GREENHOUSE TOMATO PRODUCTION IN TOP AND SUB-IRRIGATED VERTICAL BAG CULTURE

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Abstract: Two tomato plants were placed in vertical bags containing 28 liters of a cinder:hapuu growing medium. When these bags were irrigated daily with sprayer stakes, salable yields were 13 to 62 per cent lower than yields from tomatoes growing in greenhouse soil beds. When roots were allowed to grow into the soil below the bag, tomatoes yielded nearly as well as tomatoes in greenhouse soil beds. Tomatoes growing in bags placed in a covered tank containing 5 cm of nutrient solution (such that the bags were sub-irrigated) yielded as well or better than tomatoes growing in soil beds.

Keywords: containers, growing medium, greenhouse crop, hydroponics, irrigation, tomatoes

Introduction

Vertical bag culture for the production of greenhouse tomatoes is less common than horizontal bag culture because vertical bags require more water and do not maintain uniform moisture levels in the growing medium. (1). However, vertical bags and large pots appear to be more available in Hawaii and are easier to fill with a locally available growing medium, and thus, are the most likely to be used here. Vertical bags are normally irrigated by overhead drip or sprayer stake irrigation.

Lettuce and cucumbers have been successfully grown by placing aluminum cans or pots in a shallow tank of nutrient solution such that water and nutrient uptake occurs by sub-irrigation (2,3). The purpose of this study was to compare yields from tomatoes growing in bags which were given overhead irrigation or sub-irrigation with yields obtained from tomatoes growing in greenhouse soil beds.

Methods and Materials

All experiments were conducted in an open-sided fiberglass-covered greenhouse at a 1300 m elevation at the Volcano Experiment Station. Mean monthly ambient minimum air temperatures typically ranged from 8.8C (January-February) to 12.5C (July) and mean monthly outside ambient maximum air temperatures ranged from 17.4C (April) to 20.3C (September-October). Greenhouse temperatures can exceed outside ambient maximum air temperatures by up to 15C on a sunny day. Greenhouse soil (Manu silt loam) bed treatments were drip-irrigated and

received rates of fertilizers which were similar to the other treatments. All bag treatments were oriented vertically. 'Vendor' tomatoes were trellised to a single stem and were spaced 30 cm apart in rows which were 1.2 m apart. Insecticides and fungicides were applied as needed. Experiments were arranged as randomized complete blocks with 3 replications.

Top-irrigated bags. Bags were drip-irrigated daily. They were filled with 14 liters of 2 red or black cinder:1 hapuu (from Hawaiian tree ferns) and there was 1 plant per bag. These plants were fertilized with 30 g Osmocote 18-6-12, 8 g potassium nitrate and 2 g diammonium phosphate/plant, and 17 foliar applications of 12-24-24+micronutrients. In addition, the growing medium contained residual dolomite, Kmag and triplesuperphosphate from a previous trial. In another trial, bags contained 28 liters of 1 or 2 black cinder:1 hapuu and there were 2 plants/bag. They were irrigated daily with sprayer stakes. Fertilizers applied on a per plant basis were: 45 g Osmocote 18-6-12, 30 g Kmag, 30 g triplesuperphosphate, 42 g dolomite, and 6 g diammonium phosphate.

Top-irrigated bags from which roots penetrate into the soil. Tomatoes were grown in 28-liter bags containing 2 black cinder:1 hapuu growing medium and there were 2 plants/bag. Either all of the roots remained in the bags (the bags were separated from the greenhouse soil by a polyethylene barrier) or an opening in the bottom of the bag enabled the roots to enter the greenhouse soil and also allowed excess water and fertilizer to leach into the greenhouse soil. Bags were fertilized with 50 g Magamp (7-40-6) plus 11 to 16 applications of 5 g/plant of a foliar 12-24-24+micronutrients. Bags were irrigated daily with sprayer stakes.

Sub-irrigated bags. Plastic pots (40 x 15 cm) with 1 plant/pot and 28-liter bags (or plastic pots) with 2 plants/bag were filled with 2 black cinder:1 hapuu growing medium and placed in a 10 cm high polyethylene-lined tank (60 cm wide) at ground level (Figure 1). Nutrient solution was maintained at a 5 cm depth throughout the experiment. The tank was covered except for the bags or pots. This ensured a zone of moist air (between the nutrient solution and the cover) which promoted root growth (2). Nutrient solution consisted of 0.5 g Chem-Gro 3-15-26 + 0.5 g calcium nitrate per liter of water for the first experiment reported in Table 4. The nutrient solution for other 2 experiments consisted of 0.5 g Chem-Gro 4-18-38, 0.6 g calcium nitrate, 0.2 g potassium nitrate and 0.4 g magnesium sulfate per liter of water.

