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Evaluation of different substrates on yield and fruit quality of sweet pepper using open soilless culture

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Abstract

This study was conducted at Jordan Valley to evaluate the use of locally available tuff and sand substrates in comparison with soil for growing sweet pepper (*Capsicum annum* L. cv. Reehan) using an open soilless culture. Treatments were randomly distributed according to RCBD with three replications. Sweet pepper plants, grown in soil or tuff gave higher total yield (6.0, 5.5 and 8.7, 6.5 ton/1000m^2, respectively) and yield/plant (2.0, 1.58 and 1.3, 1.38 kg/plant, respectively) in both the years, while those grown in sand produced the least. Fruit weight of plants grown in soil was the highest in the first season (200.6 g) followed by tuff and lastly the sand (177.0 and 169.4 g, respectively), however, it was not affected by the substrates in the second season. Substrates had little effect on fruit length in both seasons and fruit diameter in the first season, but, in the second season those grown in soil gave the highest diameter (74.4 mm) followed by those in tuff and sand (70.6 and 70.3 mm, respectively). This study indicated that open soilless system using tuff as a substrate may be suitable for sweet pepper production without dramatic changes in yield or fruit quality and it saved about 65-70% of water applied by conventional farmers for sweet pepper production under plastic house.

Key words: Tuff, sand, soil, sweet pepper, soilless, fruit quality, yield

Introduction

Due to the arising problems of soil and the shortage of water supply for irrigation in Jordan, several farmers are using closed soilless cultures with the non-organic volcanic tuff as a substrate for production of cash crops such as cut flowers. However, the main disadvantage of such systems is the high initial establishment cost (Cooper, 1975; Winsor and Schwarz, 1990), therefore, the The National centre for Agricultural Research and Extension (NCARE) has developed a simple, cheap and effective open soilless culture to conduct this study at the Jordan Valley using locally available substrates to reduce the cost of imported ones.

In substrate culture, the nutrient solution can be applied in open or closed systems. In open systems, the nutrient solution is not recirculated, while it is recirculated in closed systems (Alan *et al.*, 1994; Çelikel, 1999; Cooper, 1975; NeSmith and Duval, 1998; Siomos *et al.*, 2001; Winsor and Schwarz, 1990). Under different substrates study, no significant difference was found between open and closed systems with respect to sweet pepper total yield (Tüzel *et al.*, 2001). Sand culture is one of the most efficient and a cost-effective method of soilless cultures due to its relatively low construction cost, simplicity of operation, ease of maintenance and service. However, sand culture requires sterilization between crops and feed lines may be blocked with sand particles, in addition to rapid salt build-up (Wright, 1992). Tuff culture has been used to grow several vegetable crops and cut flowers (Çelikel and Çaglar,1999; Economakois and Krulji, 2001; Hurewitz and Janes, 1983; Martin-Closas and Recasens, 2001; Tüzel *et al.*, 2001; Tüzel *et al.*, 2003). No significant difference was observed among different substrates with respect to bean total yield (Tüzel *et al.*, 2003), additionally, when sweet pepper plants were grown in different soilless substrates, fruit quality was comparable to those grown in soil culture (Çelikel and Abak, 1996). However, under greenhouse conditions, tuff resulted in higher tomato yield than soil (Abak and Çelikel, 1994).

This study was carried out to evaluate two locally available soilless substrates (tuff and sand) in comparison with conventional growing in soil for the growth of sweet pepper in a non-circulating open culture.

Materials and methods

This research was conducted at Wadi Al-Rayyan, northern Jordan Valley (200 m below sea level) during the 2001 and 2002 growing seasons. Treatments were tuff culture, sand culture and in soil, therefore, unheated plastic house was divided into six rows (two rows for each treatment). Soilless beds (40 cm wide, 30 cm deep and 10 m long) were made in soil with cement blocks and the ground was zero leveled. Each bed was lined with a 400-µ black polyethylene sheet to preserve the nutrient solution. Acid-washed sand and tuff were placed in the beds with equal volume in the first season. In the second season, the same substrates were re-washed with acid in the same beds. Tuff was placed in the beds in two layers; 5 cm of coarse tuff (8-16 mm in diameter) above it 15 cm of fine tuff (0-4 mm in diameter) was placed. The upper side of beds was covered with black plastic mulch, and an empty space was made at the end of soilless beds to monitor and control the nutrient solution.

