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The influence of additives to the peat substrate on the yielding and chemical composition of sweet pepper fruits (*Capsicum annuum* L.) grown in greenhouse

Wpływ dodatków do substratu torfowego na plon i skład chemiczny owoców papryki (*Capsicum annuum* L.) uprawianej w szklarni

Summary. The aim of this work was to determine the effect of using various additives to the substrate on the yield and quality of sweet pepper fruits grown in greenhouse. In the experiment four objects were used: 1) peat substrate (control object), 2) peat substrate with coconut fiber, 3) peat substrate with an addition of expanded keramzite, and 4) peat substrate with an addition of perlite. The experiment showed no significant effect of additives on the early, marketable and total yield of fruits and on the content of chlorophyll b. Beneficial effects of coconut fiber added to the substrate were found on the fruit quality: dry matter content, soluble sugar and L-ascorbic acid. The additive of perlite to the substrate had a significant effect on chlorophyll a and chlorophyll a : b ratio. Significant differences in the content of the analysed macroelements: Ca, K, Mg and P in fruits were found depending on the type of substrate used.

Key words: coconut fiber, keramzite, nutritional value, peat, perlite

INTRODUCTION

Red sweet pepper (*Capsicum annuum* L.) is one of the most popular vegetable worldwide, liked for its colour, taste, aroma, flavour and health-beneficial effects. Sweet pepper is well-known as a source of natural pigments (e.g. β-carotene), antioxidant properties, one of the highest content of ascorbic acid and phenolic compounds such as phenolic acids, flavonoids (e.g. quercetin) and flavones [Serrano *et al.* 2010, Kołton *et al.* 2011, Ahmed *et al.* 2014]. One of the most important and very popular change made in greenhouse production is modification of the substrate medium [Jarosz and Horodko 2004]. In sweet pepper greenhouse cultivation following inert substrates can be used with success: peat substrate, keramzite and perlite. They are mostly light, durable, low cost, sterile and easily absorb and release water. Their appropriate fraction of granules allow to control water and air conditions. Nowadays also organic substrate like coconut fiber (coconut coir) is day by day more popular. It is safe and environmentally friendly solution with very high water holding capacity. The additives differ in physical, chemical and biological properties, which may affect crop management and behaviour. It can significantly influence yield and quality of sweet pepper fruits in greenhouse cultivation [Del Amor and Gómez-López 2009, Jarosz *et al.* 2012].

The aim of the research work was to determine the effect of using various additives to the peat substrate on yield and quality of sweet pepper fruits.

MATERIAL AND METHODS

The study was carried out in 2010–2011 years in the greenhouse of Faculty of Biotechnology and Horticulture, University of Agriculture in Cracow, Poland (19°58'E, 50°04'N, 211 m a.s.l.). The experiment was established as a one-factor experiment, in a randomized complete block design. The study was laid out in four repetitions. Sweet pepper cultivar Yecla F1 (Syngenta Seeds) used in the experiment, is characterized as an early maturing, high yielding, with intense and uniform coloured fruits and long post-harvest life of fruits. It is recommended for greenhouse cultivation. In the experiment four objects with various additives to the peat substrate were used: 1) peat substrate (control); 2) peat substrate with coconut fiber in ratio 1 : 1; 3) peat substrate with the addition of keramzite in ratio 2 : 1 and 4) peat substrate with the addition of perlite in the following ratio 2 : 1. The seeds were sown in the greenhouse on 23th February 2010 and 2011 in seed-boxes, containing peat substrate and placed in a controlled environment: temperature 26–28°C and RH 80–90%. After emergences, temperature was maintained at 23 ± 3°C (day) and 20 ± 2°C (night), RH at 80%. At the beginning transplants were overhead supplementary lighted for 6 h per day, during growth of plants the time was shorten. Transplants with expanded the first true leaf were pricked out into plastic pots Ø 10 cm, filled with peat substrate. In the beginning of April uniform plants with 8–9 leaves were transplanted into plastic containers Ø 20 cm, 18 cm high. It was respectively 72 plastic containers filled with peat substrate with appropriate additives. The containers were placed directly on the production surface in a spacing of 80 × 30 cm. The experimental unit was 18 plants (first 2 plants from the unit were treated like marginal belts) on an area of 4.32 m^2. Plants were led with strings tied to transversal wires 2.5 m above ground. Typical procedures for sweet pepper greenhouse cultivation were carried out, i.e. pruning to two shoots with leaving on every node 1 fruit set and 2 leaves. The fertilizer application rate was based on typical recommendations. Every 7 days plants were fertilized with calcium nitrate and NPK fertilizer (Superba Red) with microelements in dose 15 + 10 g per plant. Fully matured sweet paper fruits were harvested from end of July till the beginning of November, for 10 weeks. The first two harvests were treated as an early yield. Fruits were sorted into two classes according to the Agricultural Quality Standard Unece for Sweet pepper (Unece 2010). In the time of fully fruiting laboratory analyses were performed by examining the content of the fruit dry matter (oven-dry method by Pijanowski), soluble sugars (by using the anthrone method), L-ascorbic acid (determined with Tillman's method) and some of the macroelements: K, Ca, Mg (using the Pinta method – AAS Varian Spectr AA-20 spectrophotometer) and P (using the colorimetric method – Helios ß spectrophotometer), chlorophyll a, chlorophyll b, carotenoids (acc. to the Lichtenthaller method). The presented results were given as means from the two-year experiment 2010–2011. All data were subjected to the analysis of variance ANOVA in the program STATISTICA 10.1. The significance of differences was estimated with the use of Fisher's LSD test with p = 0.05.