Results and Discussion

Top-irrigated bags. Moisture uniformity of the growing medium was not satisfactory when the bags were drip irrigated. A significant portion of the medium in the upper portion of the bag remained dry. Total salable yields from tomatoes growing in bags were 41 per cent lower than yields from tomatoes growing in soil beds (Table 1).

When tomatoes were irrigated with sprayer stakes, yields were only lowered by 13 to 20 per cent in one experiment (Table 2). However, yields of tomatoes irrigated with sprayer stakes were 36, 41 and 62 per cent lower than yields from tomatoes growing in soil beds in 3 other experiments, respectively (Table 3).

Thus, it was clear that our method of growing tomatoes in top-irrigated, vertical bags containing hapuu:cinder media was inferior to growing tomatoes in greenhouse soil beds.

Top-irrigated bags from which roots penetrate into the soil. Roots were allowed to penetrate through an opening in the bottom of the bag and grew into the greenhouse soil below the bag. Tomato plants growing in these bags yielded nearly as well as those growing in the greenhouse soil beds (Table 3). This method ensures a greater water reservoir for the plants and a larger area from which the roots may extract nutrients. However, the roots growing in the soil may suffer damage if the soil is infested with nematodes or disease organisms.

Sub-irrigated bags. Both 28-liter bags (or plastic pots) and 40 x 15 cm polyethylene pots rested in a covered, shallow tank containing 5 cm of nutrient solution. Irrigation was accomplished by simply maintaining the nutrient solution depth at 5 cm. The growing medium was irrigated either by direct contact with the nutrient solution or by capillary action. Sub-irrigated tomatoes growing in the bags produced 19 per cent less than tomatoes in soil beds in the first experiment reported in Table 4. However, sub-irrigated tomatoes outyielded the tomatoes in the soil bed treatments by 3 and 30 per cent in 2 succeeding experiments (Table 4). Tomatoes growing in the polyethylene pots yielded 31, 2 and 7 per cent less than tomatoes growing in soil beds in 3 experiments, respectively (Table 4). The lower yields obtained in the first experiment were probably due to a shortage of magnesium in the nutrient solution.

Lifting the top cover of the tank revealed significant root growth in the nutrient solution. Thus, the tank increased the water and nutrient reservoir for the plants and also promoted increased root growth. The sub-irrigation system provided a uniform and steady supply of water and nutrients to the plants. The growing medium in bags which were irrigated daily by drip irrigation or by sprayer stakes may have dried out somewhat between irrigations, especially near the top of the bags. This reduced the quantity of effective growing medium in the bags.

The sprayer stake irrigation method is subject to plugging, equipment malfunction and power failures. The sub-irrigation system relies on stagnant, non-pressurized tanks of nutrient solution. These are less likely to fail, because they may be filled manually with a hose or water depth may be maintained with a simple plastic float valve. Of course, leaks can and do occur. It is important that the water depth in the tanks is not raised by more than 2 cm in one filling or else root damage will occur. For example, plants would severely wilt or die if the tanks were allowed to go dry and they were then filled with 10 cm of nutrient solution.

Conclusions

Tomatoes growing in top-irrigated vertical bags containing 28 liters of cinder:hapuu growing medium yielded 13 to 62 per cent less than tomatoes growing in greenhouse soil beds. However, tomatoes growing in similar bags which were sub-irrigated with nutrient solution yielded as well or better than plants growing in soil beds.

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Table 1. Salable yields from tomatoes growing in soil beds and drip irrigated 14-liter bags containing cinder:hapuu media.[1]

Treatment	Total Salable Wt. kg/plant	Percent of Soil Bed Salable Wt.
Soil Bed	5.57	
Bags with 2 Red Cinder:1 Hapuu[2]	3.30	59
Bags with 2 Black Cinder:1 Hapuu[2]	3.29	59
LSD 5%	0.88	16

[1]Harvested - 1/3/84 to 4/13/84.
[2]There was 1 plant per bag.

Table 2. Salable yields from tomatoes growing in soil beds and 28-liter bags containing cinder:hapuu media which were irrigated with sprayer stakes.[1]

Treatment	Total Salable Wt. kg/plant	Percent of Soil Bed Salable Wt.
Soil Bed	4.45	
Bags with 1 Black Cinder:1 Hapuu[2]	3.85	87
Bags with 2 Black Cinder:1 Hapuu[2]	3.56	80
LSD 5%	0.44	10

[1]Harvested - 5/31 to 9/11/84.
[2]There were 2 plants per bag.

Table 3. Salable yields from tomatoes growing in soil beds and 28-liter bags containing 2 black cinder:1 hapuu media which were irrigated with sprayer stakes.[1]

Treatment	Total Salable Wt. kg/plant	Percent of Soil Bed Salable Wt.
	Harvested - 12/15/86 to 4/15/87	
Soil Bed	4.95	
Bags	3.19	64
Bags - roots penetrate into soil	4.41	89
LSD 5%	0.66	13
	Harvested - 11/16/87 to 2/16/88	
Soil Bed	2.75	
Bags	1.62	59
Bags - roots penetrate into soil	3.42	88
LSD 5%	0.48	17
	Harvested - 7/1/88 to 11/22/88	
Soil Bed	6.68	
Bags	2.52	38
Bags - roots penetrate into soil	5.76	86
LSD 5%	1.44	22

[1]There were 2 plants/bag.

