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# Effects of Cell Size on the Production of Containerized Strawberry Transplants in Florida

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**Containerized transplants could be an alternative to bare root transplants to save 80% of water use during strawberry (*Fragaria ×ananassa* Duch.) establishment, whereas their price is double compared to bare root transplants mainly due to shipping. Daughter plants of 'Strawberry Festival' cultivar were planted into plug trays with 36, 40, 50, and 72 cells per tray. After field establishment, plants planted in 72-cell trays had smaller crown size and plant diameter than those in 36-cell trays. Early fruit weight from plants planted in 36-cell trays was similar to those in 40 and 50-cell trays, but 43% more than those in 72-cell trays. Similar total fruit number and yield were produced from plants planted in trays with 36, 40, and 50 cells, but they were at least 17% and 18% higher, respectively, than those from plants grown in trays with 72 cells.**

Strawberries are grown commercially all over the world. In 2010, the total worldwide production of strawberry was 4.1 million ton and the cultivated area was 635,000 acres (FAO, 2010). Florida growers produced the second most strawberry in the U.S. with 15% of the total harvested acreage (8,800 acres) and 7% of total production just behind California (USDA, 2011). The value of strawberries produced in Florida was more than $362 million in 2010 (USDA, 2011). Strawberry production in Florida occurs mostly in the west-central region of the state. The conventional production system uses raised beds and drip irrigation covered with black polyethylene mulch. Currently, the majority of the Florida strawberries are grown from bare root transplants planted in the fall. Because of high temperatures in September and early October in west-central Florida, overhead sprinkler irrigation is needed daily for 7 to 12 d and 8 h/day for transplant establishment (Peres et al., 2010) to reduce water stress due to rapid evapotranspiration. However, such type of establishment practice uses as much as 20 acre-inch/acre (1 acre-inch/acre = 27,154 gal) of water application (Albregts and Howard, 1985). Since water sources for strawberry production and for public use come from the same sources in this major production area, agricultural activities and residential use may compete during the production season for water volumes, which could affect agricultural sustainability.

Containerized transplants could be an alternative to bare root transplants to reduce the water consumption for plant establishment, increase early yields, faster establishment, better plant survival, and greater total yield (Durner et al., 2002), whereas they also require higher investment at the beginning of the season compared to bare root transplants. Generally, both of bare root or containerized transplants used in Florida are shipped from northern states or Canada for cool temperature conditioning. For containerized transplants, it results in fewer transplants per shipping unit but higher unit price ($0.30/plant) than bare root transplants ($0.14/plant) because of their intact root systems covered with media.

Photoperiod and temperature are generally considered as the two major factors affecting strawberry flower bud initiation (Hancock, 1999). It has been reported that short-day strawberries could be induced to flower by lower red light to far-red radiation ratio reaching the crown under long photoperiod environment without cool temperature condition (Takeda et al., 2008). This result shows the possibility for the subtropical area such as Florida to produce its own transplants for reducing shipping cost from purchasing transplants from nurseries outside the state.

Containerized transplants would be a potential option to relief the intense water use competition between agricultural and urbanization use and improve sustainability. Based on the possibility of producing containerized transplants in Florida, the potential benefits of this technology would reduce water use on plant establishment, save shipping costs, and increase net income with higher early fruit production. Thus, the objective of this study was to determine the optimal cell size for containerized strawberry transplants produced in Florida.

## Materials and Methods

A field study was conducted at the Gulf Coast Research and Education Center (GCREC) of University of Florida in Balm, FL, from Aug. 2010 to Mar. 2011. The soil of strawberry field was a fine sandy Spodosol with less than 1.5% of organic matter and a pH of 7.2. The "mother" plants of 'Strawberry Festival' were obtained from the University of Florida's strawberry breeding program at GCREC without any previous cool temperature conditioning. Daughter plants were cut from mother plants and planted into the plug trays on 16 Aug. 2010 in a greenhouse. Plugging trays had the same dimensions (21 inches long × 11 inches wide × 3 inches deep) with 36, 40, 50 or 72 cells per tray. The containerized transplants were transplanted into 11-ft plots in the field in double rows, 15 inches apart, with 20 plants per plot on 1 Oct. 2010. A completely randomized block design was used with four replications. Raised beds were built 28 inches at

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the base, 24 inches at the top, and 10 inches high on 4-ft centers. Simultaneously with bedding, the soil was fumigated with 35 gal/acre of 1,3-dichloropropene + chloropicrin (65/35, v/v) in early September. Within 1 min after fumigation, a single drip tape line (0.23 gal/100 ft per minute, T-Tape Systems International, San Diego, CA) was buried 2 inches below the surface on bed centers and beds were covered with black high-density polyethylene mulch (0.025 mm-thick, Intergro Co., Clearwater, FL). The experimental area was equipped with 4.5 gal/min sprinklers for freeze protection and transplant establishment. Overhead sprinkler irrigation was used for the first 2 d after transplanting (8 h/day) to ensure transplant establishment. The nutrition and pest managements were applied to the field according to the recommendation from Peres et al. (2010).

