 58, 20-068 Lublin, Poland, e-mail: zbigniew.jarosz@up.lublin.pl

INTRODUCTION

The technology of tomato growing in inert substrates using an automatic fertigation system allows the nutritional status of plants to be controlled precisely, and the role of such substrate comes down to holding mechanically the root system and providing optimal air and water conditions [Jarosz and Dzida, 2011; Nurzyński et al. 2012]. Numerous studies confirm the high effectiveness of expanded clay as a growing medium in greenhouse tomato cultivation [Chohura and Komosa, 1999; Jarosz and Horodko, 2004; Jarosz and Dzida, 2011]. Homogeneous expanded clay medium is light, sterile and exceptionally durable; moreover, it easily absorbs and releases water [Pawlińska and Komosa, 2000]. Komosa [2002] stresses that air and water relations of expanded clay can be easily changed and adjusted to plant requirements by selecting an appropriate fraction of granules. By increasing the granule diameter, the proportion of air is increased through the reduction of the proportion of water.

As emphasized by Nurzyński et al. [2012], in selecting a medium, in addition to its usefulness in growing a particular species, purchase costs and the possibility of easier management of post-production waste left after the cultivation is finished are taken into consideration. The possibility of reusing the same material is a way that significantly reduces the cost associated with medium replacement [Piróg, 1998b]. In the literature, there is a lack of detailed data on the possibility of reusing expanded clay substrate in greenhouse tomato culture in extended cycle. A major problem in applying this solution, in addition to the risk of the loss of sterility, is the possibility of uncontrolled accumulation of nutrients supplied in the nutrient solution in the root environment [Meinken, 1997].

In the literature sources, expanded clay used as a growing medium in greenhouse culture of plants is classified as an inert substrate, that is, chemically and biologically passive in relation to plant roots and the nutrient solution supplied [Komosa, 2002; Sonneveld and Voogt, 2009]. Nevertheless, some detailed studies of this material indicate the possibility of the occurrence of cation exchange sorption [Drizo et al. 1999; Kleiber and Komosa, 2008] as well as phosphate adsorption [Johansson Westholm, 2006; Cucarella and Renman, 2009]. These properties may significantly modify the composition of the root environment of plants, at the same time affecting their growth, development, and yield.

The aim of the study was to evaluate yield and chemical composition of fruits of tomato grown under extended cycle conditions in a medium of expanded clay being post-production waste from year-round tomato cultivation.

MATERIALS AND METHODS

The study was conducted in the period 2007–2008. The test object was the tomato cultivar 'Cunero F_1' grown in a greenhouse in a medium of expanded clay with granulation of 8–16 mm (Optiroc-Gniew). The study used new expanded clay (I) as the control and expanded clay being post-production waste from year-round tomato cultivation with the following experimental design: chemically sterilized material (II); material washed in water with the remains of the old root system of the plants removed and additionally chemically sterilized (III); and material without any modifying treatments (IV). A 2% solution of the fungicide Previcur 607 SL was used for chemical sterilization.

