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Using Low-volume Irrigation Programs and Crop Protectants to Establish Strawberry Transplants

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Strawberry (*Fragaria ×ananassa*) production in Florida relies on bare-root transplants to establish the crop between September and October. During strawberry establishment, sprinkler irrigation is applied during 10 to 14 consecutive days to cool down strawberry crowns and provide moisture to promote new roots and shoots. This activity consumes approximately 540,000 gal/acre of water. Two studies were conducted to assess the influence of low-volume sprinklers and crop protectants on required water volumes during transplant establishment. The effects of various irrigation programs using high impact and mini-sprinklers [continuous irrigation at 4.5 gal/min, continuous irrigation at 1.5 gal/min, and intermittent irrigation (10 minutes on and 10 minutes off) at 1.5 gal/min] were evaluated for strawberry transplant establishment. There were no significant differences among treatments, with an average early yield of 1.9 tons/acre. Kaolin clay was also evaluated as a crop protectant for strawberry transplants at six grower fields. Treatments were: a) 10 days of sprinkler irrigation as the control and b) 7 days of sprinkler irrigation with application of kaolin clay on the 8th day. Establishment, leaf greenness, and plant diameter were measured between 2 and 3 weeks after transplanting. There was no difference between the treatments with 99.5% of establishment. These two technologies have the potential to reduce water volumes for strawberry establishment by 16% to 33%, which is equivalent to 600 to 1000 million gal of water per season.

Strawberry production in Florida occupies the second position among suppliers in the U.S. during the winter season, with Florida providing 90% of all the fruit for the country. The total planted area is approximately 9900 acres, concentrated around Plant City and Dover in Hillsborough County, about 90% of the total state acreage and representing $362 million in gross sales per season (USDA, 2011). The primary water source in this area is underground water, which is shared between agricultural production and urban uses. Water savings during transplant establishment may allow growers to reduce water pumping costs or to have more water available for use during other crop stages.

For strawberry transplant establishment, the most common method is setting bare-root transplants from northern nurseries into fumigated polyethylene mulched beds, and using sprinkler irrigation for 8 to 10 h/day for the first 10 to 12 d. The reason for this water application is to maintain a microclimate that cools down crowns and provides enough moisture to promote growth of new roots. This practice consumes water at about 16 to 20 acre-inches/acre per season (1 acre-inch = 27,154 gal). The establishment phase accounts for up to one-third of the total season use of water on the strawberry crop (Hochmuth et al., 2006). These studies focused on how water volumes used during transplant establishment could be reduced using new technologies such as low-volume sprinklers and crop protectants. Sprinklers delivering water at 4.5 gal/min is a standard practice during strawberry establishment and freeze protection, although this is highly inefficient due to the large volumes of water, most of which ends up running off to the drainage canals and leaching nutrients from the root zone to the water table (Bish et al., 1997). Low-volume sprinklers providing 1.5 gal/min have the potential to make this practice more efficient.

Kaolin clay is a natural degradable mineral, which forms a white film on the leaves that reflects infrared and ultraviolet radiation, thus reducing heat stress in new transplants. Previous studies combining days of irrigation and kaolin clay application showed that either 6 or 8 d of sprinkler irrigation plus kaolin clay application on the next day resulted in the same establishment as 10 d of sprinkler irrigation (Santos et al., 2012). The objectives for these studies were: a) evaluate the effect of reduced-volume irrigation programs for strawberry establishment and early yields, and b) validate the effect of kaolin clay on the strawberry establishment and plant growth in grower fields.

Materials and Methods

Small plot establishment trial

A field study was conducted in the 2011–12 season at the Gulf Coast Research and Education Center in Balm, FL. The soil at the experimental site is a Myakka fine sand siliceous hyperthermic Oxyaquic Alorthod with <1.5% organic matter and pH of 6.6. Prior to the experiment, the soil was tilled twice at an approximate depth of 8 inches to ensure proper soil structure. In late August 2011, planting beds were formed with a standard bedder that were 27 inches wide at the base, 24 inches wide at the top, 8 inches high, and 4 ft apart on the centers. Simultaneously with bedding, the soil was fumigated with methyl bromide plus chlo-

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ropicrin (67:33 v/v) at a rate of 350 lb/acre. Two drip lines (0.12 gal/100 ft per min, 12 inches between emitters; T-Tape Systems International, San Diego, CA) were buried 2 inches below the surface at 8 inches from the bed edges. Beds were then covered with high-density, black, polyethylene mulch (0.025-mm thick; Intergro Co., Clearwater, FL).

