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Evaluation of Soilless Media for Strawberry Production in Vertical and Horizontal Systems under a Nethouse

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Florida strawberries (*Fragaria ×ananassa*) are commonly grown in sandy soils in open field conditions. Protective structures are used to improve strawberry yield and quality, which has led to a significant increase in this practice in Florida. Prices of structures are high and there is a need to find the appropriate combination of production systems to increase the space use efficiency, which maximizes strawberry yields. Soil fumigants and land preparation are costs that also could be reduced by using soilless strawberry culture. Two preliminary studies were conducted to determine the performance of four different soilless media under two production systems. In one study, a soilless horizontal system (wooden boxes) was set up with different media (pine bark, coconut coir, potting mix, and perlite). In the other study, a vertical (Vertigro®) soilless system was used with the same four media. The results indicated that for the horizontal system, there were no significant differences among treatments for early and total fruit number and weight. In the vertical production system study, there were no significant differences among soilless media for early fruit number and weight, and for total fruit weight. However, the total fruit numbers were the highest in pots filled with either coconut coir, potting mix or perlite.

Strawberry is one of the most important small fruit crops throughout the world. Florida has the second largest production value in the U.S., generating more than $350 million from 9,900 acres (U.S. Department of Agriculture, 2011). Most Florida acreage is established in Hillsborough County using the annual hill system, in which raised planting beds are fumigated for soilborne pest control, irrigated with drip lines, and covered with polyethylene mulch. In this part of the state, strawberries are produced in deep sandy soils with rapid infiltration, very low organic matter, and high water table. The nutrient leaching potential of these soils is relatively high, which has important environmental and crop production implications. Open-field production of strawberry uses large water volumes for plant establishment, crop maintenance, and freeze protection. For plant establishment, bare-root transplants are set into mulched beds and sprinkler-irrigated for at least 8 d with an estimated water volume of 60,000 gal/acre for 8 h of irrigation (2.2 acre-inches/acre for 8 h or 17.6 acre-inches/acre for 8 d). This water volume is almost equivalent to the amount needed to maintain the crop during the whole planting season (about 14 acre-inches/acre). For freeze protection, the same sprinkler irrigation system (4 to 5 gal/min per sprinkler) is used between 12 to 14 h for each freezing event.

Currently, alternative production systems are being tested and implemented by growers and rural home owners to produce strawberry and vegetable crops. These consist of soilless (hydroponic) systems, which could be either vertical or horizontal. These systems may provide several advantages from the environmental and economic standpoint in comparison with the open-field production system: a) reduced irrigation volumes and nutrient leaching because watering is more focused with smaller underground volumes, while leaching is controlled more effectively by recirculating nutrient solutions and/or planting a second crop at the bottom of each vertical unit; b) the use of strawberry plug transplants considerably reduces establishment water volumes (estimated as more than 80% reduction) compared with bare-root plants; c) reusable growing media (i.e., pine bark and coconut coir) that reduces the cost for future seasons; d) higher yield per plant as has been widely demonstrated throughout the world with strawberry and other crops; e) elimination of soil fumigation because most growing media do not accumulate soilborne disease inocula, thus eliminating high associated labor and equipment costs (i.e., tractors, bedders, fumigation rig, and knives); and f) efficient use of limited space/land because more than 46,400 plants/acre could be established in 1 acre of vertical soilless culture, whereas it would take almost 3 acres for the same number of plants in the traditional open-field system. Some of the possible drawbacks of these systems are high initial set-up costs, which might be offset by higher yield per plant and/or reduced unit costs prorated over time, and the need for retraining and educating growers and field personnel on the differences between the systems, namely changing from "extensive" to "intensive" agriculture.

Among the several growing media available for use on soilless systems; there are the traditional materials such as sand, gravel, and volcanic rock; manufactured materials, including rockwool and perlite; and others of organic origin, such as pine bark, coconut coir, and rice hulls (Hochmuth and Hochmuth, 2012). The chemical and physical properties of the soilless media will vary depending on the origin of the materials, their structure, water and nutrient retention, and microbial activity. Two preliminary studies were conducted to determine the performance of strawberry grown in soilless media in the horizontal and vertical production systems.

Materials and Methods

Two preliminary studies were conducted from Oct. 2011 to Feb. 2012 at the Gulf Coast Research and Education Center in Balm, FL, to determine the performance of four soilless media

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under two production systems. The trials were conducted under a closed 1200-ft[2] nethouse structure with white, antivirus, 50-mesh insect net (American Farm Systems, Jemison, AL). The structure was built using wooden poles for support, 12 ft tall in the center and 8 ft at the sides. Two soilless systems were used: a) a horizontal system, which consisted of wooden boxes with a volume of 42 gal per box, and b) a vertical system with three levels of 1-gal containers per plot (Verti-Gro® Hydroponic Growing Systems, Summerfield, FL). The media used were fine-grade coconut coir (Botanicoir, London, UK), 1-inch-diameter pine bark (Elixson Wood Products, Starke, FL), perlite, and potting mix (65% sphagnum peat moss + 35% perlite, vermiculite, and dolomitic limestone; Fafard 2, Fafard, Agawam, MA).