RESULTS AND DISCUSSION

Although using all types of additives caused a tendency to decrease a marketable and total yield, there was no significant effect stated (Tab. 1). No significant effect on sweet pepper yield can be caused by large cyclic fluctuations in fruit set during sweet pepper production, even under controlled and constant climate conditions [Heuvelink and Korner 2001, Del Amor and Gómez-López 2009]. Jarosz and Horodko [2004] in greenhouse tomato cultivation in inert media: perlite, keramzite and rockwool also showed no significant effect on the marketable and total yield of tomato fruits. Pawlińska and Komosa [2004] obtained significant differences in yield of tomato fruits grown in rockwool, sawdust, mixture of peat with bark and keramzite. The lowest total yield of tomato fruits was from plants grown in keramzite. By contrast to demonstrated results, Del Amor and Gómez-López [2009] pointed out that from coconut coir dust yield of sweet pepper fruits was the highest. In another experiment by Jarosz *et al.* [2012] in greenhouse tomato cultivation with reused keramzite, all types of substrate caused a significant differences in yield of tomato.

Table 1. Yield parameters of sweet pepper (means for 2010–2011)
Tabela 1. Parametry plonu owoców papryki (średnie dla lat 2010–2011)

Object Obiekt	Early yield Plon wczesny ($kg \cdot m^{-2}$)	Marketable yield Plon handlowy ($kg \cdot m^{-2}$)	Total yield Plon całkowity ($kg \cdot m^{-2}$)
PS	1.79 a*	4.11 a	4.47 a
PS+C	1.82 a	3.85 a	4.07 a
PS+K	1.62 a	3.66 a	3.87 a
PS+P	1.92 a	4.06 a	4.30 a

PS – peat substrate/ substrat torfowy
PS+C – peat substrate with coconut fiber/ substrat torfowy z dodatkiem włókna kokosowego
PS+K – peat substrate with keramzite/ substrat torfowy z dodatkiem keramzytu
PS+P – peat substrate with perlite/ substrat torfowy z dodatkiem perlitu
* Values sharing same letter(s) in each column do not differ at p < 0.05 according to LSD test/ Wartości oznaczone tą samą literą nie różnią się statystycznie

Analysis of the early and total yield structure (Fig. 1) showed that the share of class I fruits was the highest 84.47 and 77.12%, respectively, in the object with clay aggregate. The second group of fruits was those in class II which the highest share was 20.44 and 19.00% from plants grown with additive of coconut fiber. The highest non-marketable yield was obtained from control plants grown only in the peat substrate: 10.02 and 8.28%, respectively, in early and total yield. In the opinion of Jarosz *et al.* [2012], such a high percentage of marketable yield in total yield is an argument of a high usefulness of these additives to the substrate. Del Amor and Gómez-López [2009] noted, that higher marketable yield from sweet pepper plants grown on the coconut coir dust can be connected with higher water availability in this substrate, because sweet pepper plants are very sensitive to the lack of water during flowering and fruit development, what confirms results obtained in this experiment.

