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THE EFFECT OF DIFFERENT SUBSTRATES ON THE QUALITY OF F. CARMELLO TOMATOES (LYCOPERSICON ESCULLENTUM MILL) GROWN UNDER PROTECTION IN A HYDROPONIC SYSTEM

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Abstract : F. Carmello GC 204 tomato plants (Lycopersicum esculentum Mill) were cultivated on five substrates (rockwool, perlite, and mixtures of perlite to zeolite 1:1, 1;2 and 2:1) in an open soilless culture system to determine the fruit quality responses. Differences in yield and fruit quality were observed among the five substrates used, with the highest performance obtained by the mixture of perlite to zeolite 2:1 followed by perlite. While EC was not significantly affected by the substrates type, the tomatoes grown on perlite:zeolite 2:1 had the best distribution of better sized fruit, the highest soluble solids content as well as the best sensorial quality, however, the highest total dry matter was found with the fruits coming from perlite culture.

INTRODUCTION

The trend of present day horticultural production of tomatoes is to be based entirely on artificial substrates rather than in soil which was the common practice up to fifteen years ago (Wilson, 1986). The occurrence of soil limiting factors has emphasized the interest in soilless culture and the demand for a suitable technology adapted to the Mediterranean conditions characterized by poor water quality and availability, simple greenhouse installations, and reasonable investment ability (Martinez and Abad, 1992). The possibility of using different substrates materials, which are locally available and less costly than those imported, with no pollution limitations, but adequate physical and chemical properties could lead toward a solution to the above problems (Blanc, 1981; Smith, 1987; Verdonck, 1975). The selection of a particular material depends on its aveability, cost, and local experience of its use (Klougart, 1983; Verdonck et al., 198 1; Verdonck et al., 1983).

The objective of this work was to examine the effect of different substrates: perlite, perlite to zeolite mixtures, 1: 1, 1:2, and 2: 1, as well as rockwool on the yield and quality of Carmello of tomatoes.

MATERIAL AND METHODS

Tomato seeds (Lycopersicon esculentum Mill), cultivar Carmello FI-hybrid, a late cultivar with determinate growth, were sown in 21110195. Tomato seedlings were transplanted (on 30/12195, at 9 true leaves) into white polyethylene bags (2m in length and 30 cm in diameter), covered with coextruded black and white polyethylene film (for protection from sun rays), containing 80 L of substrate (10 L per plant, 8 plants per bag): perlite (particle size of 3-5mm), zeolite (particle size of 2-5mm), their 1:1, 2:1 and 1:2 mixtures (P/Z). Seedlings were also transplanted into rockwool slabs (90 cm long, 15 cm wide and 7.5 cm thick). Thirty-two bags were used, i.e. 8 for each substrate type. The plants were placed in single rows perpendicularly to greenhouse orientation, within spacing of 1.20 m between rows. The plants on the row were separated 20cm. A randomized complete block design with four replications was employed. The experiment took place from Oct. 95 to May 96. Plants were decapitated at two leaves above the 6th flower cluster in 28/3196.

The experiment was installed in a heated double-span glasshouse located at the Mediterranean Agronomic Institute of Chania, Crete-Greece, covered with black plastic mulch to eliminate the evaporation effect of the ground level, to avoid substrate contamination and prevent growth of weeds. The greenhouse was heated from January 1st to end of April by warm water circulation in a pipe network placed at the ground level around the substrate bags. The greenhouse was shaded from the middle of May until September, using white powder.

Fertigation was applied 8-16 times daily for 60sec using drippers of 21/hr capacity. Nutrient solution, prepared in a $1m^3$ tank, was applied through the irrigation system and contained the following concentration of nutrients: $N0_3^-$=13 mmol/l; $H_2PO_4^-$=2.1 mmol/l; $S0_4^{-2}$ = 1.7 mmol/l; NH_4^+=2.3 mmolil; K^+ =9.2 mmol/l; Ca^{++} =5.2 mmol/l; Mg^{++}=1.7 mmol/l, Fe=25 μmol/l; Mn=15 μmol/l; Zn=4 μmol/l; B=20 μmol/l; Cu=0.5 μmol/l; Mo=0.5 μmol/l. The electrical conductivity (EC) of the nutrient solution was 3 mScm-1 and the pH was maintained at 5.5 to 6 by nitric acid.

The fruits were harvested at the orange stage and conserved 5 days at ambient temperature of 18-20'C to reach the red ripening stage at which the fruit quality analysis was performed. Dry matter, soluble solids content (SSC), pH, electrical conductivity (EC) and titratable acidity (TA) were measured. additionally, the fruits were sorted into five size grades according to fruit diameter: class I: 77-78mm, class II:67-77mm, class III: 57 67mm., class IV: 47-57, class V: < 47mm.

Besides the fruit analysis, a sensory evaluation panel test (evaluation of parameters by scale from 1: Very bad, 2: Bad, 3. Indifferent, 4. Fair, 5- Pleasant, 6- Good, 7- Very good) was also performed to take the subjective evaluation of people about the quality parameters of fruits produced in the different substrates.

