



Comparison of Foliar and Root-dip Crop Protectants for Strawberry Transplant Establishment

IXCHEL M. HERNANDEZ-OCHOA AND BIELINSKI M. SANTOS*

University of Florida, IFAS, Gulf Coast Research and Education Center, 14625 CR 672, Wimauma, FL 33598

ADDITIONAL INDEX WORDS. *Fragaria xananassa*, kaolin clay, calcium carbonate, aluminum silicate, water absorbent polymer, biofungicide, water management, heat stress

During strawberry transplant establishment, the standard practice is the use of sprinklers delivering water at 4.5 gal/min. This activity is highly inefficient due to the use of large volumes of water with only an estimated 3% of the water ending up in the planting holes. The objective of these studies was to determine the effects of using foliar and root-dip crop protectants on strawberry transplant establishment growth, early marketable yield, and water savings. Two studies were conducted to assess the effect of foliar and root-dip crop protectants as alternatives to reduce water volumes used during this crop stage. For the first study, treatments were: 1) 10 days of sprinkler irrigation (DSI) as a control, 2) 7 DSI, 3) kaolin clay, 4) aluminum silicate, and 5) calcium carbonate. The crop protectants were applied on the plant canopy during the morning after 7 DSI. There was non-significant difference among the treatments with yield of 6 tons/acre and 226,000 fruits, except for the treatment with 7 days of sprinkler irrigation, which had the lowest yield (4.7 tons/acre and 187,930 fruits). For the second study, a water absorbent polymer and a biofungicide as root-dip crop protectants were compared with 10 and 7 DSI. Both crop protectants were applied at transplanting and were followed by 7 DSI. There were no significant differences among the treatments in yield, averaging 4.3 tons/acre, except for the 7 DSI control, which was 16% lower than the rest of the treatments. Crop protectants are suitable alternatives to reduce water usage during transplant establishment.

Florida is the second largest strawberry (*Fragaria xananassa*) producer in the U.S. with \$366 million in gross sales in the 2011–12 season (USDA, 2012). During the winter season, Florida supplies 90% of the market for the United States (Boriss et al., 2006). Production is concentrated in Plant City and Dover with approximately 10,000 acres. The primary water source in this area is underground water, which is shared between agricultural production and urbanization. During strawberry establishment, the standard practice is using sprinklers delivering water at 4.5 gal/min. Sprinkler irrigation is used from 8 to 12 h/day during the first 10 days to provide a microclimate that cools down crowns and promotes new root growth. This activity consumes about 540,000 gal/acre of water, which is equivalent to one-third of the total water use for strawberry production (Albregts and Howard, 1985). Most of the applied sprinkler irrigation water ends up running off to the drainage canals, leaching nutrients from the root zone or lowering the water table, causing water deficit that may result in sinkholes and dried wells in urbanized areas (Bish et al., 1997; Domoto, 2006; Hochmuth et al., 1986).

Crop protectants for transplant establishment can be used either with foliar or root-dip application, depending on the nature of the material. Foliar crop protectants are usually based on naturally-occurring materials such as kaolin clay, aluminum silicate, and calcium carbonate. These products are applied to the foliage, creating a white film that reflects radiation and reduces heat and water stress on the transplants. Previous studies with strawberries, apples (*Malus domestica*), grapefruit (*Citrus paradisi*) and tomato (*Solanum lycopersicum*) showed that these coatings reduce transpiration, leaf temperature, and sun scalding on fruit (Glenn et al. 2003; Melgarejo et al., 2003).

Polymers are materials based on water-absorbent crystals that can absorb 100 to 1000 times of water in weight. They are used to establish new seeds especially in dry, arid areas where water is a limited resource. The polymer concentrates moisture around the root system promoting new growth. They can last between 5 to 7 years in the soil and they break down into ammonium, carbon dioxide, and water (Ekebafe et al., 2011). Hodges et al. (2006) determined that the application of a water absorbent polymer on muskmelon (*Cucumis melo*) enhanced plant growth and plant survival after transplant.

Biofungicides based on plant extracts such as knotweed (*Reynoutria sachalinensis*) may be another alternative for transplant establishment to control fungal and bacterial diseases on strawberries, tomatoes, and blueberries (*Vaccinium* spp.) (Hai, 2012; McGovern et al., 2012).

