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Transplant Tray Comparison Study: Winstrip, Speedling, Growing Systems

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Introduction

Recently NeSmith and Duval (1997) reviewed the research on the effect of container cell size (volume) on transplant growth and development, and concluded that by increasing transplant cell volume a potential yield increase often resulted. Plants raised in larger cells result in earlier yield; yield that favors extra-large size fruit, and often greater overall yield (NeSmith and Duval, 1997; Vavrina, 1997). If the size of the container cell can impact crop yield, perhaps the construction of the transplant tray itself may be instrumental in affecting crop yield as well. The Winstrip (Mills River, North Carolina) cell, a truncated inverted pyramid, exhibiting grooved/open-air sides to allow for additional root pruning and aeration, is a new design that requires evaluation of its suitability for the FL transplant market.

The objective of this study was to determine the impact of Winstrip container (tray) architecture on transplant growth, stand establishment and yield of tomato in the spring season.

Materials & Methods

A trial was established to compare the Winstrip tray with two other transplant production trays which are commercially available. Due to the diversity of tray designs within the industry it was difficult to set up an experiment where the trays had identical plant populations and cell volumes. The three tray types used were selected modified where necessary to provide valid comparisons:

Winstrip [WS] - a hard plastic, 72 plant, 55 cc cell volume tray, with a truncated inverted pyramid cell, exhibiting grooved (open-air) sides to allow for additional root pruning. These trays can be stacked one within another.

Speedling [SP] (Sun City, Florida) - a styrofoam, 128 plant tray cut to the dimensions of the WS tray which resulted in 72 plants, 38 cc volume cell of the inverted pyramid design.

Growing Systems [GS] (Milwaukee, Wisconsin) - a vacuum-formed plastic, 51 plant, 71 cc cell volume tray (only filled to a 55 cc volume), of a slightly tapered cylindrical design. This tray was of the same dimensions as the WS tray.

Since the WS and SP cells were of different cell volumes, inclusion of the GS tray enabled to us to test the WS tray against a tray of similar plant population (SP), and a tray of similar cell volume (GS) within the same square footage.

Cell volumes were measured by sealing all drainage and aeration openings in the cell and then filling the cell with water. The volume of water filling the cells was then measured and used as the cell volume. Also apparent in this experimental design was the variant of cell shape which could not be readily separated out.

The trays were filled with Verlite (Tampa, FL) Vegetable Transplant Mix A which contained lime, superphosphate, iron, and micronutrients. The trays were seeded with the tomato cultivar FTE 30 (Petoseed, Saticoy, CA), and grown for 6 weeks. A 100 ppm N feed from Nutri-Leaf 20-20-20 (Miller Chemical, Feasterville, PA) was applied twice weekly. Plants in this study were irrigated and fertilized similarly.

Four weeks after seeding, 5 randomly selected plants from each trial tray (4 replications) were subjected to a battery of measurements designed to determine transplant quality. These measurements included: root length, stem length, stem diameter, top-fresh weight, root-fresh weight, leaf area, stem-dry weight, leaf-dry weight, root-dry weight, top-dry weight, root:shoot ratio, and number of true leaves.

Field planting on an Immokalee fine sand included: seepage irrigation, methylbromide fumigation (320 lbs/A, broadcast), granular fertilization (220N-78P-300K), plastic mulch (3 mil, black for the first planting, white from a previous cucumber crop [i.e., double cropped] for the second planting), on a 32" wide bed. Two weeks were allowed for fumigant action. Holes were punched in a single row with an 18" in-row pattern on beds with 6' centers. Transplants were set on Feb. 18, 1997 and two weeks later on March 6. Fourteen plants were set for each treatment by replication. Six replications were set out in a randomized complete block design.

An equal number of plants were held an additional two weeks (i.e., 6-week-old transplants) to simulate a situation where plants could not be field planted on the specified "pull date" (e.g. due to weather, rolled back planting schedule, etc.). These plants were irrigated and fertilized less frequently in order to keep top growth to a minimum in accordance with industry practices. Measurements of transplant quality were not taken on this group.

Manzate, copper, and Bravo fungicides were applied weekly in rotation to prevent the advancement of fungal diseases and bacterial spot. Late blight (*Phytophthora infestans*) was present in the first planting of this trial, but was controlled and resulted in only minimal foliage loss. Various Bt's insecticides were also applied to reduce worm pressure.

Field sample data was taken on plant dry weight (1 plant per treatment/replication at 30 and 45 DAP), developing fruit (45 DAP), and yield (3 harvests of 10 plants per treatment/replication). Field plant growth and early fruit set (30 and 45 DAP) were assessed for the first planting only. Yield from both trials was separated into red/breaker and mature green fruit, and further subdivided into medium, large, and extra-large categories. Data were analyzed by ANOVA (SAS) with mean separation via Fisher's Protected LSD at $p<0.05$.

