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Horticultural Potential of Producing Florida Strawberry Cultivars under High Tunnels

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Protected strawberry (*Fragaria ×ananassa* Duch.) production is widely used in Europe and other parts of the world. However, in California and Florida open-field production remains the main production system. Strawberry production in high tunnels could potentially increase yield, improve fruit quality, promote early ripening, reduce pest incidence and rain damage. If adopted in Florida, this technology would open new opportunities for long-term changes on strawberry production practices and an eventual increase in grower profits. The objective of this study was to compare growth, fruit earliness and yield of strawberry cultivars grown under tunnels and in open fields. The cultivars 'Strawberry Festival', 'Winter Dawn' and 'Florida Elyana' were tested inside of 16-ft high tunnels and in open fields during the 2007–08 season. Results showed that total marketable yields of 'Strawberry Festival', 'Winter Dawn', and 'Florida Elyana' increased by 39%, 87%, and 85%, respectively, in tunnels, compared with the open fields in the 2007–08 season when freeze temperatures occurred.

Florida is the second largest strawberry producer in the U.S. after California, with over 7000 acres under production, and sales over $330 million (USDA, 2007). About 95% of the acreage is located on Hillsborough County. Florida produces strawberries between November and late March, and it is the main domestic supplier during winter. Winter production in the state can be strongly affected by weather, especially by low temperatures or freeze, diminishing yields and grower profits. Fruit produced early in the season allows growers selling fruit at premium prices (Santos et al., 2007).

The main production system used in the U.S. is open field, while in Europe high tunnel, mini-tunnel, and greenhouse systems are used (Santos et al., 2008). High tunnels are unheated, plastic covered, solar greenhouses, where ventilation is passive through roll-up side walls (Orzolek et al., 2004). High tunnel production could potentially improve strawberry yield, enhance fruit quality, reduce disease, insect and mite incidence, weed interference, rain damage, and promote early ripening (Chism, 2002; Jett, 2007; Kadir et al, 2006; Ozdemir and Kaska, 1997; Voca et al, 2007). Another benefit of protected agriculture is that it may diminish the effect of cold weather during Dec., Jan. and Feb. in Florida.

However, the benefits of high tunnels for strawberry production need to be investigated in Florida. Shifts on cultivar adaptability and growth patterns may change due to variations in tunnels on photosynthetic active radiation, temperature, relative humidity, and air movement. The objectives of this study are to compare the growth, fruit earliness and yields of three Florida strawberry cultivars 'Strawberry Festival', 'Winter Dawn,' and 'Florida Elyana' under high tunnels and open field growing conditions.

Materials and Methods

This study was conducted during the 2007–08 strawberry season at the Gulf Coast Research and Education Center of the University of Florida. The soil is a fine sandy Spodosol with <1.5% organic matter and pH of 7.2. Planting beds were pre-formed with a standard bedder, 28 inches wide at the base, 24 inches wide on the top, and 8 inches high. In Sept. 2007, the soil was fumigated with 350 lb/acre of methyl bromide + chloropicrin (67/33, v/v). Beds were covered with black high-density polyethylene mulch after injection of the fumigant. No pre-plant fertilizer was used. Fertilization and pest control was done according the requirements of the crop (Peres et al., 2006). Fertigation was applied trough a single-drip tape line (0.45 gal/100 ft/min) buried 2 inches, and the experimental area was equipped with 4 gal/min sprinklers for frost protection and crop establishment.

Six treatments were tested using three strawberry cultivars and two production systems. The experimental design was a split-plot design with 4 replications with the production system in the main plots, and cultivars in the subplots. The production systems used were high tunnels and open-field; and the cultivars were 'Strawberry Festival', 'Winter Dawn', and 'Florida Elyana'. One-half of an acre of passively ventilated tunnels 16 ft-high and 300 ft long were utilized for this study (Haygrove Tunnels, Herefordshire, United Kingdom). Bare-root strawberry transplants from nurseries in Canada were planted in 15 Oct. 2007 in double rows 15 inches apart, 20 plants per 25-ft plot. After transplant-

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ing, overhead irrigation was used for 8 hours for the first 10 d to ensure plant establishment.

Strawberry plant diameter were determined at 11 and 15 weeks following transplanting, as well as marketable fruit weight and number, two times per week for a total of 30 harvests during the season. Early yield was considered as the yield from the first 12 harvests, and the total yield included the 30 harvests through the season. Collected data were analyzed using SAS general linear model procedure to determine factor main effects and interactions among factors. Treatment means were separated using a Fisher's protected LSD test at the 5% significance level.

Results and Discussion

Production systems and cultivars had significant effects on strawberry plant diameter and early and total yields. However, the interaction between both factors was not significant. Plants grown inside the tunnels were 17% and 13% wider than those outside the tunnels at 11 and 15 weeks after transplanting, respectively (Figs. 1 and 2). 'Strawberry Festival' had the largest plant diameter with 11 and 13 inches, followed by 'Winter Dreawn' with 9 and 12 inches, and 'Florida Elyana' with 9 and 10 inches at 11 and 15 weeks, respectively.