A complete Hoagland's nutrient solution (Hoagland and Arnon, 1938) containing all macro and micronutrients was added to soilless beds manually (as needed) in a great caution since no drainage was available for excess solution. The level was kept between 5-15 cm according to the growth stage and its volume was recorded. The nutrient solution was daily monitored for EC

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and pH and adjusted to 2.0-2.5 dS/m, and 5.5-6.0, respectively.

Soil beds were solar-sterilized, prepared, irrigated and fertilized as practiced by pepper farmers in the area of the study. Soil samples were collected from soil beds prior to planting and analyzed and contained Na 11 (meq/L), Mg 15 (meq/L), Ca 15 (meq/L), K 971 (ppm), P 20 (ppm), pH 7.5, EC 3.5 (dS/m) and $CaCO_3$ 37.9 (%). The total volume of water applied to soil was recorded using water meter. For all treatments, sweet pepper cv Reehan seedlings were planted on October 15th in double rows with 40 cm spacing.

At each harvest, fruits were collected; counted and weighed to determine total and marketable yields, yield per plant and average marketable fruit weight, length, diameter and skin thickness. At the end of the study, whole plants were collected, weighed and oven-dried to determine plant dry weight and N, P, and K content (A.O.A.C., 1970). Air temperature at 50 cm above ground and soil, sand and tuff temperature at 10 cm depth were measured with a data logger and recorded.

Treatments were randomly assigned the experimental units in a Randomized Complete Block Design (RCBD) with three replications per treatment. Collected data were statistically analyzed using MSTAT software (version 4.0, 1985) and mean separation was performed according to the Least Significant Difference (LSD) method, $P \leq 0.05$.

Results and discussion

Total, marketable, non marketable yield and plant productivity: Results indicated that there is no significant differences for total and marketable yields between tuff and soil cultures while yield in culture decreased significantly in the 1st season. In 2nd season, significant differences were observed among the substrates; yield in soil was the highest followed by tuff and sand (Table 1).

For non-marketable yield, no significant differences were observed among different substrates in 1st season, while in the 2nd season yield was significantly higher in soil than tuff and sand cultures (Table 1).

For total yield, no significant difference was observed between tuff and soil, but yield decreased significantly in sand in 1st season. However, in the 2nd season, significant differences among different media were observed (Table 1).

Physical fruit properties: In 1st season, soil gave significantly higher average fruit weight than tuff and sand, but no significant difference was observed among different media in the 2nd season (Table 2).

In addition, no significant difference was observed among different media in 1st and 2nd seasons in respect to fruit length. For fruit diameter, no significant differences among different media were observed in 1st season. However, in the 2nd season it was significantly higher in soil than tuff and sand (Table 2).

Also, in the 1st season tuff gave significantly higher fruit skin thickness than soil and sand, but, no significant differences among different media were observed in the 2nd season (Table 2).

Mineral composition of vegetative growth: Results indicated that in 1st season, nitrogen % was significantly lower in tuff than soil and sand. But, no significant differences were observed among different media in 2nd season. For phosphorous %, no significant differences were observed among different media in 1st season, however, in 2nd season, P% was significantly higher in sand than tuff which was also higher than in soil but the difference was not significant (Table 3). Potassium and dry matter percentage showed no significant differences among different media in 1st and 2nd season.

Percentage of applied water: Calculation for percentage of water applied to tuff and sand was based on the total amount of water applied to the soil. Comparison between tuff and sand with soil show that amount of applied water to tuff culture was 31.8% for 1st season and 33.7% for 2nd season, while for sand, 26.7% for 1st season and 23.7% for 2nd season (Fig. 1).

Tuff, sand, soil, and air temperatures: Results revealed that the lowest difference between the maximum and the minimum temperatures was observed in tuff (Fig. 2). Temperature stress and variation in day and night temperatures may affect several aspects of plant growth, fruit quality and yield in soil as well as soilless

Table 1. Total, marketable, non-marketable yield and productivity of Pepper cv. Reehan

Treatment	Total yield ($ton/1000\ m^2$)		Market yield ($ton/1000\ m^2$)		Non-market yield ($ton/1000\ m^2$)		Yield/plant (kg)	
	2001	2002	2001	2002	2001	2002	2001	2002
Tuff	5.5 a	6.8 b	5.0 a	6.5 b	0.5 a	0.3 b	1.38 a	1.58 b
Sand	2.8 b	2.9 c	2.5 b	2.8 c	0.3 a	0.1 b	0.58 b	0.63 c
Soil	6.0 a	8.7 a	5.7 a	8.1 a	0.3 a	0.6 a	1.30 a	2.00 a

* Mean separation within columns by LSD test, values that don't share the same letter are significantly different at the 5 % level.