The objective of these studies was to determine the effects of using foliar and root-dip crop protectants on strawberry transplant establishment growth, early marketable yield and water savings.

Materials and Methods

Both studies were conducted in the 2012–13 season at the Gulf Coast Research and Education Center of the University of Florida 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 approximate 8 inches deep to ensure proper soil structure. In late Aug. 2012, 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 in the centers. Simultaneously with bedding, the soil was fumigated with 1,3-dichloropropene plus chloropicrin (40:60 v/v) at a rate of 300

*Corresponding author; phone: (813) 633-4128; bmsantos@ufl.edu

lb/acre. One drip tape line (0.23 gal/100 ft per min, 12 inches between emitters; T-Tape Systems International, San Diego, CA) was buried 2 inches below the surface at 8 inches from the bed edges. Beds were covered with high density black polyethylene mulch (0.025-mm thick, Intergro Co., Clearwater, FL). Transplants were set in double rows with 12-inches spacing within each row, and the rows were 15 inches apart.

Plant nutrients (N, K, Mg, Fe, Zn, B, and Mn) were applied under non-limiting conditions following the current recommendations for the crop in the state (Santos et al., 2011), starting at 2 weeks after transplanting (WAT) and applied through the drip lines daily with a hydraulic injector (Dosatron, Clearwater, FL). Irrigation lines were pressurized at 10 psi. Irrigation volumes were equivalent to the average reference evapotranspiration for the area from October to March, and they were split equally into two daily irrigation cycles starting at 8:00 AM and 1:00 PM, respectively (Simonne and Dukes, 2009). Recommendations for insect and disease control were followed depending on pest pressure (Santos et al., 2011).

Bare-root transplants with three to five leaves were brought from nurseries in Canada (Lareault Nursery, Lavaltrie, Quebec, Canada). ‘Strawberry Festival’ transplants for the foliar crop protectant trial were planted on 9 Oct. 2012. ‘Florida Radiance’ was used for the root-dip crop protectant trial, and they were set in the field on 16 Oct. 2012. Each plot consisted of 12.5-ft-long rows with 20 plants and 5-ft alleys between each plot with four replications. Experimental area was set with 4.5 gal/min sprinkler heads spaced 48 ft apart. Immediately after transplanting, sprinkler irrigation was turned on at 8:00 AM each morning for 8 h/day.

For the foliar crop protectant study, treatments were as follows: 1) 10 d of sprinkler irrigation (DSI) (control), 2) 7 DSI, 3) kaolin clay (Surround WP, Tessengerlo Kerley Inc., Phoenix, AZ) at 25 lb/acre, 4) aluminum silicate (Screen Duo WP, Crop Microclimate Management Inc., Apex, NC) at 10 lb/acre, and 5) calcium carbonate (Purshade, Tessengerlo Kerley Inc.) at 3 gal/acre. Foliar crop protectants were dissolved in 60 gal of water and applied on the plant canopy on the next day after 7 DSI.

For the root-dipped crop protectant study, a water absorbent polymer (SuperSorb F, Aquatrols, Paulsboro, NJ) and a biofungicide (Regalia, Marrone Bio Innovations Inc., Davis, CA) root-dip crop protectants were compared to 7 and 10 DSI. SuperSorb F and Regalia were applied at the moment of transplanting at the rate of 10 and 3.5 g/L of water, respectively. Sprinkler irrigation was turned on immediately after transplanting for 7 d. Both experiments were set in a randomized complete-block design with four replications.

To assess the effect of treatments on strawberry growth and

development, five randomly selected plants avoiding borders were chosen to measure canopy plant diameter at 4, 8, and 12 weeks after transplanting (WAT). The same plants were used for the three observations. Canopy plant diameter was measured perpendicular to the direction of the rows. The plots were harvested twice a week on Mondays and Thursdays, and marketable fruit was defined as fruit over 10 g in weight, physiologically mature with more than 80% fruit dark red, and free of defects or disease injury. Early and total marketable fruit weight and marketable fruit number were collected for the first 10 and 30 harvests, respectively. Maximum and minimum temperatures between 6 to 10 inches above the canopy level were monitored for each treatment with data loggers (HOBO data loggers, Onset Corp., Bourne, MA). Data were analyzed using general linear model ($P \leq 0.05$) and treatment values were separated using Fisher’s protected least significant difference tests (Statistix Analytical Software, version 9, Tallahassee, FL).