Expanded clay was placed in 12 dm^3 poly sleeves and formed in the shape of growing slabs. Two plants were grown in each slab. The experiment was set up as a completely randomized design with seven replications. A slab in which two plants were grown was one replication. Tomato plants were planted in their permanent place in the first decade of February (9 February 2007; 6 February 2008). Tomato was cultivated in extended cycle (22 clusters), at a density of 2.3 $plant \cdot m^{-2}$, until the middle of October (12 October 2007 and 14 October 2008). Crops were grown using a drip irrigation and fertilization system with closed nutrient solution circulation, without recirculation. The study used a nutrient solution with the following average composition ($mg \cdot dm^{-3}$): $N\text{-}NH_4$ – 12.2; $N\text{-}NO_3$ – 235; $P\text{-}PO_4$ – 56.5; K – 350; Ca – 256; Mg – 94; $S\text{-}SO_4$ – 185; Na – 26; Cl – 18.5; Fe – 1.25; Mn – 0.55; B – 0.30; Cu – 0.05; Zn – 0.30; Mo – 0.03 as well as pH_{H2O} – 5.95 and EC 2.3–2.9 $mS \cdot cm^{-1}$. The nutrient solution was prepared with the following chemical composition of water ($mg \cdot dm^{-3}$): $N\text{-}NH_4$ – 0.02; $N\text{-}NO_3$ – 5.0; $P\text{-}PO_4$ – 4.0; K – 1.4; Ca – 121; Mg – 13.8; $S\text{-}SO_4$ – 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 $mS \cdot cm^{-1}$. The solution was supplied to all plants in the same amount and with the same composition. The composition and proportions of particular elements in the nutrient solution were changed during plant growth and adjusted to plant development stages in accordance with the latest recommendations [Sonneveld and Voogt, 2009]. The amount of nutrient solution supplied was determined with an excess of about 25%. The frequency of nutrient solution supply, controlled by a solar timer, depended on solar radiation intensity. Flowers were pollinated by the large earth bumblebee (*Bombus terrestris*). Plant protection treatments were carried out using biological agents. All tending treatments were performed in accordance with the applicable recommendations [Adamicki et al. 2005].

Fruit picking, lasting from 27 April 2007 and from 29 April 2008, was done twice a week. Fruits were counted, weighed and sorted out, determining total fruit yield, marketable fruit yield, and average fruit weight in accordance with EU standards (Commission Regulation (EEC) No. 778/83).

Fruits were sampled for analysis at the harvest maturity stage twice: from the 9th and 18th clusters. Dry weight was determined in fresh material by the gravimetric method (PN-90/A-75101/03), vitamin C by Tillmans' method [PN-A-04019 1998], and total sugars by Schoorl-Rogenbogen's method [Rutkowska 1981]. After the material was dried (temp. 105°C), total nitrogen was determined using Kjeldahl's method [Ostrowska et al. 1991]. Following mineralization of the material in a mixture of nitric and perchloric acids at a proportion of 3:1 (v:v) [Ostrowska et al. 1991], phosphorus was determined colourimetrically with ammonium-vanadium-molybdate (Thermo, Evolution 300), while potassium, calcium, magnesium, iron, manganese, zinc and copper by AAS (Perkin-Elmer, AAnalyst 300).

The results were statistically analysed using analysis of variance on the mean values and employing Tukey's test to evaluate the significance of differences at the level of significance $\alpha = 0.05$.

RESULTS AND DISCUSSION

One of the way to reduce costs of soilless tomato culture is to reuse the same growing medium in the production cycle [Piróg 1998b; Markiewicz et al. 2004]. This solution is also advantageous for ecological reasons, since it allows post-production waste to be reduced, which is frequently troublesome to manage. In the study of Markiewicz et al. [2004] in which organic substrates were reused in the production cycle, a significant decline in yield was recorded due to excessive accumulation of salts and phytotoxic compounds in the root environment. Expanded clay is classified as an inert substrate that is chemically and biologically passive in relation to the nutrient solution supplied [Komosa 2002; Kleiber and Komosa 2008]. Moreover, when plants are grown in this medium, the nutrient solution is supplied to plants with an excess of 20–30%, which is designed to prevent excessive ion accumulation in the root environment. However Drizo et al. [1999] report that expanded clay is characterized by significant sorptive capacity in relation to cations, which is 9.5 $cmol \cdot kg^{-1}$. Furthermore, Johansson Westholm [2006] argues that under laboratory conditions this material shows the phosphate adsorption capacity in the range from 46 to 565 $mg \cdot kg^{-1}$ of material. These properties may significantly modify the composition of the root environment of plants, thereby affecting fruit yield and chemical composition.