'Treasure' bare-root transplants with three to five leaves from a Canadian nursery were planted in early Oct. 2011. The transplants were set in double rows, 15 inches apart. Treatments were: a) intermittent irrigation with sprinklers delivering 1.5 gal/min (10 min on and 10 min off), b) continuous irrigation with sprinklers delivering 1.5 gal/min, and c) continuous irrigation with sprinklers delivering 4.5 gal/min (control). Irrigation was turned on for 10 h/day for the first 10 d during establishment. The fertilization program followed current recommendations for strawberry production in Florida (Peres et al., 2010). Plots were 17.5 ft long with 30 plants (20 plants were used for harvest and 10 plants were used for measuring root biomass) with three replications. Leaf number and fresh root weight were measured 2 weeks after transplanting (WAT). Plots were harvested twice a week and marketable fruit were defined as being over 10 g in weight and physiologically mature, free of defects or disease injury, with more than 80% of the fruit dark red. For early yield, marketable fruit weight and number were collected for the first eight harvests.

Large plot validations in grower fields

A study was conducted in the Plant City and Dover area at six growers' farms covering 16 acres. Bare-root strawberry transplants were established between the first and second weeks of Oct. 2011. Treatments were: a) 7 d of sprinkler irrigation delivering 4.5 gal/min of water plus kaolin clay applied on the 8th day at a rate of 25 lb/acre in 60 gal of water, and b) 10 d of sprinkler irrigation delivering 4.5 gal/min of water (control). Plots were between 400 and 600 plants per treatment with six replications (one for each farm). Kaolin clay (Surround WP, Tessenderlo and Kerley Inc., Phoenix, AZ) was applied on the foliage of transplants with a conventional foliar nutrient sprayer. No other special equipment was needed. Plant number, leaf greenness, and canopy diameter were measured between 2 and 3 weeks after kaolin clay application. Data from both studies were analyzed using a general linear model ($P < 0.05$) and treatment values were separated using Fisher's protected least significant difference test (Statistix Analytical Software, version 9, Tallahassee, FL).

Results and Discussion

Small plot establishment trial

There were no significant differences among treatments in early yield and fruit number regardless of the water volumes or intermittent scheduling. Early yield averaged 1.9 tons/acre and fruit number averaged 10,118 fruit/acre (Table 1). The treatments did not affect fresh root weight and leaf number. Fresh root weight at 2 WAT averaged 101 g and leaf number at 2 WAT averaged five leaves per plant. Water savings in this study ranged from 33% with low-volume intermittent irrigation to 16% with low-volume constant irrigation, which would be equivalent to 608 and 1254 million gal per season in the Plant City–Dover area.

With low-volume sprinklers, the water volume provided was enough to cool down the crowns and provide enough moisture to avoid heat stress in the transplants. In addition, by reducing water volume during establishment, growers may: a) have more water available for freeze protection during the season or b) opt for lower water use and therefore lower irrigation costs.

Validations in grower fields

There were no significant differences in the number of established plants between treatments, with about 99.5% plant survival (Table 2). Kaolin clay application did not affect leaf greenness and canopy diameter. Leaf greenness averaged a SPAD value of 43 and mean canopy diameter was 26 cm. With this technology, water savings were about 30%, which would be the equivalent to 1140 million gal per season in the Plant City–Dover area. Based on yield reports from cooperating growers, this technology did not have a negative impact on early yield or plant growth compared with the standard practice of 10 d of sprinkler irrigation.

These results are supported by previous studies with strawberries and other crops in which kaolin clay application resulted in

Table 1. Effects of irrigation programs on the leaf number, fresh root weight, early fruit weight and early fruit number during the establishment of bare-root strawberry transplants in Balm, FL during the 2011–12 season.

Irrigation program	Leaf no. at 3 WAT[z] (no./plant)	Fresh root wt at 3 WAT (g/10 plants)	Early fruit wt (ton/acre)	Early fruit no. (no./acre)
1.5 gal/min intermittent	5	100	1.7	9388
1.5 gal/min continuous	5	105	1.8	9971
4.5 gal/min (control)	4	98	2	10997
Significance ($P < 0.05$)	NS	NS	NS	NS

[z]WAT = weeks after transplanting. Early yield was the result of the first eight harvests.
[NS]Nonsignificant at $P < 0.05$ according to the analysis of variance.

Table 2. Effects of transplanting establishment practices on the average established plant number per farm, leaf greenness, and plant diameter between 2 and 3 weeks after kaolin clay application in six grower farms in the Plant City and Dover area, Hillsborough County, FL, in 2011–12.

Transplanting establishment practice	Established plant no. per farm (no./farm)	Leaf greenness (SPAD value)[z]	Plant diam (cm)
7 days of sprinkler irrigation + kaolin clay on the 8th day	444	44	26
10 days of sprinkler irrigation	440	43	26
Significance ($P < 0.05$)	NS	NS	NS

[z]SPAD = soil analysis plant development.
[NS]Nonsignificant at $P < 0.05$ according to the analysis of variance.

reduced heat stress and vapor pressure deficit in the treated plants (Glenn et al., 2002; Jifon and Syversten, 2003; Santos et al., 2012). With both of these technologies (i.e., low-volume sprinklers and intermittent irrigation) growers may have an alternative to reduce water use and pumping costs during strawberry transplant establishment. Further studies are needed combining these two technologies to improve water savings during strawberry transplant establishment and to assess the economic impact of this practice.

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