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Effect of Three Different Substrates on Growth and Yield of Two Cultivars of *Capsicum Annuum*

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Abstract

Greenhouse production of sweet peppers is gradually increasing in Kuwait as a response to increased consumer demands for local fresh produce. The major growing media currently in use are perlite and peatmoss. Since peatmoss is now considered to be a limited resource, interest to explore other relatively inexpensive substrates is of great importance in the country. A greenhouse experiment was conducted to evaluate the effect of three substrates on growth and yield of two cultivars of sweet peppers (*Capsicum annuum* cv. Yara; green and Piment Doux; red). Three substrates were considered in this study including; growing medium 1 (M1); peatmoss and perlite were mixed in the ratio of 1:1 (v/v) (this will be considered as control), medium 2 (M2); peatmoss, perlite and vermicompost 2:2:1 (v/v/v) and growing medium 3 (M3) comprised of peatmoss, perlite, vermicompost and cocopeat mixed in the ratio of 1:4:3:2 (v/v/v/v). The *Capsicum annuum* cultivars were grown in a simple and environmentally friendly soilless technique (Closed Insulated Pallet System, CIPS). A basic characteristic of CIPS is that water moves from a reservoir below the plant container through a capillary wick and then through the growth medium to the roots. Results showed that these cultivars responded differently to different substrates under this investigation. Furthermore, these substrates had significant effects on cultivars heights, number of leaves, chlorophyll index and plants' total yields. Mean water uptakes for both varieties were significantly lower in all 3 media tested compared to the control.

Keywords: Sweet pepper, growing medium, soilless culture, closed system, sub-irrigated system

Introduction

The use of soil in protected agriculture is facing many limitations in this country. After years of cultivation, deterioration in soil fertility and increase in soil salinity in addition to the incurrence of soil-born diseases limit productivity of crops have often been observed. Furthermore, a recent threatening rise in water table reported in many farmlands in Kuwait, reaching soil surface at places, as a consequence of prolonged excessive irrigation of crops is a another drawback of the traditional soil-based production systems. Therefore, utilizing substrate-based agriculture is a logical alternative to the current soil-based production approach in the country. The use of different organic and inorganic substrates allows the plants the best nutrient uptake and sufficient growth and development to optimize water and oxygen holding (Verdonck et al., 1982). However, different substrates have several materials which could have direct and/or indirect effects on plant growth and development. Therefore selecting the best substrate between the various materials is imperative to plant productivity. The addition of the upper layer of coco fibre to the perlite raised the leaf water potentials (-0.74 vs. -0.84 MPa) and the rates of net assimilation (13.7 vs. 12.1 μmol CO_2 m^{-2} s^{-1}) and transpiration (6.01 vs. 5.19 mmol H_2O m^{-2} s^{-1}) of Gerbera plants compared to the perlite alone (Paradiso and De Pascale 2008). Fascella and Zizzo (2005) evaluated the influence of perlite and perlite mixed with coconut coir dust (cocopeat) (1:1, v/v) on quantitative and qualitative parameters of cut flower (cv. Anastasia) production, they reported that the mix caused the highest amount of flowers (17.7 stems/plant) and the longest stems (65 cm). Due to diminishing supplies of peat soils for horticultural substrates, cocopeat is being considered as a renewable peat substitute for use in horticulture. Tehranifar et al., 2007 reported that the vegetative growth of a number of strawberry cultivars were higher in media with peat and cocopeat compared with 100% sand and perlite and in cocopeat 40% + perlite 60% some cultivars produced the highest number of fruits and yield per plant. The yield in substrates with peat or cocopeat was higher than in substrates with without peat or cocopeat (Tehranifar et al., 2007).

The objective of this study was to determine the effect of different substrates on growth and yield of two cultivars of *Capsicum annuum* under a closed soilless production system (Closed Insulated Pallet System, CIPS) (Albaho and Green 2004). The CIPS is an environmentally friendly soilless technique, expected to be of great potential to Kuwait for growing selected vegetable crops and ornamental of high cash value (Albaho et al., 2008).

Materials and Methods

Three substrates were used during this trial; growing medium 1 (M1); peatmoss and perlite were mixed in the ratio of 1:1 (v/v), for growing medium 2 (M2); peatmoss, perlite and vermicompost were mixed in the ratio of 2:2:1 (v/v/v) and growing medium 3 (M3) comprised of peatmoss, perlite, vermicompost and cocopeat mixed in the ratio of 1:4:3:2 (v/v/v/v).