Table 1. Yield of tomato variety 'Cunero F_1' depending on the preparing method of expanded clay
Tabela 1. Plon pomidora odmiany 'Cunero F_1' w zależności od sposobu przygotowania keramzytu

Treatment Kombinacja	Total yield ($kg \cdot plant^{-1}$) Plon ogólny ($kg \cdot roślina^{-1}$)			Marketable yield ($kg \cdot plant^{-1}$) Plon handlowy ($kg \cdot roślina^{-1}$)			Average weight of fruit (g) Średnia masa owocu (g)		
	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$
Exp. clay I	16.32	15.21	15.77	15.45	14.55	15.00	153.6	147.9	150.8
Exp. clay II	16.57	15.14	15.85	15.80	14.73	15.27	143.4	135.7	139.5
Exp. clay III	16.90	15.71	16.31	16.28	15.06	15.67	143.2	133.9	138.6
Exp. clay IV	15.71	14.49	15.10	14.89	14.07	14.48	150.2	148.5	149.3
$\bar{x}$	16.38	15.14		15.61	14.60		147.6	141.5	
$LSD_{0.05}$, $NIR_{0,05}$									
Treatment – Kombinacja	1.13			0.96			12.02		
Year – Rok	0.61			0.66			n.s. – r.n.		
Treatment × year	n.s. – r.n.			n.s. – r.n.			n.s. – r.n.		

Note: n.s. – no significant differences, r.n. – różnice nieistotne statystycznie

The present study demonstrated significant differences in total and marketable fruit yield of tomato grown in the studied treatments (Tab. 1). The highest total fruit yield (on average 16.31 $kg \cdot plant^{-1}$) and marketable fruit yield (on average 15.67 $kg \cdot plant^{-1}$)

were harvested from plants growing in the reused medium both washed and chemically sterilized. What is important, this yield was higher compared to the treatments where new expanded clay was the substrate (total yield by 3.42% and marketable yield by 4.47%), though these differences were not confirmed statistically. Likewise, Piróg [1998a] showed proper yield of tomato grown in expanded clay and rockwool when these materials were reused as growing media, in comparison with new materials. The results confirming the lower yield of tomato grown in new expanded clay (I) compared to the reused medium both washed and disinfected (III) are worth deeper consideration. The lack of stability of the pH of the root environment in new expanded clay and large differences in this parameter relative to the value recommended for tomato seem to be one of the factors that might have influenced the obtained results (Part II). This phenomenon affected the nutritional status of plants, in particular as regards nutrients. The lowest total yield (on average 15.10 kg·plant^{-1}) and marketable yield (on average 14.48 kg·plant^{-1}) were obtained from the treatments where the reused material without any modifying treatments was the medium. This yield was lower by 4.25% (total yield) and by 3.47% (marketable yield) compared to the yield obtained from the treatments with new expanded clay. The obtained results may evidence the accumulation of factors negatively affecting plant growth in the medium after the first cropping cycle, though no visual symptoms of the loss of sterility of the medium were observed during the study.

The highest fruit unit weight (150.8 g) was recorded in the treatments with new expanded clay, whereas fruits with a significantly lower unit weight (138.6 g) were found in the tomato crops grown in reused material both washed and chemically sterilized. Borosić et al. [2009] did not observe clear differences in fruit unit weight of tomato grown in new rockwool and rockwool reused for the cultivation of this species.

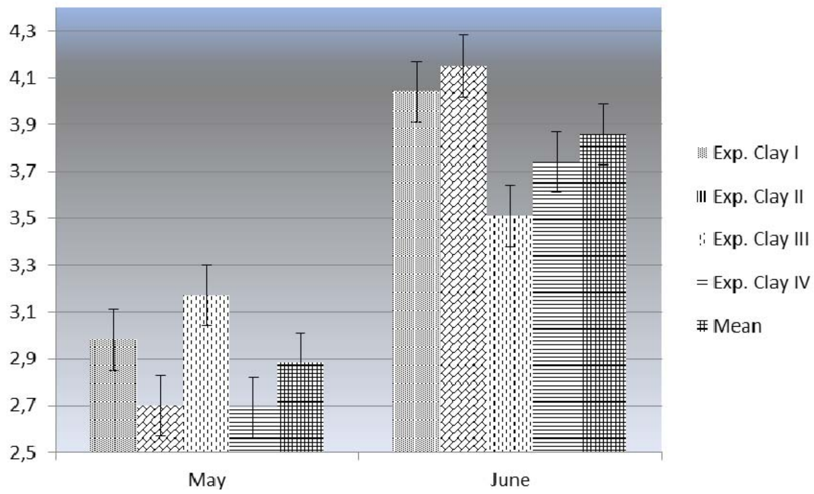

Fig. 1. Total yield of tomato variety 'Cunero F_1' (kg·plant^{-1}) in May and June depending on the preparing method of expanded clay (means for 2007-2008 years)