Table 2. Average fruit weight, length, diameter and skin thickness of pepper cv. Reehan

Treatment	Fruit weight (g)		Fruit length (mm)		Fruit diameter (mm)		Skin thickness (mm)	
	2001	2002	2001	2002	2001	2002	2001	2002
Tuff	177.0 b	131.7 a	125.3 a	120.3 a	85.9 a	70.3 b	6.3 a	4.7 a
Sand	169.4 b	134.3 a	137.1 a	120.1 a	80.6 a	70.6 b	5.8 b	4.7 a
Soil	200.6 a	150.1 a	134.2 a	131.8 a	84.5 a	74.4 a	5.8 b	4.8 a

* Mean separation within columns by LSD test, values that don't share the same letter are significantly different at the 5 % level.

Table 3. Percentage of nitrogen, phosphorus, potassium, and dry matter of pepper vegetative growth

Treatment	N (%)		P(%)		K(%)		Dry matter (%)	
	2001	2002	2001	2002	2001	2002	2001	2002
Tuff	0.8 b	2.3 a	0.3 a	0.3 b	5.1 a	2.1 a	17.0 a	18.3 a
Sand	1.3 a	2.6 a	0.4 a	0.5 a	4.4 a	2.4 a	17.8 a	19.3 a
Soil	1.6 a	2.6 a	0.3 a	0.4 ab	5.2 a	2.2 a	16.6 a	21.3 a

* Mean separation within columns by LSD test, values that don't share the same letter are significantly different at the 5 % level.

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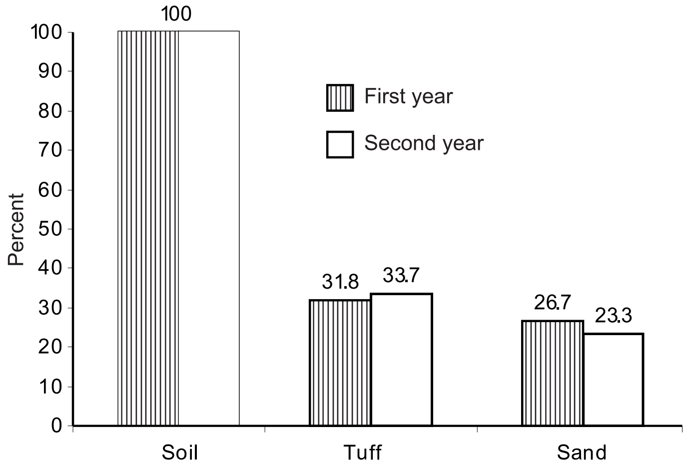

Fig. 1. Percentage of applied water to treatments of pepper in both years

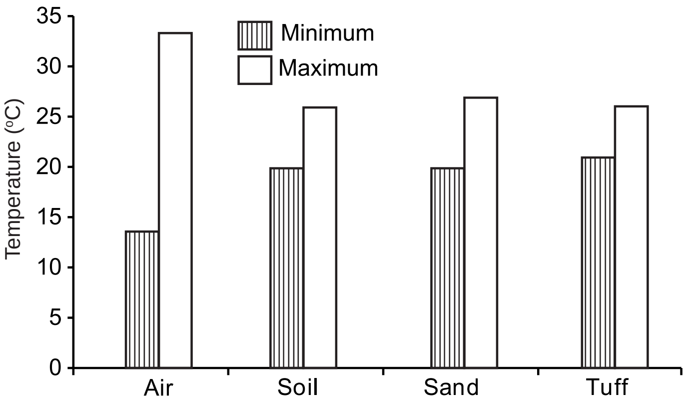

Fig. 2. Temperatures of tuff, sand, soil (at 10 cm deep), and air (at 50 cm height) of pepper.

culture (Hurewitz and Janes, 1983; Kafkafi, 2001; Papadopoulos, 1991; Woitke and Schitzler, 2005). Thus, maintaining optimum root temperature is the main factor in plant production under soilless culture conditions, and the least temperature variation in tuff substrate may reduce the negative effects on yield and quality.