The Closed Insulated Pallet System (CIPS) used in this study comprises of opaque, reflective, insulated containers. Each container has a lid with eight holes which can accommodate eight plants with a planting density of 6.5 plants per m^2. Each pallet holds approximately 375 liters of water. The baskets were constructed from polyethylene nursery containers with rectangular openings cut from four sides. The baskets used were of the dimension 25 cm diameter x 21 cm deep (9.1 L). Water permeable cloth pouches were treated with copper hydroxide to regulate root growth and confine roots within the pouch. The copper hydroxide was dissolved in water-based acrylic emulsion primer at the rate of 100 g/l; the cloth pouches were dipped in it and dried in sun forming a thick even coating.

Capillary strips made of spun-bonded poly-ester fabric about 10 cm wide x 60 cm long were used.

The pallets were filled with measured quantity of good quality irrigation water up to 2 cm below the bottom level of the basket. The baskets were suspended from the precut holes in the CIPS lid. Two capillary strips were placed across the bottom of baskets and extended downwards 30 cm to the bottom of the pallet. The copper hydroxide treated cloth pouches were thoroughly soaked in water to permit easy diffusion of water across the pouch wall. The pouches were uniformly filled with the growth medium and saturated with water (field capacity) to establish continuous capillarity.

The medium filled and compacted pouches centrally planted with healthy seedlings of bell pepper were placed in the baskets, ensuring direct contact with the capillary mats. The top exposed surface of the growth medium was topped with 2 semicircular urethane collars provided with a hole in the center to accommodate the plant stem. Surface of the urethane collars were sealed with reflective, heavy duty aluminum foil preventing evaporation loss of water and to drive away white flies. Water level in the CIPS reservoir was monitored periodically to prevent a drop below 10 cm from the bottom of the basket.

Water sample was taken initially from the source of reservoirs' replenishment. Growing media used were also sampled and the result of analysis is given in Table 1.

The plants were fertilized with Nitrophoska Blau (12+12+17+2+TE; 2% MgO, 0.02% B and 0.01% Zn). 100g/ plant of this fertilizer was taken in canisters and embedded in the lower stratum of the growth medium. Along with this 30g/ plant of calcium nitrate (calcinit) was provided in another canister and embedded adjacent to Nitrophoska Blau.

Seeds of bell pepper cultivars Yara (green color) and Piment Doux (red color) were sown in 5cm pots filled with a mixture of peatmoss and perlite in the ratio of 1:1 (v/v). Well established and healthy seedlings were transplanted into regular sized pots in the second week of January, 2008.

Experiment was laid out in a randomized complete block design with three growing media and two bell pepper cultivars replicated four times. A total of 48 pallets were used for this experiment. Observations on vegetative growth parameters such as plant height, number of leaves per plant and chlorophyll index and reproductive growth parameters; i.e. number of fruits/plant and fruit yield were recorded at twenty day intervals during the course of study. Observations were recorded from fifteen plants for each treatment.

Table 1: Chemical Analysis of Irrigation Water and Growing Media

Sample	pH*	EC (mS/cm)	(meq/l)						
			Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	CO_3^{-2}	HCO_3^{-1}	Cl^{-1}
Irrigation Water	7.7	0.6	0.8	0.5	0.1	4.4	<0.1	0.4	3.3
M1**	5.9	2.0	12.3	8.0	0.2	2.8	4.1	0.3	5.9
M2	6.0	1.6	62.3	69.3	14.4	27.7	25.0	11.0	6.0
M 3	6.5	1.8	53.0	83.3	30.8	31.6	29.1	13.5	6.5

*pH: Analysis of saturated paste, EC: Electrical Conductivity, Growing media soil:water extract at 1:10 ratio.:

**(M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Results and Discussion

Vegetative Parameters. Invariably in all the treatments maximum growth rate was recorded between 20 and 40 days after planting (DAP) and maximum plant height was attained between 100 and 140 DAP. In general, plant heights were significantly greater in all evaluated media 1, 2 and 3 than the control (Table 2). Similar patterns were obtained for the number of leaves per plant (Table 3) and chlorophyll index (Table 4).

Reproductive Parameters. the variety Yara produced significantly greater number of fruits than when grown in all growing media under investigation than the control. However, in Piment Doux, Medium 3 had greater mean number of fruits than the other two growing media.

Although there were no significant difference in the weight per fruit (similar size) (Table 6), significantly greater mean fruit yields per plant were produced in Medium 1 in both bell pepper cultivars than the other growing media (Table 7). Greater number of fruits and more yields produced by plants grown in medium 1 suggests that this treatment is best suited for growing bell pepper in CIPS.