Rys. 1. Plon ogólny pomidora odmiany 'Cunero F_1' (kg·plant^{-1}) w maju i czerwcu w zależności od sposobu przygotowania keramzytu (średnio z lat 2007-2008)

The yield results for tomato grown in the treatments under study presented on a monthly basis for May and June as the means for both study years look interesting (Fig. 1). In the first month, plants grown in reused expanded clay washed and chemically sterilized produced the largest amount of fruits. This yield was higher by 6.55% than the weight of fruits harvested from plants grown in new expanded clay and higher by 10.27% than the average for all treatments. In June the highest yield was obtained from the treatments in which reused, chemically sterilized expended clay was the medium. This result is higher by 2.75% than the yield of plants grown in new expanded clay and higher by 7.51% than the average for all treatments. It should be added that in the second month of harvest the lowest amount of fruits was picked from the treatments where washed and chemically sterilized reused expanded clay was the medium (9.07% less than the average for all treatments).

The high percentage of marketable yield in total tomato fruit yield needs to be stressed; depending on the treatment, it was from 94.67 to 97.29% (Fig. 2). A similar high percentage of marketable yield in total fruit yield was obtained by Piróg [1998b] who investigated the usefulness of several reused media in greenhouse cucumber growing. In the opinion of this author, such a high percentage of marketable yield in total yield is evidence of the high usefulness of this substrate as reused medium.

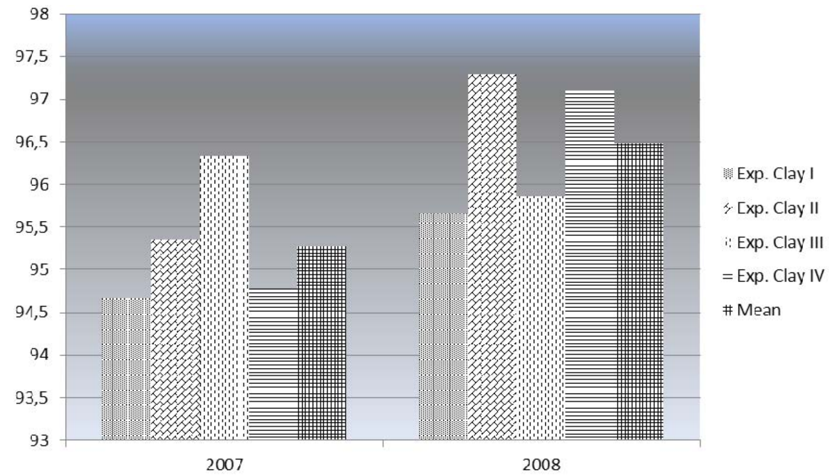

Fig. 2. Percentage of marketable yield in total yield of fruit 'Cunero F_1' variety depending on the preparing method of expanded clay in 2007 and 2008 year

Rys. 2. Procentowy udział plonu handlowego w polnie ogólnym owoców odmiany 'Cunero F_1' w zależności od sposobu przygotowania keramzytu w 2007 i 2008 roku

The highest dry weight (on average 5.71%) and total sugars (on average 3.08% FW) were found in fruits of tomato grown in reused expanded clay both washed and chemically sterilized (III), whereas these parameters were significantly lower in fruits of plants growing in reused expanded clay only chemically sterilized (II) (Tab. 2). Banasiak et al. [2001], studying the possibility of multiple use of a substrate composed of peat, vermiculite and perlite (1:2:2), recorded a linear decrease in dry matter content in leaves and bulbs of radish grown in media reused for cultivation. These authors explain the obtained results by a significant increase in total salt concentration in the media used many times. The analysis of the results obtained in the present study did not confirm these relationships.