Results

The spring 1997 growing season was very mild lending to good plant growth and high yields. The crop was never under nutrient or water stress. The data presented in the Transplant Parameter and Stand Establishment sections below contain only data collected from seedlings planted on Feb. 18. The later planting (Mar. 6) was simply assessed for yield.

Transplant Parameters. Plant fresh weight (FW) response in each category of plant growth measured (root length, stem length, stem diameter, top FW, root FW, leaf area) was greater for plants grown in the GS cell compared to either the WS or SP cell (Table 1). This may have been due to the fact that the drain holes of the GS cell were exceedingly small, offering little loss of fertilizer and water. Greater accessibility to water and nutrients would certainly have given plants grown in the GS cell an advantage during the spring season. Vavrina et al. (1998) found that southern grown transplants receiving higher nitrogen levels in the spring result in higher yields.

The WS cell out-performed the SP cell by producing plants of greater stem length, stem diameter, top FW, root FW, and leaf area. The slightly larger cell volume of the WS cell may have been the defining factor in these differences as suggested by NeSmith and Duval (1997).

Table 1. Tomato transplant fresh weight (FW) responses to growth in various tray types* at Immokalee, FL in spring 1997.

Container	Root Length	Stem Length	Stem Dia.	Top FW	Root FW	Leaf Area
	(cm)	(cm)	(mm)	(g)	(g)	(cm^2)
Winstrip	15.5	8.0	2.16	0.798	0.349	19.65
Speedling	16.3	5.8	1.78	0.460	0.273	11.09
Growing Systems	31.2	9.5	2.57	1.219	0.564	26.51
LSD 0.05	7.8	0.8	0.13	0.076	0.070	1.68

* Speedling vs. Winstrip = trays of equal population per unit area, Growing Systems vs. Winstrip = trays of equal cell volume.

FL growers traditionally request a 4 inch (10 cm) tomato transplant for field planting which, during certain times of the year, requires considerable manipulation of nutrient and water inputs. In the current study, all trays produced plants that were less than 4 inches in height due in part to the cooler growing temperatures during February. However, under fall conditions, when plant growth could be excessive, increased management for height control would be required when using the GS cell.

Of interest with both the WS and SP cell, was the amount of root pruning that occurred as indicated by root length Table 1). The WS cell, designed with grooved sides, pruned more roots, though not significantly more than the SP cell. The GS cell afforded no appreciable root pruning.

Transplant dry matter analysis (leaf, stem, top, root) revealed that the GS cell produced the "biggest" transplant, followed by the WS cell and then the SP cell (Table 2). Root-to-shoot ratios among the cells were quite similar. True leaf number was slightly greater for the GS cell compared to the SP cell. True leaf production was low in general as these plants were transplanted after 28 days in the plant house (typically 42 days) to simulate production schedules.

Table 2. Tomato transplant dry weight (DW) responses to growth in various tray types* at Immokalee, FL in spring 1997.

Container	DW Leaf	DW Stem	DW Top	DW Root	Root to Shoot Ratio	True Leaf No.
	(g)	(g)	(g)	(g)		(#)
Winstrip	0.0652	0.0275	0.0909	0.0254	0.286	2.15
Speedling	0.0429	0.0154	0.0582	0.0192	0.336	2.00
Growing Systems	0.0980	0.0459	0.1439	0.0383	0.268	2.30
LSD 0.05	0.0072	0.0039	0.0104	0.0056	NS	0.17

* Speedling vs. Winstrip = trays of equal population per unit area, Growing Systems vs. Winstrip = trays of equal cell volume.

Stand Establishment Parameters. The GS transplants where larger at planting (Table 1) and continued to advance in dry matter production at an increased rate compared to either the WS or SP plants at 30 DAP (Table 3). Forty-five DAP, all plants showed similar DW, fruit number, and fruit weight, however, the GS plants could still be seen to have a slight advantage in these measures.

Yield Parameters. A concern that the treatments (i.e., cell types) would produce different results based on the differing field planting dates (early vs. late) prompted a treatment by planting date interaction analysis on the combined yield data from the two plantings. No interactions of consequence were found, therefore, the yield data were pooled over the two planting dates to develop a stronger understanding of the treatment effect.

Tables 4, 5, and 6 describe yield by fruit number, fruit weight, and fruit grade respectively, for each of three harvests and total yield, respectively. The first indication of maturity in a tomato crop is the onset of color. FL growers typically wait for about 5% "color" in the crop before harvesting mature green tomatoes. This advent of color assures the grower that the crop is sufficiently mature to benefit from the post harvest ethylene ripening procedure. All plants in this study were harvested at the same time, so red fruit (actually fruit that

Table 3. Tomato transplant stand establishment responses to growth in various tray types* at Immokalee, FL in spring, 1997.