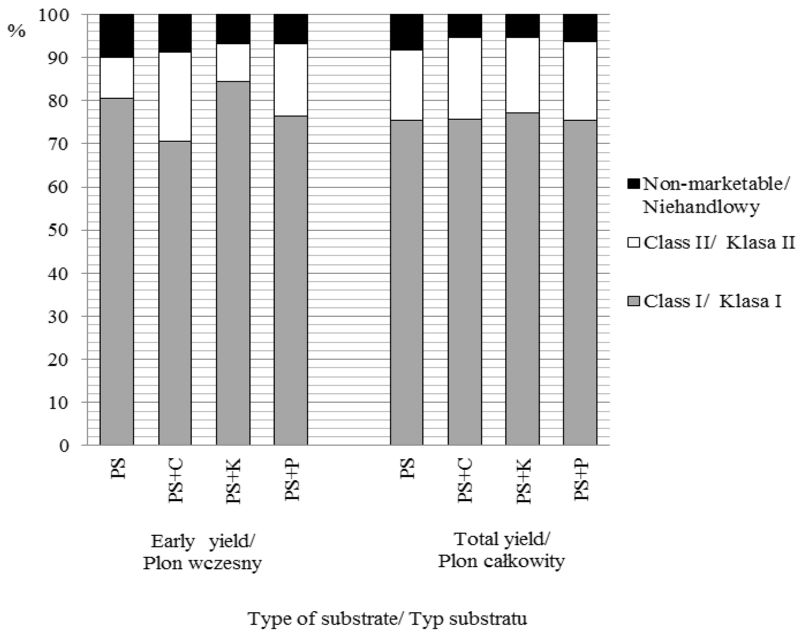

Fig 1. Structure of early and total yield of sweet pepper depending on type of substrate
Rys. 1. Struktura plonu ogólnego i wczesnego papryki w zależności od dodatku do substratu torfowego

Explanation – see Tab. 1/ Objaśnienia – zob. tab. 1

Using a different types of substrate had a significant effect on the dry matter, soluble sugar, L-ascorbic acid content in sweet pepper fruits (Tab. 2). The content of dry matter ranged from 9.15 to 9.58% FW, soluble sugar 3.91–4.25% FW, and L-ascorbic acid 152.0–158.1 mg·100 g^{-1} FW. The highest dry matter and L-ascorbic acid content was shown in object with additive of coconut fiber. Significantly higher amount of soluble sugar (4.21 and 4.25% FW) was observed in fruits from plants cultivated in peat substrate with coconut fiber and perlite. In an experiment carried out by Buczkowska and Michałojć [2012] results on the dry matter and L-ascorbic acid content in sweet pepper fruits grown in greenhouse were higher 10.50% FW and 178.62 mg·100 g^{-1} FW respectively, than showed in this experiment. Kołton *et al.* [2011] noted similar content of dry matter 9.64% FW, but higher content of L-ascorbic acid 186.4 mg·100 g^{-1} FW and soluble sugar 5.77% FW in red sweet pepper fruits grown on rockwool in plastic tunnel.

Table 2. Content of chosen chemical compounds in sweet pepper fruits (means for 2010–2011)
Tabela 2. Zawartość wybranych składników chemicznych w owocach papryki (średnie dla lat 2010–2011)

Object Obiekt	Dry matter Sucha masa	Soluble sugars Cukry rozpuszczalne	L-ascorbic acid Kwas L-askorbinowy	K	Ca	Mg	P
	% FW/s.m.		mg·100 g^{-1} FW/s.m.				
PS	9.37 b	3.98 a	153.1 a	229.34 b	9.57 b	14.30 b	27.16 b
PS+C	9.58 c	4.21 b	158.1 b	235.61 b	10.10 b	12.93 ab	28.03 b
PS+K	9.15 a	3.91 a	154.1 a	215.70 a	9.40 ab	12.79 ab	25.54 a
PS+P	9.43 b	4.25 b	152.0 a	227.81 b	8.32 a	11.65 a	24.85 a

