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Hydroponic pepper growing on baked clay pellets

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Summary: Nowadays one of the most important issues of greenhouse vegetable production in soilless media is the protection of the environment, in particular, the selection of the root medium to be applied. The objective of the trial was to test the applicability of baked (expanded) clay granules in hydroponic pepper growing with special respect to the growing pot (plastic tubes and buckets with bottom and lateral holes). From the result of the experiment it can be concluded that baked clay pellets, similarly to rockwool, are a suitable medium for providing root anchorage for pepper, however, it is necessary to examine some technological issues (e.g. fertilization, irrigation) prior to starting a large scale commercial cultivation. Relative to the three growing containers tested, it can be concluded that with the 4-8 mm crushed clay pebbles cultivation can be carried out successfully both in the white plastic tube and in the bucket, with the latter it is recommended to locate the drainage holes on the side of the growing container (at 6 cm from the bottom of the bucket).

Key words: *baked clay granule, rockwool, plastic tube, bucket (container)*

Introduction

For horticultural farms producing greenhouse vegetables one of the possible methods to prevent soil sickness is soilless cultivation whereby plants are grown not in the original soil of the greenhouse (*Terbe*, 1999). One of the most important demands to 'artificial' root media that they should contain no harmful materials (*Stefanovits-Bányai* et al, 1998), should not influence the composition of the nutrient solution applied, should ensure the necessary environmental conditions for roots (first of all, the proper air:water ratio) and should preserve these favorable characteristics possibly in a uniform manner all through the growing season (*Kovács*, 2000).

As a result of the headway of environment conscious thinking, growers must probably choose between two alternatives in the long term: the utilization of materials with continuously renewing stocks (e.g. coconut coir) or the repeated application of the same reusable media.

Researchers have been looking for suitable media for decades (pl. *Hargitai & Nagy,* 1971*; Andreas,* 1993) and investigations keep involving an ever greater number of materials nowadays (*Tompos & Gyúrós,* 2005*; Jakusné & Forró,* 2005).

As coconut coir does not occur in substantial amounts in Hungary nor any other similar environmental friendly material (and at present in no other places in Europe) due to high transport and other logistical costs this alternative goes beyond the possibilities of the majority of vegetable producing horticultural growers. Therefore it is expected that an ever greater attention will be directed to reusable media.

Imre conducted a trial in the early 1990s with the pepper variety HRF F1 in a soilless system, using zeolite and clay pellets for root media and a peat-base soil mix as the control. From his result he concluded that all the media tested were suitable for production purposes if setting up an adequate fertigation system. He received similar results in the experiment conducted with the pepper variety 'Mazurka' in which he compared the effect of rockwool, perlite and duroplast foam (*Imre*, 1994).

The trials on baked (expanded) clay granules, which are becoming ever more widely used in construction industry, were started in 2003 and in the first two years we determined the applicability of the medium relative to various vegetables (green pepper, tomato, egg plant, cucumber). In 2005 the trial was continued with the more detailed elaboration of hydroponic pepper growing on baked clay pellets. The objective of the trial was to study the technological aspects of the application of baked clay pellets in hydroponic pepper growing, with special respect to the growing container (plastic tubes and buckets with bottom and side holes).

Materials and methods

The trial was set up in Filclair type plastic tunnels under unheated conditions at the Experimental Farm of the Faculty of Horticulture.

The following treatments were applied:

A1 H4/8KK clay pellets (4-8 mm fraction, crushed round pebbles) in plastic tubes (5 liters substrate/plant)

A2 H4/8KK clay pellets (4-8 mm fraction, crushed round pebbles) in buckets with holes drilled on the bottom (10 liters substrate/plant)

A3 H4/8KK clay pellets (4-8 mm fraction, crushed round pebbles) provided with holes drilled on the side wall (10 liters substrate/plant)

A4 H4/8KK rockwool slabs (1 m) in plastic tubes (5 liters substrate/plant)

Four parallel replicates were applied with each treatment

The major technological data of the trial are summarized in *Table 1*.

Table 1. Major technological data of the trial (2005, Budapest)

Variety			Hó F1 (indeterminate shoot growth)
Sowing	Date		09.02.2005
	Place		Rockwool seed cubes
Pricking out	Date		01.03.2005
	Place		Rockwool seedling cubes
Transplanting	Date		07.04.2005
Planting pattern			90+60x33 cm
Pruning method			2 stems
Picking	date	First	02.06.2005
		last	06.10.2005
	Number	11	

In the treatment A1 i.e. containing clay pellets, the white plastic tubes used for encasing the rockwool slabs were filled with 15 liters of clay pellets. In order to allow drainage water to flow away, openings were cut in the case of the rockwool slabs at the lowest part of the plastic cover, while in the case of the clay pellet treatments at 2 cm higher.

In the treatments A2 and A3 the dark gray buckets were perforated in accordance with the treatments, 6 holes of 5 mm in diameter were drilled on the bottom of the buckets (A2) and on the side at 6 cm from the bottom (A3), equally spaced on a circle. In May, in order to prevent the root medium from getting warmed up in an excessive degree, a white plastic mantle was pulled round the walls of the buckets.