Greenhouse air temperature during plug plant growth and field air temperature during the whole season were recorded using data loggers (HOBO Temp/External H08-002-02, Onset Computer Cooperation, Bourne, MA). Measurements of photosynthetic active radiation (PAR) were taken using a quantum meter (Model BQM-SUN, Spectrum Technologies, Inc., Plainfield, IL) for both above and under the canopy for the plug plants in the greenhouse weekly from the third week after plugging until the week before field planting. The spectral distribution was measured to determine the red light to far red radiation ratio using StellarNet Green-wave spectrometer (StellarNet Inc., Tampa, FL) weekly from the third week after plugging until the week before field planting. After field planting, plant diameter, leaf greenness (by using portable colorimeter, model SPAD-520, Minolta, Ramsey, NJ), crown diameter, and crown number were measured at 6, 12, and 18 week after transplanting (WAT). Shoot and root biomass samples were harvested at 6 WAT, dried in a drying room at 60 °C for 3 d, and then weighed. Flower counts were recorded once plants started flowering until formal harvest began. Marketable fruit number and weight were collected from 24 harvests, which started on 29 Nov. 2010 (two harvests per week). The first 10 harvests were used to determine early production. Total soluble solid content, titratable acidity, and storage life were measured and evaluated at 12, 16, and 20 WAT. Data were analyzed using Statistix 9 software (Analytical Software, Tallahassee, FL). The general linear model procedure was chosen to determine treatment effects and standard error bars were used to separate means.

## Results and Discussion

At three days before plug plants were transplanted in the field, the red light to far red radiation ratio at the crown area for plants plugged in 36-cell trays was significantly lower (0.48) than those plugged in 40 (1.08), 50 (1.07), and 72-cell trays (1.20) (Fig. 1). Plants produced in trays with 72 cells had the smallest crowns at both 6 and 12 WAT compared to other cell sizes, whereas there was no significant difference among plants grown in trays with 36, 40, and 50 cells and among plants grown in trays with 40, 50, and 72 cells at 6 WAT, and the largest crowns were produced with 50 cells per tray at 12 WAT (Fig. 2). Plant size was larger when 36-cell trays were used compared to 72-cell trays at 6 WAT, but there was no significant difference among plants obtained when grown in 36, 40, and 50-cell trays, and among those in 40, 50, and 72-cell trays. Such difference was recovered by plant growth at 12 WAT (Fig. 3).

Early yield was 43% higher with plants grown in 36 cells per tray than in 72 cells per tray. There was no early yield difference among plants grown in 36, 40, and 50 cells per tray, as well as among 40, 50, and 72 cells per tray (Fig. 4). Throughout the 24 harvests, plants from 72-cell trays produced significant less total yield than plants from 36, 40 or 50 cells per tray (Fig. 5). Fruit production by using plants planted in 72-cell tray was reduced by at least 62,107 fruit/ha and 1.60 t/ha.

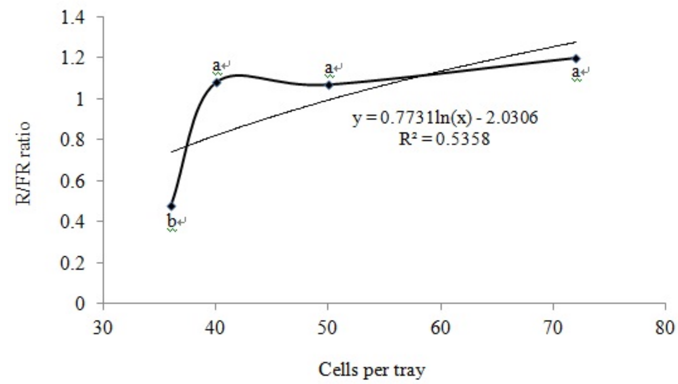

Fig. 1. Red light to far red radiation ratio at crown area of strawberry containerized transplants from different cell numbers of plug trays at 6 weeks after planting.