Results and Discussion

FOLIAR CROP PROTECTANTS. There was no evidence of treatment effect for plant diameter at 4 WAT, with an average of 16 cm. However, at 8 and 12 WAT, treatments with the crop protectant application had higher plant diameter with an average of 36 and 39 cm, respectively (Table 1). For early yield, there was no significant difference among the treatments in early fruit weight and number with an average of 6 tons/acre and 226,000 units, except for the treatment with 7 DSI, which had the lowest value with 4.7 tons/acre and 187,930 fruits (Table 1). Crop protectants decreased the plant canopy temperature between 2 and 8 °F. The amount of water applied for 7 DSI negatively affected strawberry transplants, the crop protectant application improved transplant establishment. Similar results were found in a previous experiment with strawberries where, either 7 or 8 DSI followed by the application of kaolin clay resulted in 98% plant survival and no significant difference in early yields (Santos et al., 2012).

ROOT-DIP CROP PROTECTANTS. There was no significant difference among the treatments for plant diameter at 4 WAT with an average of 17 cm, except for the 7 DSI treatment, which had the lowest value with 13 cm. At 8 WAT there was no significant difference among the treatments with an average diameter of 35 cm. However, at 12 WAT root-dip treatments had the highest plant diameter compared to the water treatments (Table 2). In early yield there was no significant difference among the treatments in fruit weight with an average of 4.3 tons/acre, except for the 7 DSI, which was 16% lower than the rest of the treatments (Table 2). For fruit number, there was no significant difference among

Table 1. Effects of foliar crop protectants on plant diameter, and total early fruit number and weight of bare-root ‘Strawberry Festival’ strawberry transplants, 2012–13. Balm, FL.

Treatments	Plant diameter			Early yield ^a	
	4 WAT (cm)	8 WAT (cm)	12 WAT (cm)	Fruit wt (ton/acre)	Fruit no. (no./acre)
10 DSI (control)	16	33 b	36 b	5.9 a	224,340 a
7 DSI	16	36 ab	39 ab	4.7 b	187,930 b
7 DSI + Surround on the 8th day	15	37 a	40 ab	6.5 a	232,290 a
7 DSI + Screen Duo on the 8th day	17	37 a	39 ab	5.4 ab	211,840 ab
7 DSI + PurShade on the 8th day	17	36 ab	39 a	6.3 a	235,770 a
Significance ($P \leq 0.05$)	NS	*	*	*	*

^aEarly yield was the result from the first 10 harvests. DSI = days of sprinkler irrigation; WAT = weeks after transplanting.

NS. *Nonsignificant or significant at $P < 0.05$, respectively.

Table 2. Effects of root-dip crop protectants on plant diameter and total early fruit number and weight of 'Florida Radiance' strawberry transplants, 2012–13, Balm, FL.

Treatments	Plant diameter			Early yield ^a	
	4 WAT (cm)	8 WAT (cm)	12 WAT (cm)	Fruit weight (ton/acre)	Fruit no. (no./acre)
10 DSI (control)	16 b	33	36 b	4.6 a	164,430 b
7 DSI	13 c	34	37 b	3.6 b	169,650 ab
Dip transplants in Regalia + 7 DSI	16 b	37	41 a	4.3 a	194,880 a
Dip transplants in Supersorb + 7 DSI	19 a	37	41 a	4.1 ab	187,920 ab
Significance ($P \leq 0.05$)	*	NS	*	*	*

^aEarly yield was the result from the first 10 harvests. DSI = days of sprinkler irrigation; WAT = weeks after transplanting.

NS. *Nonsignificant or significant at $P < 0.05$, respectively.

treatments with 184,150 fruit, except for the 10 DSI treatment with 164,430 fruit. Using 7 DSI resulted in the lowest fruit weight but higher fruit number. Hodges et al. (2006) reported an increase in early growth in muskmelon after at 3 weeks after the application of a water absorbent polymer. Root-dip applications are a viable alternative to reduce water usage during transplant establishment.