For nutrient applications, we utilized the recipe and nutrient solution concentration recommended for pepper production on rockwool, through drip irrigation.

Measurements and analyses

Plant development and fruit yield were determined by measuring the characteristics typical to green pepper. Since it is fruit quantity and quality that are the most important in production, therefore the observation of these characteristics was more focused on.

Accordingly, the following characteristics were measured or calculated:

Vegetative growth: plant height from the upper level of the rockwool slab to the longer shoot was measured every 4 weeks, 5 times, altogether (9th June, 5th July, 4th August, 1th September, 28th September).

Generative characteristics: at each picking the fruits were sorted into quality categories, in conformity with market requirements. This way the following weight classes were formed:

- healthy fruits weighing over 100 g
- healthy fruits of 80–100 grams
- healthy fruits of 60–80 grams
- healthy fruits of 40–60 grams
- substandard and tiny fruits (including the strongly deformed or blotched ones, mainly with Ca deficiency, and the ones under 40 grams).

When selling the fruits on the market in the case of the tested 'Hó F1' variety, these categories correspond to the following classes: Extra (>100 g), 1st class (80–100 g), 2nd class (60–80 g), 3rd class (40–60 g).

Picking frequency, in accordance with the production practice, was such as to conform to the dynamics of plant development as well as to pre-harvest intervals of pesticide sprayings. Fruits were picked at the stage of so-called commercial maturity.

At harvesting, the fruits were collected together and their individual weights were measured. Having produced data lines with the cumulated values, we analyzed the values of fruit yield per square meter (pieces, kg) with the passage of time. From the quantity of the fruits picked at the first 5 harvest (prior to 27th July, 2005), we determined the value of early fruit yield.

The management and the primary processing of the data from the measurements was carried out with the help of the programs Microsoft Excel 2000 SR^{-1} and Microsoft Access 2000 SR^{-1}. The program MiniStat 3.3 was used in the statistical analyses. The comparison of the treatments, as it was not possible to test the normal distribution with the majority of the parameters considering the dimensions of the experiment (4 treatments, 4 repetitions), begun with variance analyses (O'Brien's Test, Levene's Test) not requiring normality and depending on the result obtained either the F test or robust methods (James-, Welch-, Brown-Forsythe Test) were used for global comparison. The analysis of the treatments in pairs was carried out with the so-called Tukey-Kramer method in the case of equal variances and with the Games-Howell method in the case of unequal variances (*Sváb*, 1981; *Vargha*, 2000).

Results

The results from the measurements relative to plant growth (height) are illustrated in *Figure 1*. The longest shoots were developed by the plants grown in the treatments A3 and A4, apart from the first time of measurement, though each individual plant in the trial showed a dynamic growth during the growing season and due to the smallness of the differences the statistical analyses did not reveal any difference between the treatments.

Fruit yield values are shown in *Table 2*, as well as in *Figures 2–3*.

It was the treatment A4 (rockwool) that proved to be the most favorable both in terms of total and early fruit yield, considering

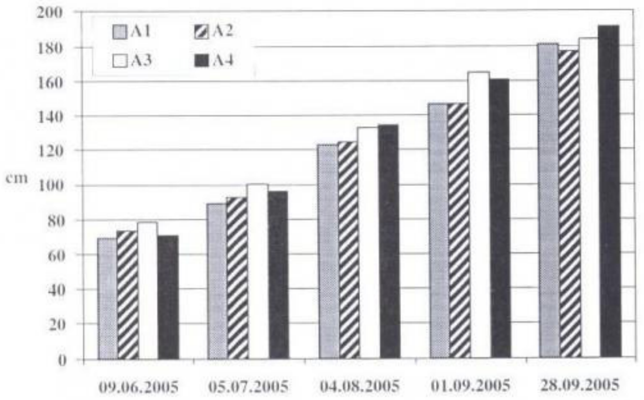

Figure 1. Change in plant height during the growing season (2005, Soroksár)

Table 2. Fruit yield of pepper (2005, Soroksár)

Treatment	Total	Early (first 5 pickings)	Extra + 1st class.	Substandard
Fruit yield (kg/m²)				
A1	16.00 ab	7.52 ab	9.56 ab	0.35 a
A2	13.67 a	6.54 a	8.65 a	0.17 a
A3	15.36 ab	7.53 ab	9.57 ab	0.27 a
A4	17.84 a	8.79 a	11.97 a	0.42 a
Fruit number (fruits/m²)				
A1	197.64 a	91.25 ab	95.96 ab	6.73 a
A2	166.41 a	78.28 a	85.61 a	4.80 a
A3	188.38 a	90.66 ab	94.70 ab	5.81 a
A4	209.43 a	97.31 a	115.15 a	8.42 a

Note: identical letters placed beside the averages designate (column by column) the treatments that are identical at the 95% probability level according to our statistical calculations

either the weight of the fruits or the number of the fruits, while the treatment A1 (filled tube) for the plants grown in clay pellets. The plants grown in buckets had higher fruit quantities when the buckets were provided with lateral holes. According to our statistical analyses in terms of total fruit yield and in terms of early fruit yield and fruit number, the plants grown in the buckets with bottom holes (A2) produced less fruit at the 95% reliability level compared to the plants grown in rockwool, but no evident difference was detectable between the three clay pellet treatments. A similar tendency was seen in total fruit number, on the other hand, the difference between the above mentioned two treatments was observable only at the 90% reliability level.