Bare-root 'Strawberry Festival' strawberry transplants from a Canadian nursery were planted in Oct. 2011. No preplant fertilizer was used. After transplanting, overhead irrigation was used for 8 h/d for the first 10 d to ensure plant establishment. Fertilization and pest control were done according to the requirements of the crop (Santos et al., 2011). For the vertical system, fertigation was applied through a single emitter per tower (250 mL/min), while two drip tape lines were used for the horizontal system (0.23 gal/100 ft per min). The nethouse area was equipped with 4 gal/min sprinklers for frost protection and crop establishment.

Treatments consisted of the four soilless media for each separate experiment (vertical and horizontal systems). The experimental design for each experiment was a randomized complete block with four replications and 12 plants per plot. Leaf greenness was measured with a SPAD-502 (Minolta, Ramsey, NJ). Numerical SPAD (Soil Plant Analysis Development) values range between 0 and 80, with 80 = dark green. These values are used to estimate chlorophyll content in leaves. Leaf greenness was taken from five mature leaves per treatment at 6, 12, and 18 weeks after transplanting (WAT). A mature, marketable strawberry was a fruit with the attached calyx, a minimum of 80% red skin, over 10 g in weight, and free of mechanical defects, insects, and diseases. Marketable fruit weight and number were collected two times per week for a total of 25 harvests during the season. Early yield was considered to be the fruit weight and number for the first six harvests, and the total yield included all the harvests. Harvesting started on 22 Dec. 2011 and finished on 15 Mar. 2012. Collected data were analyzed using the general linear model procedure. Treatment means were separated using Fisher's-protected least significant difference test at the 5% level.

Results and Discussion

For the vertical growing system, there were no significant differences for leaf greenness at 6, 12, and 16 WAT among all treatments, with SPAD values ranging from 37.4 to 48.4 (Table 1). For early yield, there were no significant differences among treatments for fruit number per plant, with an average of 9.6 fruit per plant, but there were significant differences among treatments for early fruit weight. There were no early fruit weight differences among containers filled with coconut coir, potting mix or perlite, ranging from 126.1 to 172.9 g/plant. Plants growing in pine bark produced less early fruit weight than those growing in coconut coir and potting mix. The potting media affected the total fruit number and weight in the vertical system (Table 1). Containers filled with coconut coir or potting mix had higher total fruit number and weight than those filled with pine bark, averaging 34.2 fruit per plant and 548 g/plant, respectively.

In the horizontal system, there were marginal differences in leaf greenness during the season with a media effect only at 12 WAT, when plants growing in perlite had the greenest leaves in comparison with the other media (Table 2). There were no significant differences among treatments for early and total fruit numbers and weight per plant. For early fruit yield, treatments averaged 7.2 fruit per plant and 121.4 g/plant for fruit number and weight, respectively, whereas each plant produced approximately 46 fruit and 784 g during the season. These results indicate that

Table 1. Effects of soilless media in a vertical production system on leaf greenness at 6, 12, and 16 weeks after transplanting (WAT), and early (6 harvests) and total yield (25 harvests) for strawberries in Balm, FL, 2011–12 season.

	Leaf greenness (SPAD value)			Early yield		Total yield	
Media	6 WAT	12 WAT	16 WAT	No. of fruit/plant	g/plant	No. of fruit/plant	g/plant
Pine bark	43.3	44.5	45.2	6.7	89.1 b[z]	21.8 b	295.4 b
Coconut coir	37.4	46.3	45.5	11.4	172.9 a	33.7 a	527.0 a
Potting mix	37.4	41.7	43.8	11.0	162.0 a	34.7 a	568.6 a
Perlite	45.3	48.4	46.6	9.2	126.1 ab	29.4 ab	418.1 ab
P < 0.05	NS	NS	NS	NS	*	*	*

[z]Values followed by the same letters do not significantly differ at the 5% level, according to the Fisher's-protected least significant difference test.
[NS, *]Nonsignificant and significant, respectively.

Table 2. Effects of soilless media in a horizontal production system on leaf greenness at 6, 12, and 16 weeks after transplanting (WAT), and early (6 harvests) and total yield (25 harvests) for strawberries in Balm, FL, 2011–12 season.

	Leaf greenness (SPAD value)			Early yield		Total yield	
Media	6 WAT	12 WAT	16 WAT	No. of fruit/plant	g/plant	No. of fruit/plant	g/plant
Pine bark	36.0	41.0 b[z]	37.7	5.8	97.0	46.0	781.4
Coconut coir	34.2	40.2 b	39.5	6.3	107.9	45.5	785.1
Potting mix	34.7	41.6 b	39.4	8.9	155.4	47.1	795.6
Perlite	37.9	47.7 a	43.0	7.9	125.1	46.1	771.9
P < 0.05	NS	*	NS	NS	NS	NS	NS

[z]Values followed by the same letters do not significantly differ at the 5% level, according to the Fisher's-protected least significant difference test.
[NS, *]Nonsignificant and significant, respectively.

for vertical systems, coconut coir, perlite, and potting mix are reliable growing media for strawberry production in a nethouse. In contrast, these preliminary results suggest that for horizontal systems, all four growing media were appropriate to produce the crop at a commercial level. Although the two studies were conducted separately, the media, source of plants, timing, and cultural management were similar. In this case, the fruit yields in the vertical system were lower than those obtained in the horizontal system, which hinted at the need for modified fertilization, irrigation, and management practices for production in the vertical setting. Therefore, more research is needed to address the relatively low yields in the vertical system compared with the horizontal setting.

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