Table 2. Effect of the preparing method of expanded clay on the dry matter (%), vitamin C ($mg\cdot 100\ g^{1}$ fr.w.) and total sugars (% fr. w.) content in tomato fruit variety 'Cunero F_1'
Tabela 2. Wpływ sposobu przygotowania keramzytu na zawartość suchej masy (%) witaminy C ($mg\cdot 100\ g^{-1}$ św.m.) oraz cukrów ogółem (% św.m.) w owocach pomidora odmiany 'Cunero F_1'

Treatment Kombinacja	Dry matter Sucha masa			Vitamin C Witamina C			Total sugars Cukry ogółem		
	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$
Exp. clay I	5.03	5.36	5.20	29.54	14.38	21.96	3.09	2.98	3.04
Exp. clay II	5.24	4.60	4.92	21.05	13.25	17.15	2.41	2.35	2.38
Exp. clay III	5.83	5.58	5.71	23.34	14.14	18.74	3.48	2.68	3.08
Exp. clay IV	5.10	5.25	5.17	21.22	13.62	17.42	2.88	2.42	2.65
$\bar{x}$	5.28	5.40		23.79	13.85		2.97	2.61	
$LSD_{0.05}$, $NIR_{0,05}$									
Treatment – Kombinacja		0.63			0.52			0.35	
Year – Rok		n.s. – r.n.			1.01			n.s. – r.n.	
Treatment × year		0.46			0.43			0.28	

Note: see table 1

The statistical analysis of the results obtained in the present study showed the significantly highest content of vitamin C in fruits of tomato grown in new expanded clay (on average 21.96 $mg\cdot 100\ g^{-1}$ FW). Statistically, the lowest amount of vitamin C was found in fruits of tomato grown in the reused material after chemical sterilization (on average 17.15 $mg\cdot 100\ g^{-1}$ FW) and in expanded clay without any modifying treatments reused as a growing medium (on average 17.42 $mg\cdot 100\ g^{-1}$ FW). In the opinion of Wierzbicka and Kuskowska [2002], species- and cultivar-specific predispositions, cultivation time and technology, climatic conditions, and fertilization should be included in the main factors determining vitamin C biosynthesis by the plant. In turn, the rate and form of nitrogen applied as well as proper manganese nutrition of plants are most frequently mentioned among fertilization factors determining vitamin C content in yield [Kowalska et al. 2006]. In the present study, nitrogen and manganese fertilization was the same in all treatments; therefore, the reason for differences in vitamin C content in fruits of the studied plants should be sought in relation to nitrogen and manganese contents in plants.

Table 3. Effect of the preparing method of expanded clay on the macronutrients content (% d.w.) in tomato fruit variety 'Cunero F_1'
Tabela 3. Wpływ sposobu przygotowania keramzytu na zawartość makroskładników (% s.m.) w owocach pomidora odmiany 'Cunero F_1'

Treatment Kombinacja	N Total – N ogółem			P			K			Ca			Mg		
	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$
Exp. Clay I	2.23	2.39	2.31	0.15	0.36	0.26	2.34	2.68	2.51	0.07	0.11	0.09	0.14	0.17	0.16
Exp. Clay II	2.35	2.41	2.38	0.17	0.35	0.27	3.92	2.88	3.40	0.08	0.11	0.10	0.16	0.16	0.16
Exp. Clay III	2.47	2.21	2.34	0.20	0.31	0.26	4.04	2.52	3.28	0.07	0.12	0.10	0.17	0.17	0.17
Exp. Clay IV	2.25	2.40	2.33	0.18	0.33	0.25	3.18	2.51	2.84	0.07	0.12	0.10	0.16	0.15	0.16
$\bar{x}$	2.33	2.35		0.18	0.34		3.37	2.65		0.08	0.11		0.16	0.16	
$LSD_{0.05}$ – $NIR_{0,05}$															
Treatment – Kombinacja		n.s. – r.n.			n.s. – r.n.			0.41			n.s. – r.n.			n.s. – r.n.	
Year – Rok		n.s. – r.n.			0.04			0.34			0.02			n.s. – r.n.	
Treatment × year		0.33			n.s. – r.n.			1.31			n.s. – r.n.			0.03	