The analysis of variance was performed by a SAS package. The Duncan's multiple range test and LSD were applied to compare means.

RESULTS AND DISCUSSION

Plants showed a good growth in all treatments. No visual symptoms of nutrient disorders or water stress were recorded. The first ripe fruits were harvested on the second week of April.

Plant, grown on perlite or on 2:1P/Z mixture had the highest yield (about 8 kg/m^2) followed by perlite (Fig. 1). Martinez and Abad (1992), growing tomato in a variety of substrates, found that plants grown on perlite had the highest yield (about 11 kg/m^2) followed by rockwool. Such a difference in yield could be attributed to the higher density used in our experiment as well as to the exceptionally unfavorable weather conditions (light and temperature) recorded during the cultivation. Total production of rockwool, mixture 1:1 and 1:2 were lower compared to the production obtained from perlite and mixture 2:1 (Fig 1.).

The substrates used also exerted a similar effect on the distribution of fruit size. Perlite and i-nix 2:1 had the better distribution, of fruits whereas mixture 1-1, 1:2, and rockwool have smaller fruits (Fig. 2.).

Perlite has been reported to have excellent performance when used as a substrates in hydroponic culture, probably by offering a higher rate of water uptake by the crop, more efficient water use, and topped by the economy of reusing the substrates for more than one crop growing cycle (Hall et al., 1988). However, best yield was obtained with the mixture 2:1 P/Z, while perlite performed the second, probably due to the additive positive effects of zeolite. Zeolite characterized by its high cation exchange capacity (130 meq/100gr) resulting in storage and availability of nutrients, as well as of the possibility of improved water management.