Early yields of 'Strawberry Festival', 'Winter Dawn', and 'Florida Elyana' increased by 47%, 57%, and 114%, respectively, in early yield grown under tunnel conditions. 'Strawberry Festival' had the highest early yield followed by 'Winter Dawn' and 'Florida Elyana', with early yields of 3.2, 2.2, and 3.8 ton/acre, respectively (Fig. 3). Total yields of 'Strawberry Festival', 'Winter Dawn', and 'Florida Elyana' increased by 39%, 87%, and 85%, respectively, inside the tunnels compared with the open fields. 'Strawberry Festival' had the highest yield followed by 'Winter Dawn' and 'Florida Elyana', with total yields of 13.9, 10.6, and 8.6 ton/acre, respectively (Fig. 4).

The differences between the results in the two production systems can be related to the protection that high tunnels provide to the crop. Plants inside tunnels were protected against low temperatures, rain and wind. In early January, minimum temperatures were 29 and 32 °F outside and inside the tunnels, respectively. The difference in temperatures inside tunnels as compared with open fields usually varies from 2 to 15 °F. Tunnels also affect photosynthetic active radiation, with values of 797 and 1161 $\mu mol \cdot m^{-2} \cdot s^{-1}$ for inside and outside the tunnels, respectively. Plants inside tunnels had larger diameter, which translated to larger photosynthetic area than plants in open field.

Overall, the strawberry response under the two production

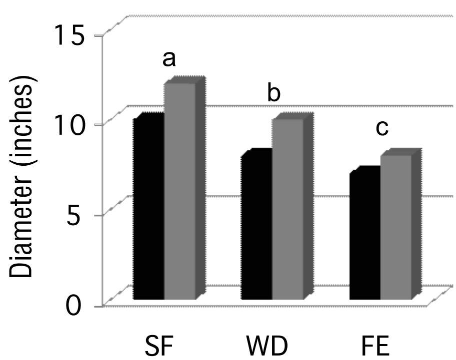

Fig. 1. Effect of high tunnels (HT) and field production systems on plant diameter at 11 weeks after transplanting on three strawberry cultivars 'Strawberry Festival' (SF), 'Winter Dawn' (WD) and 'Florida Elyana' (FE), 2007–08, Balm, FL. Values followed by the different letters represent significant differences across cultivars within the same production system. There are no interactions effects, and high tunnel was different than open field for all cultivars.

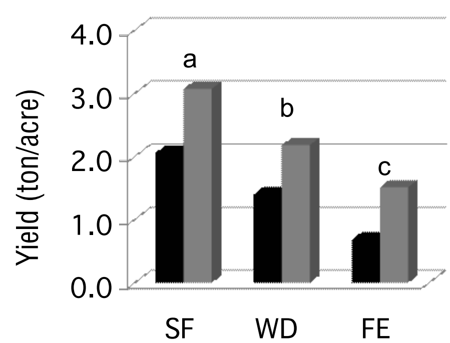

Fig. 3. Effect of high tunnels (HT) and field production systems on early yields (first 12 harvests) for three strawberry cultivars 'Strawberry Festival' (SF), 'Winter Dawn' (WD) and 'Florida Elyana' (FE), 2007–08, Balm, FL. Values followed by the different letters represent significant differences across cultivars within the same production system. There are no interactions effects, and high tunnel was different than field production for all cultivars.

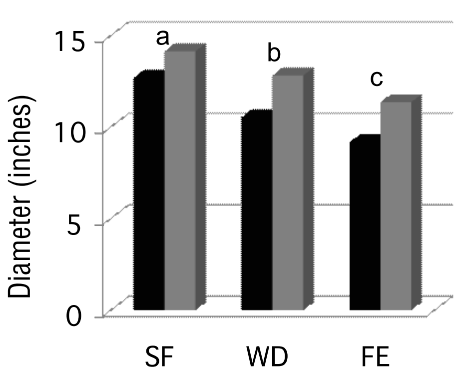

Fig. 2. Effect of high tunnels (HT) and field production systems on plant diameter at 15 weeks after transplant for three strawberry cultivars 'Strawberry Festival' (SF), 'Winter Dawn' (WD) and 'Florida Elyana' (FE), 2007–08, Balm, FL. Values followed by the different letters represent significant differences across cultivars within the same production system. There are no interactions effects, and high tunnel was different than field production for all cultivars.

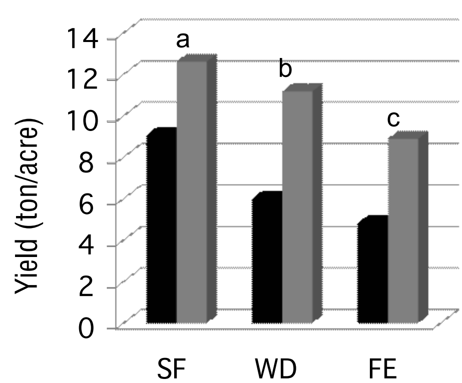

Fig. 4. Effects of high tunnels (HT) and field production systems on total yields (30 harvests) for three strawberry cultivars 'Strawberry Festival' (SF), 'Winter Dawn' (WD) and 'Florida Elyana' (FE), 2007–08, Balm, FL. Values followed by the different letters represent significant differences across cultivars within the same production system. There are no interactions effects, and high tunnel was different than field production for all cultivars.

systems suggested that high tunnels could be an alternative to the growers to improve early and total yields of strawberries and potentially increasing profits. However, this alternative system needs to be further validated for horticultural and economic feasibility.

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