Note: See table 1 – Patrz tab. 1

Table 4. Effect of the preparing method of expanded clay on the micronutrients content ($mg \cdot kg^{-1}$ d.w) in tomato fruit variety 'Cunero F_1'
Tabela 4. Wpływ sposobu przygotowania keramzytu na zawartość mikroskładników ($mg \cdot kg^{-1}$ s.m.) w owocach pomidora odmiany 'Cunero F_1'

Treatment Kombinacja	Fe			Mn			Zn			Cu		
	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$
Exp. clay I	47.75	42.07	44.91	37.52	26.25	31.88	28.93	22.79	25.86	6.86	5.34	6.10
Exp. clay II	63.12	48.12	55.62	35.26	24.49	29.88	25.80	18.37	22.08	5.51	3.54	4.52
Exp. clay III	43.42	30.50	36.92	38.13	25.09	31.61	19.70	20.75	20.27	5.15	2.74	3.95
Exp. clay IV	52.98	45.81	49.40	31.28	24.76	28.29	16.14	17.93	17.04	5.75	3.71	4.73
$\bar{x}$	51.82	41.36		35.68	25.15		22.64	19.96		5.82	3.83	
$LSD_{0.05}$ – $NIR_{0,05}$												
Treatment – Kombinacja		6.10			n.s. – r.n.			2.95			0.52	
Year – Rok		3.15			1.87			0.99			0.34	
Treatment × year		n.s. – r.n.			3.98			3.41			n.s. – r.n.	

Note: See table 1 – Patrz tab. 1

The analysis of the results obtained in the present study did not show significant differences in the content of total nitrogen, phosphorus, calcium, magnesium and manganese in fruits of tomato grown in the treatments under study (Tab. 3-4). The significantly highest amount of iron (on average 55.62 mg·kg^{-1} DW) was recorded in fruits of plants grown in the reused, chemically sterilized substrate (II), while the content of zinc (25.86 mg·kg^{-1} DW) and copper (6.10 mg·kg^{-1} DW) was the highest in fruits of tomato grown in new expanded clay. The contents of macro- and micronutrients found in the present study are in agreement with the data cited in the literature sources [Tantawy et al. 2009; Nurzyński et al. 2012], which is evidence of the proper development of plants growing in the treatments under study.

The results obtained in this study show that if expanded clay from year-round tomato cultivation is reused, this material, being post-production waste, should be washed and chemically sterilized.

CONCLUSIONS

1. The lowest total and marketable tomato fruit yield cv. 'Cunero F$_1$' was found in tomato crops grown in reused expanded clay without any modifying treatments (IV), whereas this yield was significantly higher in crops growing in the washed and additionally chemically sterilized material (III).

2. Fruits with the highest unit weight were picked from plants grown in new expanded clay (I), while fruits with a significantly lower weight were obtained from the treatments with the reused medium both washed and chemically sterilized (III).

3. Fruits of tomato plants growing in reused expended clay washed and chemically sterilized (III) contained the highest amount of dry matter and total sugars, whereas fruits of tomato grown in the new medium (I) had the highest amount of vitamin C, zinc and copper.

REFERENCES

Adamicki F., Dyśko J., Nawrocka B., Ślusarski C., Wysocka-Owczarek M., 2005. Metodyka integrowanej produkcji pomidorów pod osłonami. Instrukcja PIORIN, Warszawa.

BonasiaA., Gonella M., Santamaria P., Elia A., 2001. Substrate re-use affect yield and quality of seven radish cultivars grown in a closed soilless system. Acta Hort. 548, 367–376.