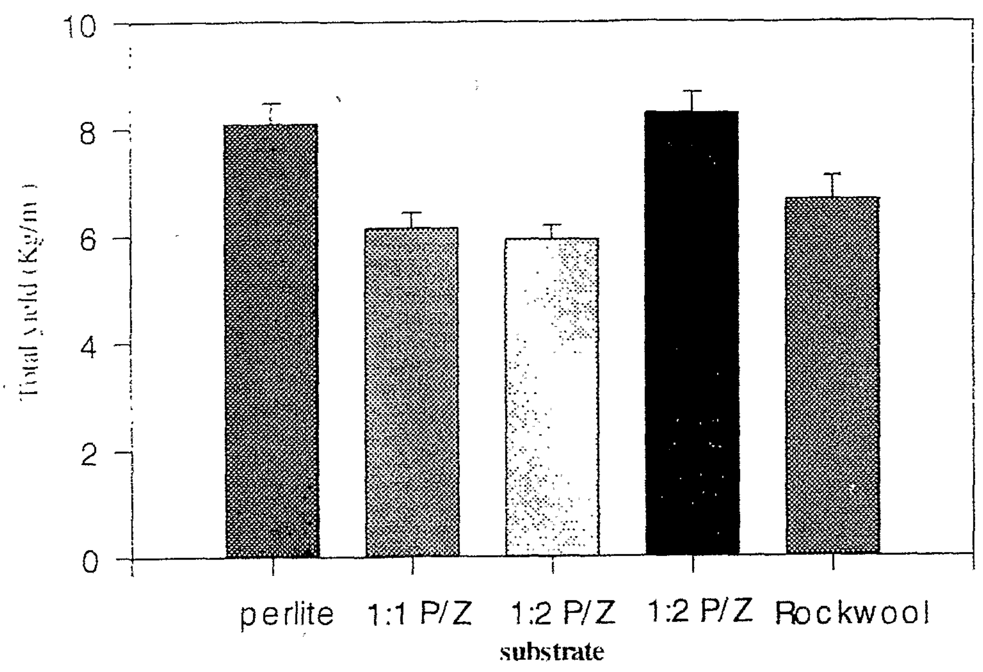

Fig.1. Total yield of tomatoes grown hydroponically on five different substrates

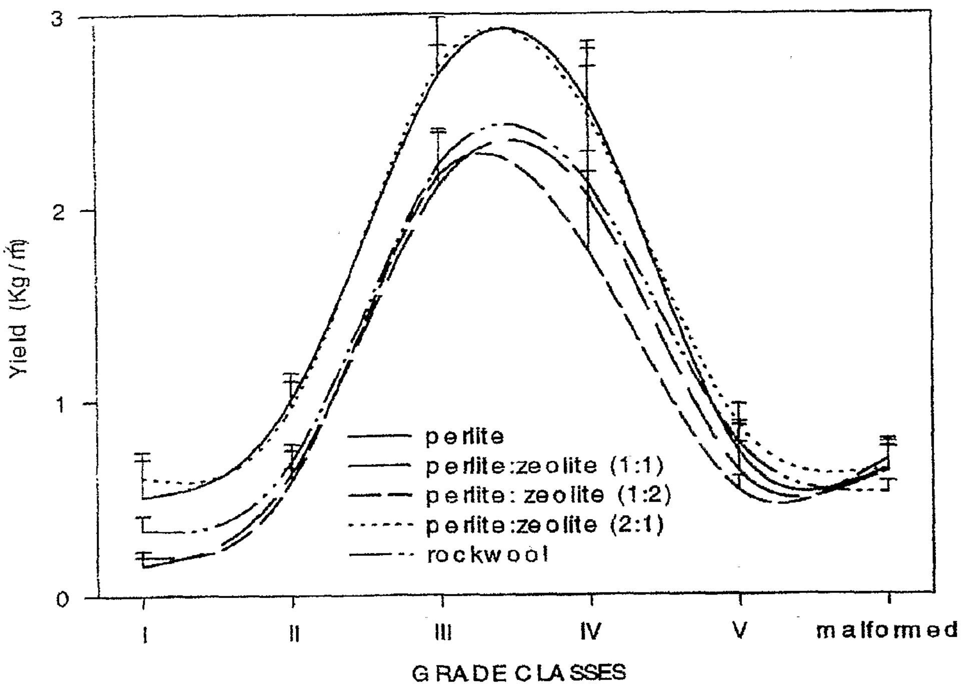

Fig. 2 Distribution of fruitsizes of tomatoes grown hydroponically on five different substrates

SSC was 5.2% in fruits of plants grown in the mixture perlite:zeolite 2:1 culture. However, tomato fruit from plants produced in ail the other substrates had SSC ranging from 4.6% for mixture 1:2 P/Z to 4.8,Vo for perlite (Table 1). Sugars represents 65% of the SSC in tomatoes

(Winsor, 1979) and they represent its major taste components along with the organic acids (Hobson and Kilby, 1984).

All tomato fruit analyzed had total dry matter within the range of 6.40-6.48% (table 1). The highest dry matter of 6.48% was recorded on perlite followed by mixture 1:1 and 2:1 P/Z. Good quality tomatoes have been reported within the rang from 4.8% to 7% (Winsor, 1976).

TA, mainly citric acid, of 0.34 g/l was recorded in tomatoes obtained from culture on rockwool, whereas, culture in all the other substrates resulted in fruit with TA ranging from 0.22 to 0.27 g/l (Table 1). This could be explained by the possibility of higher salt accumulation in the rockwool slabs (Sonneveld and Welles, 1988). pH values of the fruit juice were relatively high and fruit from perlite culture bad the highest pH of 5.97.

EC of tomato fruit juice was ranged from 2.22 mS/cm for mixtures 1:2 and 2:1 P/Z to 2.28 mS/cm for rockwool (table 1). No significant differences in the EC of juice were observed between fruits produced in all the substrates.

Table 1. Quality parameters of tomato fruit hydoponically grown on five different substrates.

Substrate	EC (mS/cm)	PH	SSC (%)	Acidity (g/l)	Dry M. (%)
Perlite	2.26 a*	5.97 a	4.76 b	0.22 d	6.48 a
1:1 P/Z**	2.28 a	5.89 c	4.67 bc	0.25 c	6.45 ab
1:2 P/Z	2.22 a	5.86 d	4.59 c	0.27 b	6.40 c
2:1 P/Z	2.22 a	5.92 c	5.17 a	0.23 d	6.45 b
Rockwool	2.27 a	5,94 b	4.62 bc	0.34 a	6.43 b

*Values in the same column followed by different letters are significantly different by Duncan's multiple range test (æ=0.05)
**P/Z: perlite to zeolite mixture

Stevens et al., (1977) reported that the overall flavor intensity was more related to sugar content and slightly less to TA. The same researchers also found that sugars decreased sourness when the pH was relatively high. Since mixture 2:1, P/Z had the best level of SSC, presented a good dry matter range and relatives high pH, we can deduce that this substrate produced the best quality fruits.

All fruit quality parameters examined in the sensory panel test showed that all substrates produced fruits of similar quality. This subjective sensory evaluation of fruits suggested that ail substrates used produce pleasant to good quality fruits. The overall acceptability ranged between 4.8-5.4. The perlite to zeolite 2:1 mixture showed a tendency to have good aroma and sweetness whereas 1:2 P/Z was classified the last (Table 2).

Table 2. Subjective evaluation of fruit quality by sensory panel test*.

Substrate	color	sweetness	acidity	aroma	saltiness	overall accept
Perlite	4.6 a**	4.0 a	3.2 a	4.7 a	3.5 a	5.2 ab
1:1 P/Z***	4.5 a	3.7 a	3.4 a	4.5 a	3.3 a	4.9 ab
1:2 P/Z	4.5 a	3.8 a	3.0 a	4.6 a	3.3 a	4.8 b
2:1 P/Z	4.7 a	4.1 a	3.1 a	4.9 a	3.4 a	5.4 a
Rockwool	4.4 a	3.9 a	3.3 a	4.7 a	3.4 a	5.1 ab

*Evaluation of parameters by scale from 1 to 7 (from least 1 to most 7). Overall acceptability: 1. Very bad, 2. Bad, 3. Indifferent, 4. Fair, 5. Pleasant, 6. Good, 7. Very good.
**Values in the same column followed by different letters are significantly different by Duncan's multiple range test (æ=0.05).
***P/Z. perlite to zeolite mixture

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