The main disadvantage of using soilless culture systems is the high cost of substrates particularly the imported ones. In order to lower the cost of substrate, locally available material such as black volcanic rock (tuff) may be used. Results of this study indicated that open soilless system using tuff as a substrate may be suitable for sweet pepper production without dramatic changes in its yield or fruit quality. It is concluded that open soilless culture system using tuff substrate may save about 65-70 % of water applied by conventional farmers for sweet pepper under plastic house. However, maintaining the optimum media (root) temperature and controlling the nutrient solution (water) levels may be used as a new technique for growers to manage open system in order to increase oxygen availability to the plant roots.

References

Abak, K. and G. Çelikel, 1994. Comparison of some Turkish originated organic and inorganic substrates for tomato soilless culture. *Acta Horticulturae*, 366: 423-428.

Alan, R., A. Zulkadir and H. Padem, 1994. The influence of growing media in growth, yield and quality of tomato grown under greenhouse conditions. *Acta Horticulturae*, 366: 429-436.

A.O.A.C., 1970. *Official Methods of Analysis*. Association of Official Analytic. Chemist., Washington, D.C., 11th ed.

Çelikel, G. 1999. Effect of different substrates on yield and quality of tomatoes. *Acta Horticulturae*, 491: 353-356.

Çelikel, G. and K. Abak, 1996. Fruit quality of tomatoes grown in soilless culture. *Alata Horticultural research institute* (Abstract).

Çelikel, G. and G. Çaglar, 1999. The effect of re-using different substrates on the yield and earliness of cucumber on autumn growing period. *Acta Horticulturae*, 492: 259-264.

Cooper, A.J. 1975. Crop production in re-circulating nutrient solution. *Scientia Horticulturae*, 3: 251-258.

Economakois, C.D. and L. Krulji, 2001. Effect of root-zone warming on strawberry plants grown with nutrient film technique (NFT). *Acta Horticulturae*, 548: 189-196.

Hoagland, D.R. and D.I. Arnon, 1938. The water-culture method for growing plants without soil. *Calif. Agric. Exp. Stn. Circ.*, 347: 39.

Hurewitz, J. and W. Janes, 1983. Effects of altering the root-zone temperature in growth, translocation, carbon exchange rate and leaf starch accumulation in the tomato. *Plant Physiol.*, 73: 46-50.

Kafkafi, U. 2001. Root zone parameters controlling plant growth in soilless culture. *Acta Horticulturae*, 554: 27-38.

Martin-Closas, L. and X. Recasens, 2001. Effect of substrate type (perlite and tuff) in the water and nutrient balance of a soilless culture rose production system. *Acta Horticulturae,* 559: 569-574.

MSTAT, 1985. MSTAT Statistically User's Guide, Version 4.0 ed., Michigan State University, USA.

NeSmith, D. and R. Duval, 1998. The effect of container size. *HortTechnology*, 8(4): 495-498.

Papadopoulos, A.P., 1991. *Growing Greenhouse Tomatoes in Soil and Soilless Media*. Agriculture Canada Publication, Ottawa, Canada.

Siomos, A.S., G. Beis, P.P. Papadopoulou and N. Barbayiannis, 2001. Quality and composition of lettuce (cv. Plenty) grown in soil and soilless culture. *Acta Horticulturae*, 548: 445-450.

Tüzel, I.H., Y. Tüzel, A. Gül, M.K. Meric, O. Yavuz and R.Z. Eltez, 2001. Comparison of open and closed systems on yield, water and nutrient consumption and their environmental impact. *Acta Horticulturae*, 554: 221-228.

Tüzel, I.H., G.B. Öztekin and Y. Tüzel, 2003. Effects of substrates on bean growing in the greenhouse. *Acta Horticulturae*, 608: 37-42.

Winsor, G.W. and M. Schwarz, 1990. *Soilless Culture for Horticulture Crop Production*. FAO Publications, 188 pp.

Woitke, M. and W.H. Schitzler, 2005. Biotic stress relief on plants in hydroponic systems. *Acta Horticulturae*, 697: 557-565.

Wright, L. 1992. *Sand Culture.* Practical Hydroponics & Greenhouses Magazine, issue (2) Jan/Feb.

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