Container	DW Top 30 DAP	DW Top 45 DAP	Fruit Number 45 DAP	Fruit Weight 45 DAP
	(g)	(g)	(#)	(g)
Winstrip	40.383	174.52	28.0	495.6
Speedling	42.183	169.47	27.5	553.7
Growing Systems	53.167	205.00	31.3	773.4
LSD 0.05	9.659	NS	NS	NS

* Speedling vs. Winstrip = trays of equal population per unit area, Growing Systems vs. Winstrip = trays of equal cell volume.

exhibited any color) was a general indication of early maturity.

Tomatoes grown in the GS cell had earlier maturing fruit than those grown in either the WS or SP cells as evidenced by the greater number of medium, extra-large, and total red fruit (Table 4). Of the total number of fruit harvested at first harvest for each treatment, the GS fruit showed 21% color, the WS fruit showed 9% color, and the SP fruit showed 5% color. The WS plants produced more extra-large and total red fruit than the SP plants at first harvest, demonstrating the maturity advancing attributes of this cell.

Cell type (GS, WS, or SP) did not impact the number of mature green tomatoes in any size category (medium, large, extra-large) at first harvest (Table 4). Although, a greater number of overall fruit (both red and green) at first harvest was produced with the GS cell.

No differences were found among fruit yields (number) in harvests two and three. Total number of red fruit (from the three harvests), however, reflected the maturity finding noted above: GS plants matured more rapidly than either WS or SP plants, and WS plants matured more rapidly than SP plants. The number of green fruit and the number of fruit in the overall yield (red and green) showed no evidence of a treatment effect.

Similarities between fruit number yield and fruit weight yield were strongly evident as seen in Table 5. These data also suggest that the overall yield of fruit from a single tomato plant (red and green fruit) was about 10 pounds, regardless of cell type. This is fairly consistent with yields found in the literature, falling typically within the range of 8 to 12 pounds (Vavrina and Orzolek, 1992).

Overall analysis of fruit grade results are shown in Table 6. No significant differences were noted in the average fruit weight across treatments at any harvest (i.e., a fruit of any particular grade weighs essentially the same as any other fruit from that grade regardless of cell type).

GS plants provided more extra-large (XL) fruit than either the WS or SP plants at first harvest. This finding appears to be the result of the advanced maturity afforded by the GS cell, as earliness "tends" to push more fruit into the XL category. The impact of the GS cell on XL fruit production at first harvest was also seen after three harvests, where it yielded more XL fruit overall than the SP cell, but not more than the WS cell.

Discussion

Several results from this study were quite compelling. Plants produced in the WS cell were larger at transplanting and yielded earlier than plants produced in the SP cell with comparable plant population. This could have been predicted utilizing the information in NeSmith and Duval (1998), as the WS cell had a larger cell volume than the SP cell. The GS cell, which had a cell volume identical to the WS cell, resulted in a larger transplant, yielded earlier, produced more XL fruit and more total fruit (red and green) at first harvest than the WS cell.

It should be noted that the soilless medium filling of the GS cell (originally 70 cc, but filled to 55 to mimic the WS cell) may not have been completely accurate in all cases, resulting in some cells with a soilless medium volume larger than 55 cc. But would these filling errors be sufficient to cause the large differences noted? For example, use of the WS cell resulted in an 84% increase in the number of red fruit at first harvest over the SP cell with only a 53% increase in cell volume. Use of the GS cell resulted in a 147% increase in the number of red fruit at first harvest over the WS cell from a 27% increase in cell volume, if efforts to make the cell volumes equal were completely ignored.

If the yield differences between the GS and WS cells cannot be attributed to cell volume, two other aspects need to be considered: plant population and root mass. The GS tray contained only 51 plants compared to the 72 in the WS tray. Perhaps the lower plant population of the GS tray afforded greater accessibility to water, nutrients, light, and airflow. Any or all of these factors may have provided a competitive advantage for the GS plants.

The GS transplant had nearly 100% more roots than the WS transplant, perhaps the effect of GS cell shape or the lack of sizeable drain holes. Considering the role of root produced cytokinin plant hormones on flowering and fruit set/development, one must wonder if such root pruning affects these developmental processes. These issues require further investigation to discern their impact on transplant quality and subsequent yield.

These data represent the results from a single spring season of transplant production, and subsequent field establishment and yield assessment. Before an informed decision can be made concerning the choice of (or change from) a transplant tray for tomato production, this trial must be replicated several times. For FL production these tray trials must also be carried out during the summer, fall, and winter production runs for an accurate depiction of tray performance.

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