Table 2: Mean Plant Height Measured Overtime in Sweet Pepper (*Capsicum annuum*)

Variety/ Fertilizer Type Growing Medium	Days After Planting (DAP)								
	0	20	40	60	80	100	120	140	$LSD_{0.5}$
Yara									
M1*	28.7	41.3	77.0	82.8	83.5	84.1	85.5	86.3	b
M2	28.5	41.0	75.0	79.1	85.0	84.9	85.8	86.1	b
M3	28.5	42.5	76.5	84.1	84.6	89.3	89.6	90.1	a
Piment Doux									
M1	17.9	28.2	50.3	51.9	52.2	53.6	53.9	54.7	b
M2	18.1	28.1	52.5	53.0	54.7	55.1	55.4	55.9	b
M3	19.1	29.3	52.6	57.2	58.9	59.7	59.0	61.3	a

*(M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Table 3: Mean Number of Leaves Produced Overtime in Sweet Pepper (*Capsicum annuum*)

Variety/ Fertilizer Type– Growing Medium	Days After Planting								
	0	20	40	60	80	100	120	140	$LSD_{0.5}$
Yara									
M1*	6.5	13.4	43.5	44.1	54.5	49.4	45.9	54.0	a
M2	6.4	12.3	33.6	34.8	61.0	68.7	71.5	69.8	a
M3	6.5	13.5	37.1	39.5	63.1	51.3	50.9	56.2	a
Piment Doux									
M1	6.1	12.5	32.7	33.4	38.3	30.2	25.5	33.7	b
M2	6.3	10.1	35.5	36.4	39.9	40.4	32.9	36.5	b
M3	6.5	12.9	34.1	35.9	35.5	42.4	44.1	43.0	a

*(M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Table 4: Mean Chlorophyll Index Recorded Overtime in Sweet Pepper (*Capsicum annuum*)

Variety/ Fertilizer Type– Growing medium	Days After Planting								
	0	20	40	60	80	100	120	140	$LSD_{0.5}$
Yara									
M1*	7.9	55.5	58.1	71.6	62.9	51.9	34.4	38.6	a
M2	8.2	63.9	65.6	86.2	73.0	55.3	47.7	45.3	a
M3	7.8	76.9	68.9	84.7	65.9	57.4	45.0	41.0	a
Piment Doux									
M1	13.2	55.8	63.9	66.7	57.6	54.7	40.6	47.3	a
M2	15.0	56.1	55.6	79.9	65.7	56.0	44.1	42.1	a
M3	13.0	64.0	70.9	74.9	73.3	66.3	49.7	48.7	a

*(M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Table 5: Mean Number of Fruits Produced per Plant under Different Treatments

Variety/ Fertilizer type	M1*	M2	M3	Soil	$LSD_{0.5}$
Yara	12.2	12.7	12.0	4.6	2.0
Piment Doux	6.5	6.8	12.4	4.4	3.8

*(M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Table 6: Mean Weight (per fruit) under Different Treatments (g)

Variety/ Fertilizer Type	M1*	M2	M3	Soil	$LSD_{0.5}$
Yara	85.6	78.8	85.9	88.7	12.0
Piment Doux	76.1	73.9	81.1	91.0	10.1

*(M1); peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Table 7: Mean Fruit Yield (per plant) under Different Treatments (g)

Variety/ Fertilizer Type	M1*	M2	M3	Soil	$LSD_{0.5}$
Yara	1026.0	933.0	921.8	408.0	92.2
Piment Doux	953.3	474.4	492.7	400.4	73.1

*(M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

Mean Water Uptake. The mean water uptake per plant in different treatments were compared with the soil based control system are presented in Figs 1 (Yara) and 2 (Piment Doux). The data presented in Fig. 1 for variety Yara and Fig. 2 for the variety Piment Doux suggest that all the treatments tested effectively reduced water consumption compared to the control.

Figure 1: Mean water uptake of Bell Pepper (Yara) plants under different treatments. (M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).