Borosić J., Benko B., Nowak N., Toto N., Zutić I., Fabek S., 2009. Growth and field of tomato grown on reused rockwool slabs. Acta Hort., 819, 221–226.

Chohura P., Komosa A., 1999. Wpływ podłoży inertnych na plonowanie pomidora szklarniowego. Zesz. Probl. Postęp. Nauk Rol., 466: 471–477.

Cucarella V., Renman G., 2009. Phosphrus sorpction capacity of filter material used for one-site wastewater treatment determined in batch experiments – a comparative study. J. Environ. Qual., 38, 381–392.

Drizo A., Frost C.A., Grace J., Smith K.A., 1999. Physico-chemical screening of phosphate removing substrates for use in constructed wetland systems. Water Res., 33(17), 3595–3602.

Ho L., C., Hand D., J., Fussell M., 1999. Improvement of tomato fruit quality by calcium nutrition. Acta Hort., 481., 463–468.

Jarosz Z., Dzida K., 2011. Effect of substratum and nutrient solution upon yielding and chemical composition of leaves and fruits of glasshouse tomato grown in prolonged cycle. Acta Sci. Pol., Hortorum Cultus, 10(3), 247–258.

Jarosz Z., Horodko K., 2004. Plonowanie i skład chemiczny pomidora szklarniowego uprawianego w podłożach inertnych. Rocz. AR Pozn., CCCLIV, Ogrodn. 37, 81–86.

Johansson Westholm L., 2006. Substrates for phosphorus removal – potential benefits for one-site wastewater treatment. Water Res., 40(1), 23–36.

Kleiber T., Komosa A., 2008. Comparsion dynamic of N, P, K, contents in different anthurium cultivars (*Anthurium cultorum* Birdsey) grown in expanded clay. Acta Sci. Pol., Hortorum Cultus, 7(4), 77–88.

Komosa A., 2002. Podłoża inertne – postęp czy inercja? Zesz. Probl. Post. Nauk Roln., 485, 147–167.

Kowalska I., Sady W., Szura A., 2006. Wpływ formy nawozu azotowego, dokarmiania dolistnego i miejsca uprawy na plonowanie i jakość sałaty. Acta Agrioph., 7(3), 619–631.

Markiewicz B., Golcz A., Politycka B., 2004. Effect of substrate utilization time on the yield of eggplant (*Solanum melongena* L.). Rocz. AR Pozn., CCCLVI, Ogrodn. 37, 153–157.

Meinken E., 1997. Accumulation of nutrients in expanded clay used for indoor plantings. Acta Hort., 450, 321–328.

Nurzyński J., 2006. Plonowanie i skład chemiczny pomidora uprawianego w szklarni w podłożach ekologicznych. Acta Agroph., 7(3), 681–690.

Nurzyński J., Jarosz Z., Michałojć Z., 2012. Yielding and chemical composition of greenhouse tomato fruit grown on straw or rockwool substrates. Acta Sci. Pol., Hortorum Cultus 11(3) 2012, 79–89.

Ostrowska A., Gawliński S., Szczubiałka Z., 1991. Metody analizy i oceny gleb i roślin. Instytut Ochrony Środowiska, Warszawa.

Pawlińska A., Komosa A., 2000. Plonowanie pomidora szklarniowego uprawianego w podłożach tradycyjnych i inertnych. VIII Konferencja Naukowa, „Efektywność stosowania nawozów w uprawach ogrodniczych. Zmiany ilościowe i jakościowe w warunkach stresu". Warszawa, 122–124.

Piróg J., 1998a. Plonowanie pomidora na różnych podłożach w drugim roku użytkowania. „Agrotechniczne, fizjologiczne i genetyczne czynniki wczesności plonowania roślin warzywnych", ART. Bydgoszcz, Zesz. Nauk. 215, Rolnictwo 42, 185–189.

Piróg J., 1998b. Plonowanie ogórka szklarniowego na podłożach mineralnych powtórnie użytkowanych. Zesz. Probl. Post. Nauk Roln., 461, 357–364.