Considering the weight and number of the extra class fruits and the 1st class fruits, our results confirmed those tendencies formerly experienced in connection with the analysis of total fruit yield. Rockwool proved to be the most favorable treatment again and the plants grown in the buckets with bottom holes gave the poorest result. This was also confirmed by our statistical analyses.

Considering the change of fruit yields with time (*Figures 2–3*), it can be seen that the graphs indicated the same tendency all through the growing season.

Considering the qualitative distribution of the fruits (*Figure 4*), it can be observed that the greatest proportion of extra and 1st class fruits was harvested from the plots with the rockwool treatment A4. The highest number of substandard fruits (tiny or blotched) relative to total fruit

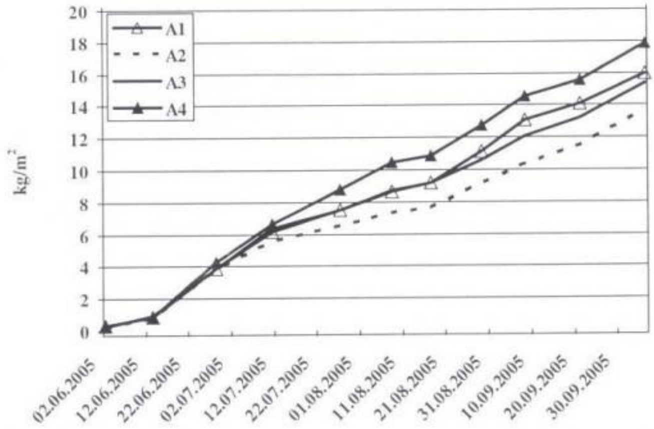

Figure 2. Change of fruit yields during the growing season (2005, Soroksár)

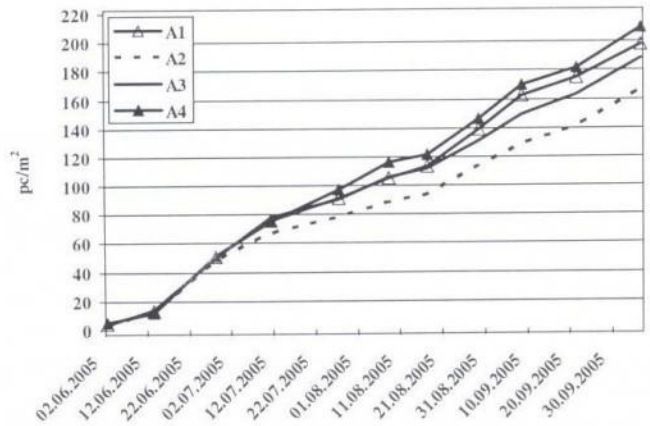

Figure 3. Change of fruit during the growing season (2005, Soroksár)

yield was picked from the plants grown in rockwool, but within the fruit yield, the proportion of this fraction did not exceed 2.5 %, and expressed in the percentage total fruit number, the figure was only 4%. Relative to the quantity of substandard fruits, our statistical tests did not reveal any difference between the treatments.

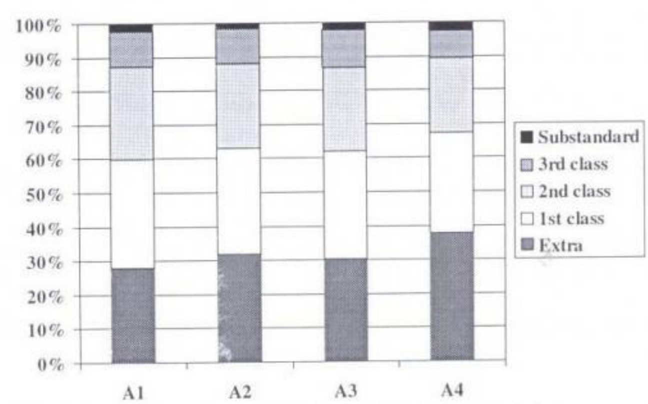

Figure 4. Qualitative distribution of fruit yield (2005, Soroksár

Conclusions

From the result of the experiment it can be concluded that baked clay pellets, similarly to rockwool, are a suitable medium for providing root anchorage for pepper, however, it is necessary to examine some technological issues (e.g. fertilization, irrigation) prior to starting a large scale commercial cultivation. Relative to the three growing containers tested, it can be concluded that with the 4-8 mm crushed clay pebbles cultivation can be carried out successfully both in the white plastic tube and in the bucket, with the latter it is recommended to locate the drainage holes on the side of the growing container (at 6 cm from the bottom of the bucket).

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