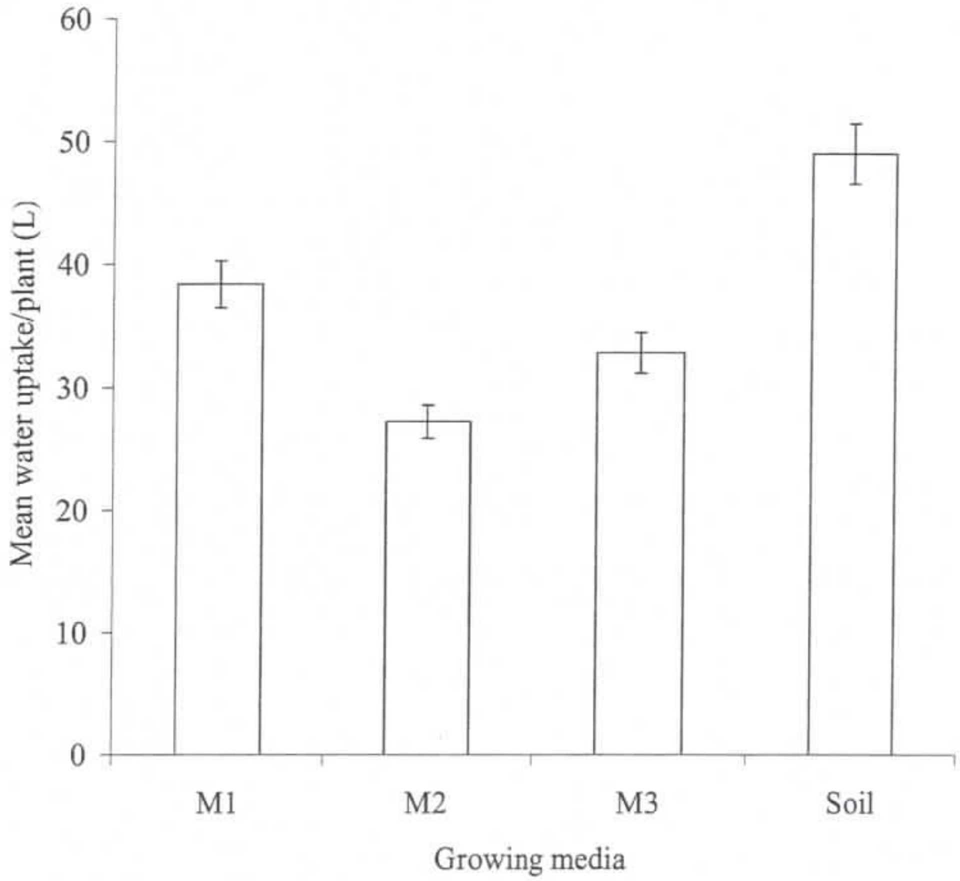
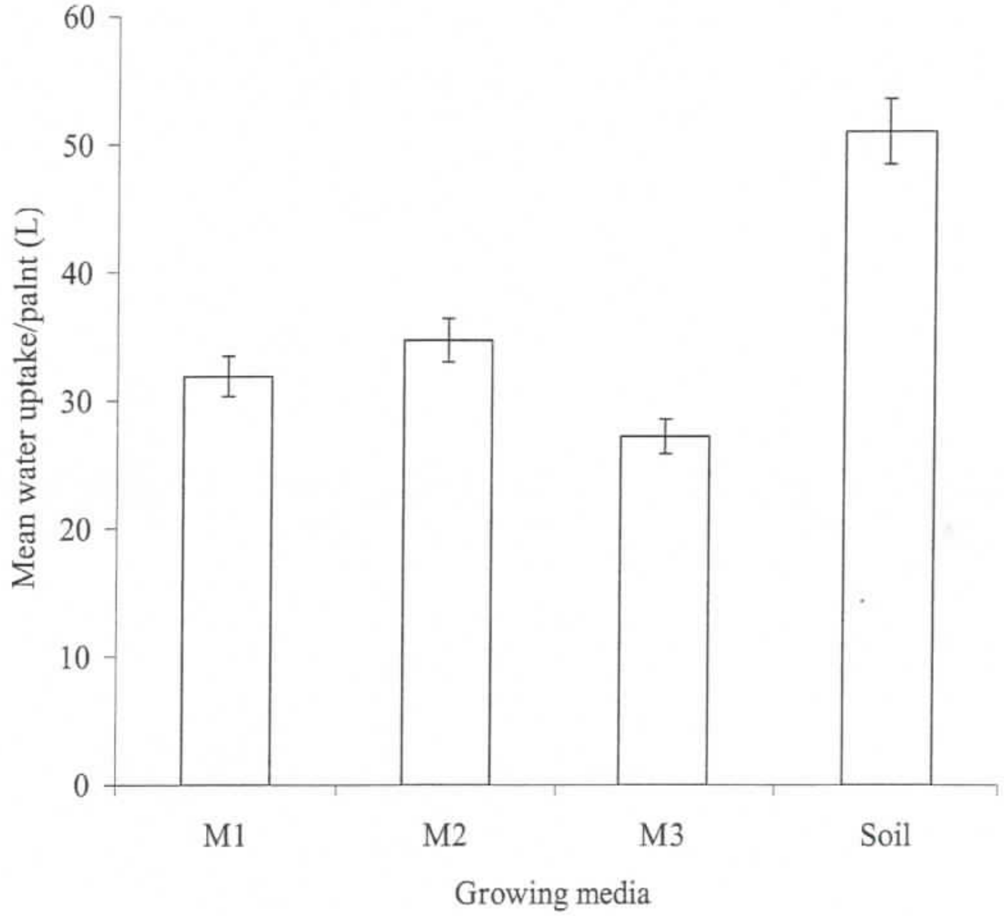


Figure 2: Mean water uptake of Bell Pepper (Piment Doux) plants under different treatments. (M1): peatmoss and perlite, 1:1 (v:v); (M2): peatmoss, perlite and vermicompost, 2:2:1 (v/v/v) and (M3): peatmoss, perlite, vermicompost and cocopeat, 1:4:3:2 (v/v/v/v).



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