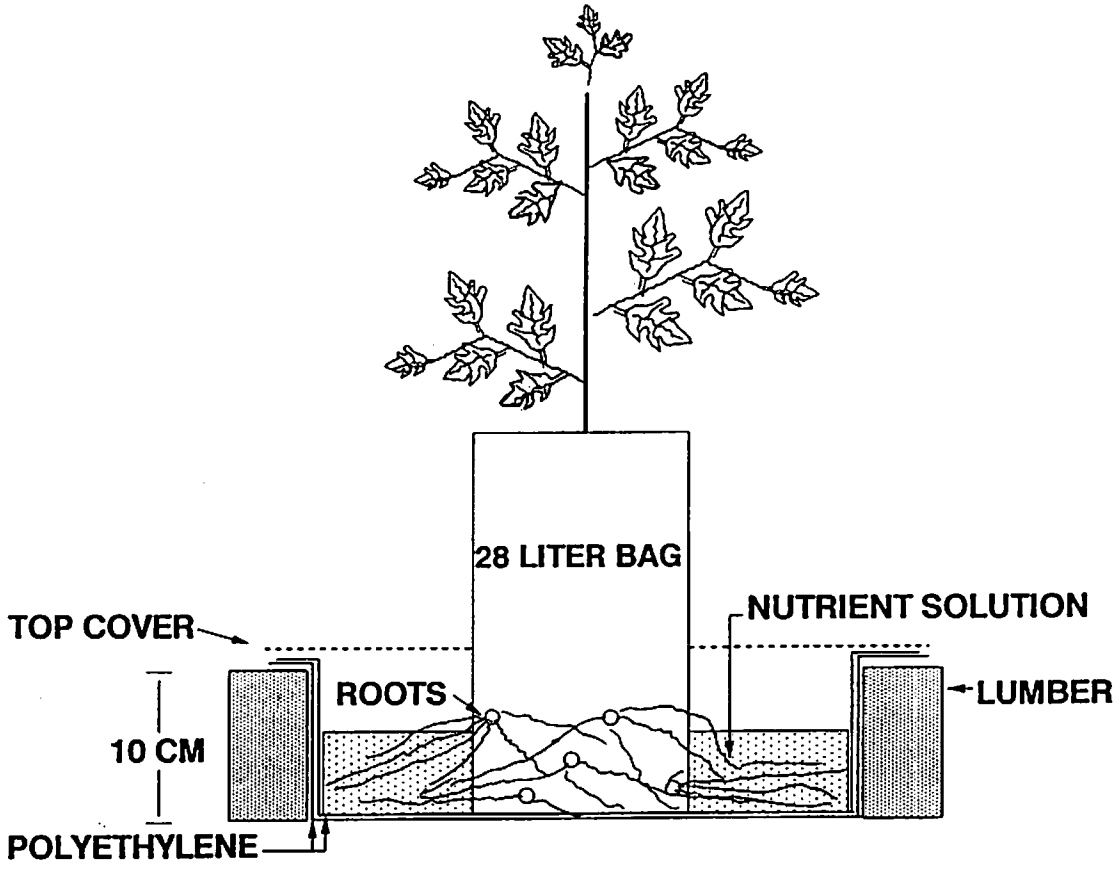

FIGURE 1. THE SUB-IRRIGATION SYSTEM.

Table 4. Salable yields from tomatoes growing in soil beds and sub-irrigated 28-liter bags (or plastic pots) and 40 x 15 cm plastic pots containing 2 black cinder:1 hapuu growing medium.[1]

Treatment	Total Salable Wt. kg/plant	Percent of Soil Bed Salable Wt.
	Harvested - 7/13 to 11/1/90	
Soil Bed	5.90	
28-liter Bags[2]	4.77	81
Plastic Pots (40 x 15 cm)[3]	4.05	69
LSD 5%	0.93	16
	Harvested - 6/17 to 10/25/91	
Soil Bed	5.69	
28-liter Bags[2]	5.88	103
Plastic Pots (40 x 15 cm)[3]	5.57	98
LSD 5%	1.30	23
	Harvested - 4/21 to 8/24/92	
Soil Bed	2.26	
28-liter Bags[2]	2.94	130
Plastic Pots (40 x 15 cm)[3]	2.10	93
LSD 5%	0.54	24

[1]Bags or pots rested in polyethylene-lined tank, 10 cm deep x 60 cm wide, containing 5 cm of nutrient solution.
[2]There were 2 plants per bag.
[3]There was 1 plant per pot.