Explanations – see Tab. 1 / Objaśnienia – zob. tab. 1

Significant differences in the content of all analysed macroelements: were found (Tab. 2). Sweet pepper fruits from plants grown in the substrate with additive of keramzite contained significantly less potassium 215.70 mg·100 g^{-1} FW. Calcium content in the fruits of sweet pepper significantly depended on the substrate type, as its content was higher in the fruits of control plants (9.57 mg·100 g^{-1} FW) and grown in peat substrate with coconut fiber (10.10 mg·100 g^{-1} FW) as compared to the fruits obtained from plants grown in peat substrate with additive of perlite. In respect to magnesium content, control fruits (14.30 mg·100 g^{-1} FW) differed significantly from the fruits of plants grown in peat substrate with perlite (11.65 mg·100 g^{-1} FW). Type of substrate had a significant effect on the phosphorus content in sweet pepper fruits. Its contents were higher in fruits of control plants grown only in peat substrate (27.16 mg·100 g^{-1} FW) and peat substrate with coconut fibre (28.03 mg·100g^{-1} FW). In research by Jarosz and Dzida [2005] phosphorus and potassium content in tomato fruits was higher from plants grown in perlite, what it opposite to results of our research. According to Charlo de O *et al.* [2012] sweet pepper showed the greatest requirement of P during fruiting and the organs that accumulated the most phosphorus (0.82 g $plant^{-1}$) were mature fruits. It can be related to the coconut fiber that shows better efficiency of utilization of nutrients.

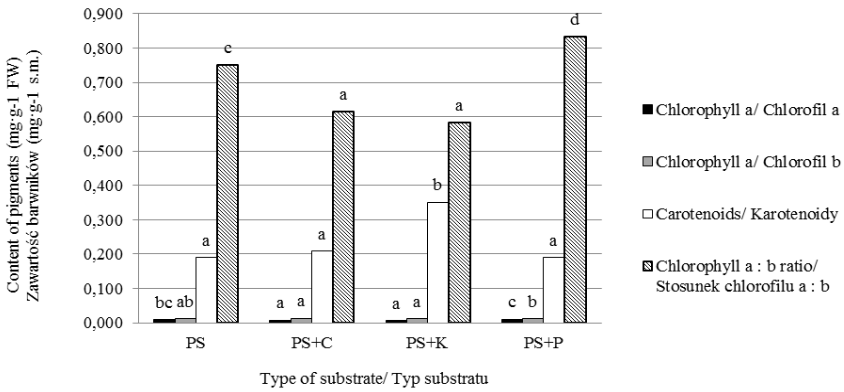

Fig 2. Content of chlorophyll a, b and carotenoids in sweet pepper fruits
Rys. 2. Zawartość chlorofilu a, b i karotenoidów w owocach papryki
Explanation – see Tab. 1/ Objaśnienia – zob. tab. 1

Statistical analysis showed significant effect of additives to the substrate on chlorophyll a and carotenoids accumulation in sweet pepper fruits (Fig. 2). The fruits from plants cultivated in substrate with perlite accumulated more chlorophyll a (0.01 $mg \cdot g^{-1}$ FW) and from plants grown with additive of keramzite accumulated more carotenoids (0.35 $mg \cdot g^{-1}$ FW). The content of chlorophyll b was unaffected by type of substrate. Significant relationships were found between chlorophyll a : b ratio and type of used substrate. Distinctly the highest chlorophyll a : b ratio was found in fruits from plants grown with additive of perlite (0.83). Similar results were reported by Deepa *et al.* [2007], where the total content of carotenoids was noted from 0.34 to 3.28 $mg \cdot 100\ g^{-1}$ FW. Results shown by Jarosz *et al.* [2012] suggest that expanded clay is characterized by sorptive capacity in relation to cations and the phosphate adsorption capacity, what can affect fruit yield and chemical composition, like in this case.

CONCLUSIONS

1. There was no significant effects all types of additives on marketable and total yield, but it was shown a tendency to decrease their values.

2. It was stated that in the early and total yield structure share of class I fruits was the highest (84.47 and 77.12%) in the object with clay aggregate.

3. The highest non-marketable yield was observed from control plants (10.02 and 8.28%).

4. The highest dry matter (9,58% FW) and L-ascorbic acid content (158,1 $mg \cdot 100g^{-1}$ FW) was shown in object with additive of coconut fiber and the lowest potassium content was (215.70 $mg \cdot 100\ g^{-1}$ FW) in the fruits from substrate with additive of expanded keramzite.