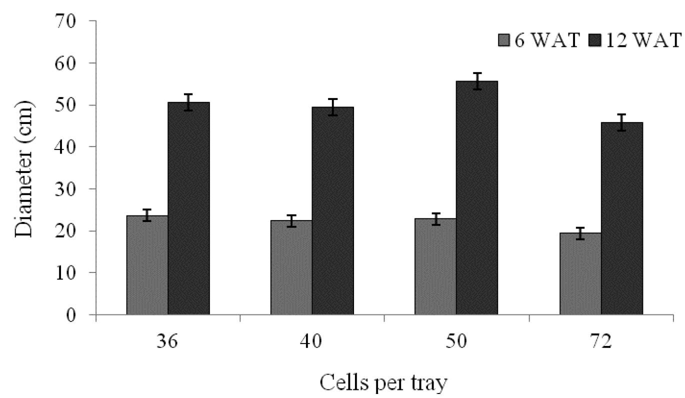

Fig. 2. Crown diameter of strawberry containerized transplants from different cell numbers of plug trays at 6 and 12 weeks after transplanting.

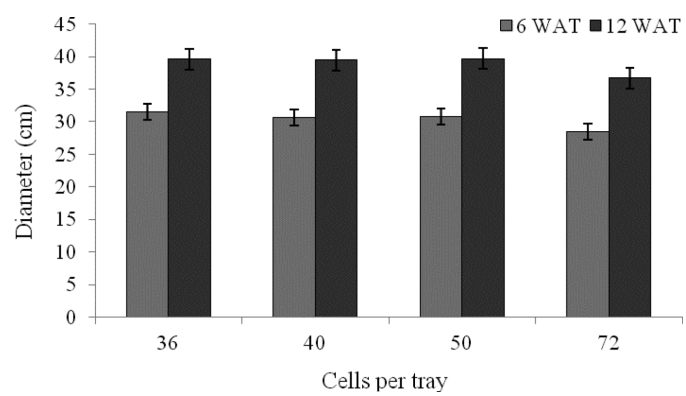

Fig. 3. Plant diameter of strawberry containerized transplants from different cell numbers of plug trays at 6 and 12 weeks after transplanting.

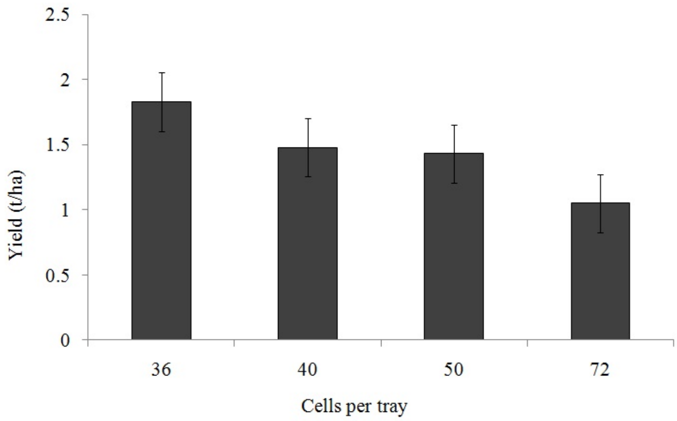


Fig. 4. Early yield of strawberry growing from containerized transplants in different cell numbers of plug trays from the first 10 harvests.

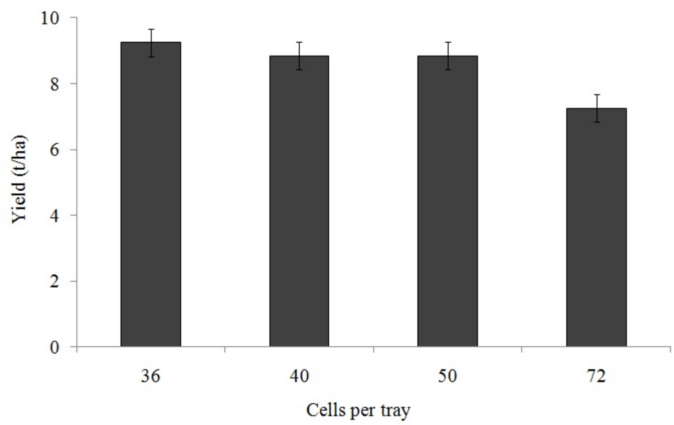


Fig. 5. Total yield of strawberry growing from containerized transplants in different cell numbers of plug trays from the total of 24 harvests.

In this study, a significant lower red light to far-red radiation ratio occurred on plants obtained in 36-cell trays than the other plug tray cell numbers (Fig. 1). This was probably because of more leaves per plug plant from trays of 36 cells than that from other plug trays, probably due to the physical restriction of dense canopies reducing red light radiation reaching crowns. However, this result was not consistent to the results of early and total fruit number and yield that only plants planted in 72-cell tray produce fewer fruit than those planted in 36-cell tray.

Based on the results from crown and plant diameter, plants obtained from 72-cell trays were generally poor in growth compared to those from 36 cells per tray, and such kind of response was similar to the results for early and total fruit number and yield. This could be explained that probably the cell size of 72 cells per tray was too small for transplant growth so that there was less carbohydrate stored in the plants and then affected their performance in the field.