PN-A-04019 1998. Oznaczanie zawartości witaminy C.

PN-90/A-75101/03. Oznaczanie zawartości suchej masy metodą wagową.

Rutkowska U., 1981. Wybrane metody badań składu i wartości odżywczej żywności. PZWL, Warszawa

Sonneveld C., Voogt W., 2009. Plant nutrition of greenhouse crops. Springer Dordrecht Heidelberg, London, New York.

Tantawy A.S., Abdel-Mawgout A.M.R., El-Nemr M.A., Chamoun Y., 2009. Alleviation of salinity effects on tomato plants by application of amino acids and growth regulators. Europ. J. Scien. Res., 30(3): 484–494.

Wierzbicka B., Kuskowska M., 2002. Wpływ wybranych czynników na zawartość witaminy C w warzywach. Acta Sci. Pol., Hortorum Cultus, 1(2), 49–57.

MOŻLIWOŚĆ POWTÓRNEGO WYKORZYSTANIA KERAMZYTU W SZKLARNIOWEJ UPRAWIE POMIDORA. CZĘŚĆ I. PLONOWANIE I SKŁAD CHEMICZNY OWOCÓW

Streszczenie. Jednym z rozwiązań umożliwiających ograniczenie kosztów uprawy pomidora w systemie bezglebowym jest ponowne wykorzystanie tego samego podłoża uprawowego. Keramzyt klasyfikowany jest jako podłoże inertne, czyli bierne chemicznie i biologicznie, chociaż niektóre badania wskazują na możliwość występowania w trakcie uprawy w tym podłożu sorpcji wymiennej i adsorpcji jonów. Badania przeprowadzone w latach 2007–2008 miały na celu określenie przydatności keramzytu będącego odpadem poprodukcyjnym w bezglebowej uprawie pomidora w cyklu wydłużonym. W badaniach zastosowano keramzyt nowy (I) jako kontrolę oraz keramzyt będący odpadem poprodukcyjnym z całosezonowej uprawy pomidora w następującym układzie: materiał odkażony chemicznie (II), materiał wypłukany w wodzie z usunięciem pozostałości starego systemu korzeniowego roślin i dodatkowo odkażony chemicznie (III) oraz materiał bez jakichkolwiek zabiegów modyfikujących (IV). Keramzyt był umieszczany w rękawach foliowych o objętości 12 dm^3 i formowany na kształt mat uprawowych. Uprawę prowadzono z wykorzystaniem kroplowego systemu nawożenia i nawadniania z zamkniętym obiegiem pożywki, bez recyrkulacji. Pod wszystkie rośliny dostarczano pożywkę w takiej samej ilości i o takim samym składzie. W badaniach stwierdzono najmniejszy plon ogólny (15,10 kg·roślina^{-1}) oraz handlowy (14,07 kg·roślina^{-1}) owoców pomidora przy uprawie w keramzycie powtórnie użytkowanym bez żadnych zabiegów modyfikujących (IV), natomiast istotnie większy przy uprawie w materiale wypłukanym i dodatkowo odkażonym chemicznie (III). Owoce o największej masie jednostkowej (150,8 g) zebrano z roślin uprawianych w keramzycie nowym (I) a istotnie mniejsze (138,6 g) z obiektów z podłożem powtórnie użytkowanym płukanym i jednocześnie odkażanym chemicznie (III). Najwięcej suchej masy (5,71%) oraz cukrów ogółem (3,08% św.m.) zawierały owoce pomidora rosnącego w keramzycie powtórnie użytkowanym po płukaniu i odkażaniu chemicznym (III) natomiast witaminy C (21,96 mg·100 g^{-1} św. m.), cynku (25,86 mg·kg^{-1} s.m.) i miedzi (6,10 mg·kg^{-1} s.m.) owoce pomidora uprawianego w podłożu nowym (I).

Słowa kluczowe: uprawa bezglebowa, podłoże powtórnie użytkowane, witamina C, cukry ogółem, zawartość składników w owocach

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