5. More chlorophyll a and carotenoids (0.01 $mg \cdot g^{-1}$ FW and 0.35 $mg \cdot g^{-1}$ FW) had fruits from plants cultivated in substrate with perlite and keramzite, respectively. The content of chlorophyll b was unaffected by type of substrate.

6. The highest chlorophyll a : b ratio was found in fruits from plants grown with additive of perlite (0.83).

REFERENCES

Ahmed W., Yaseen M., Arshad M., Shahis M. 2014. Effect of polyethylene coated calcium carbide on physiology, photosynthesis, growth and yield of sweet pepper. Pak. J. Agri. Sci. 51, 59–65.

Buczkowska H., Michałojć Z. 2012. Comparison of qualitative traits, biological value, chemical compounds of sweet pepper fruit. J. Elem. 3, 367–377.

Charlo de O H.C., De Oliveira S.F., Vargas P.F., Castoldi R., Barbosa J.C., Braz L.T. 2012. Accumulation of nutrients in sweet peppers cultivated in coconut fiber. Hortic. Bras. 30, 125–131.

Deepa N., Kaur C., George B., Singh B., Kapoor H.C. 2007. Antioxidant constituents in some sweet pepper (*Capscicum annuum* L.) genotypes during maturity. LWT-Food Sci. Technol. 40, 121–129.

Del Amor F.M., Gómez-López M.D. 2009. Agronomical response and water use efficiency of sweet pepper plants grown in different greenhouse substrates. HortScience 44, 810–814.

Heuvelink E., Korner O. 2001. Parthenocarpic fruit growth reduces yield fluctuation and blossom-end rot in sweet pepper. Ann. Bot. 88, 69–74.

Jarosz Z., Dzida K. 2005. Wpływ podłoży inertnych na plonowanie i skład chemiczny owoców pomidora uprawianego w szklarni. Annales UMCS, sec. EEE, Horticultura 15, 59–64.

Jarosz Z., Horodko K. 2004. Plonowanie i skład chemiczny pomidora szklarniowego uprawianego w podłożach inertnych. Rocz. AR Pozn. 356, Ogrodnictwo 37, 81–86.

Jarosz Z., Dzida K., Nurzyńska-Wierdak R. 2012. Possibility of reusing expanded clay in greenhouse tomato cultivation. Part I. Yield and chemical composition of fruits. Acta Sci. Pol., Hortorum Cultus 11, 119–130.

Kołton A., Wojciechowska R., Leja M. 2011. Effect of maturity stage and short-term storage on the biological quality of sweet pepper fruits. Veget. Crops Res. Bull. 74, 143–152.

Pawlińska A., Komosa A. 2004. Wpływ podłoży i pożywek na plonowanie pomidora szklarniowego. Rocz. AR Pozn. 356, Ogrodnictwo 37, 173–180.

Serrano M., Zapata P.J., Castillo S., Guillén F., Romero D.M., Valero D. 2010. Antioxidant and nutritive constituents during sweet pepper development and ripening are enhanced by nitrophenolate treatments. Food Chem. 118, 497–503.

United Nations Economic Commission For Europe 2010. UNECE Standard FFV-28 concerning the marketing and commercial quality control of sweet peppers. New York–Geneva (available online with updates at www.unece.org, 21.07.2016).

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Streszczenie. Celem pracy było określenie wpływu różnych dodatków do substratu torfowego na plon i wybrane parametry jakościowe owoców papryki uprawianej w szklarni. Zastosowano cztery kombinacje: 1) substrat torfowy (obiekt kontrolny); 2) substrat torfowy z dodatkiem włókna kokosowego; 3) substrat torfowy z dodatkiem keramzytu; 4) substrat torfowy z dodatkiem perlitu. Doświadczenie wykazało brak wpływu dodatków do podłoża na plon wczesny, handlowy oraz całkowity, a także na zawartość chlorofilu b. Zaobserwowano korzystny wpływ dodatku włókna kokosowego na zawartość suchej masy, cukrów rozpuszczalnych oraz kwasu L-askorbinowego. Dodatek perlitu znacząco wpływał na zawartość chlorofilu a oraz na stosunek chlorofilu a : b. Wykazano statystycznie istotne różnice w zawartości analizowanych makroelementów (Ca, K, Mg, P) w owocach, zależne od zastosowanego podłoża.

Słowa kluczowe: włókno kokosowe, keramzyt, wartość odżywcza, substrat torfowy, perlit

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