Takeda and Glenn (2007) suggested that the spectral distribution at crown can be changed by improving the plant canopy and then inducing flower for short-day type strawberry. In this experiment, the data showed that even though the difference of red light to far-red radiation ration differed from different cell number per tray, all the transplants produced flowers successfully (Fig. 1). It has been reported that smaller plug tray size might cause root restriction with impact on shoot growth, and even affect plant growth and stress recovery after transplanting (NeSmith and Duval, 1998). Using 72-cell trays to produce transplants likely restricted crown expansion and carbohydrate accumulation in comparison with plants growing 36-cell trays. This growing condition seemed to have a more profound impact on plant growth than the actual light spectrum penetrating the canopy.

Bish et al. (2002) evaluated the performance of strawberry containerized transplants in container sizes of 75, 150, and 300 $cm^3$ by using polyvinyl chloride pipes in different length and found larger plants were produced with container sizes between 150 and 300 $cm^3$, but yield was not consistently higher for plants from larger container volume. Similarly, smaller plants were obtained from plants produced using plug trays with 72 cells per tray (63 $cm^3$ per cell volume) compared to with 36 cells per tray (162 $cm^3$ per cell volume), but the response of cell size on early and total yield was still significant for plants from 72-cell trays, which produced lower early and total yield than those produced in 36 cells per tray. However, the diameter of cells in different cell numbers of plug trays was different in our study, which might cause different condition for shoot growth and light penetration through the canopy.

Container sizes of 26.5, 50, 100, and 150 $cm^3$ were compared with strawberry plug transplants by Giménez et al. (2009), and it was found that 100 $cm^3$ container size can be used to produce plants with optimal plant growth compared to other container sizes, whereas there was no difference among container sizes in early and total fruit yield. In our study, the cell volume of plug trays in 36, 40, 50, and 72 cells was 162, 124, 86, and 63 $cm^3$, but plant growth was only significant different for plants produced from plug tray with 36 cells and 72 cells. Moreover, the difference occurred on plants from 72-cell trays which was lower than from 36-cell trays for early yield, and the lower total yield was produced by plants planted in 72-cell trays than in 36, 40, and 50-cell trays.

In summary, strawberry containerized transplant can be produced successfully with flower induction under Florida conditions, which could be used by growers to reduce shipping costs from northern nurseries. Instead of 36-cell plug trays, 50-cell plug trays should be used for producing strawberry transplants in Florida without affecting production. This means the plug transplant production could be enhanced for 25% per unit area and 25% more transplants can be shipped per unit. However, 72-cell plug trays may not be a good option for transplant production in Florida due to poor transplant growth and field performance.

## 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, and C.K. Chandler. 2002. Temperature conditioning and container size affect early season fruit yield of strawberry plug plants in a winter, annual hill production system. HortScience 37:762–764.

Durner, E.F., E.B. Poling, and J.L. Maas. 2002. Recent advances in strawberry plug transplant technology. HortTechnology 12:545–550.

[FAO] Food and Agriculture Organization of the United Nations. 2010.

FAOSTAT. Food and Agriculture Organization of the United Nations. 17 July 2011. <http://faostat.fao.org/>.
Giménez, G., J.L. Andriolo, D. Janisch, C. Cocco, and M.D. Picio. 2009. Cell size in trays for the production of strawberry plug transplants. Pesq. Agropec. Bras. 44:726–729.
Hancock, J.F. 1999. Strawberries. CABI Publishing, New York.
NeSmith, D.S. and J.R. Duval. 1998. The effect of container size. HortTechnology 8:495–498.
Peres, N.A., J.F. Price, W.M. Stall, C.K. Chandler, S.M. Olson, S.A. Smith, E.H. Simonne, and B.M. Santos. 2010. Strawberry production in Florida, p. 263–272. In: S.M. Olson and B.M. Santos (eds.). Vegetable production handbook for Florida, 2010–2011. Inst. Food Agr. Sci. Publ., Univ. of Florida, Gainesville.
Takeda, F. and D.M. Glenn. 2007. Development of short-day-type strawberry transplants that flower in fall. HortScience 42:865.
Takeda, F., D.M. Glenn, and G.W. Stutte. 2008. Red light affects flowering under long days in a short-day strawberry cultivar. HortScience 43:2245–2247.
[USDA] U.S. Dept. of Agriculture. 2011. Vegetables 2010 summary. National Agricultural Statistics Service. 17 July 2011. <http://usda.mannlib.cornell.edu/usda/current/VegeSumm/VegeSumm-01-27-2011_new_format.pdf>.