These technologies may allow strawberry growers to save up to 30% of the water volume used for transplant establishment, which would be equivalent to 1.8 billion gal of water in the Plant City and Dover area. Combining this technology with intermittent irrigation is another alternative to increase the amount of water savings during this stage. However, research is needed to validate this practice.

Literature Cited

- Albregts, E.E. and C.M. Howard. 1985. Effect of intermittent sprinkler irrigation on establishment of strawberry transplants. *Soil Crop Sci. Soc. Fla. Proc.* 44:197–199.
- Bish, E.B., D.J. Cantliffe, G.J. Hochmuth, and C.K. Chandler. 1997. Development of containerized transplants for Florida's winter production system. *Acta Hort.* 439:461–468.
- Boriss, H., H. Brunke, and M. Kreith. 2006. Commodity profile: Strawberries. Agricultural Issues Center. Univ. of California. 10 Oct. 2012. <<http://aic.ucdavis.edu/profiles/Strawberries-2006.pdf>>.
- Domoto, P. 2006. Frost protection for fruit crops. University Extension. Iowa State Univ. 10 Oct. 2012. <<http://viculture.hort.iastate.edu/info/06iawgmtg/frostprotectionhandout.pdf>>.
- Ekebafe, L.O., D.E. Ogiefun, and F.E. Okieimen. 2011. Polymer applications in agriculture. *Biokemistri* 23:81–89.
- Glenn, M.D., A. Erez, G.J. Puterka, and P. Gundrum. 2003. Particle films affect carbon assimilation and yield in 'Empire' apple. *J. Amer. Hort. Sci.* 128:356–362.
- Hai, S. 2012. Regalia bioprotectant in plant disease management. *Outlooks on Pest Mgt.* 23:30–34.
- Hochmuth, G.J., S.R. Kostewics, S.J. Locascio, E.E. Albregts, C.M. Howard, and C.D. Stanley. 1986. Freeze protection of strawberries with floating row covers. *Proc. Fla. State Hort. Soc.* 99:302–311.
- Hodges, L., E. Daningsih, and J.R. Brandle. 2006. Comparison of an antitranspirant spray, a polyacrylamide gel, and wind protection on early growth of muskmelon. *HortScience* 41:361–366.
- McGovern K.B., S.L. Annis, and D.E. Yarborough. 2012. Efficacy of organically acceptable materials for control of mummy berry disease on lowbush blueberries in Maine. *Intl. J. Fruit Sci.* 12:188–204.
- Melgarejo, P., J.J. Martinez, F. Hernandez, R. Martinez-Font, P. Barrows, and A. Erez. 2004. Kaolin treatment to reduce pomegranate sunburn. *Scientia Horticulturae* 100:349–353.
- Poling E.B., H. P. Fuller, and K.B. Perry. 1991. Frost/freeze protection of strawberries grown on black plastic mulch. *HortScience* 26:15–17.
- Santos, B.M., N.A. Peres, C.K. Chandler, W.M. Withaker, W.M. Stall, S.M. Olson, S.A. Smith, and E.H. Simonne. 2011. Strawberry production in Florida, p. 271–281. In S.O. Olson, and B.M. Santos (eds.). *Vegetable production handbook for Florida 2011–2012*. Inst. Food Agri. Sci. Publ., Univ. of Florida, Gainesville.
- Santos, B.M., T.P. Salame, and A.J. Whidden. 2012. Reducing sprinkler irrigation volumes for strawberry transplant establishment in Florida. *HortTechnology* 22:224–227.
- Simonne, E.H., and M.D. Dukes. 2009. Principles and practices of irrigation management for vegetables, p. 17–27. In S.O. Olson, and B.M. Santos (eds.). *Vegetable production handbook for Florida 2011–2012*. Inst. Food Agri. Sci. Publ., Univ. of Florida, Gainesville.
- U.S. Department of Agriculture. 2011. Economic Research Service. U.S. Strawberry Industry. 3 Oct. 2012. <<http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1381>>.