Tomato Transplant Production Using the Float System and Cupric Hydroxide

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SUMMARY. Comparisons were made between conventional and float system growing methods for tomato (*Lycopersicon esculentum* Mill.) transplants and subsequent production. Effects of cupric hydroxide application to the interior surface of plant-growing trays were compared to untreated controls. Tomato transplants grown in the float system had higher fresh and dry weights; were larger after establishment in the field; and produced higher early yields of small, medium, and large tomatoes than plants grown by conventional methods. Mean fruit weight was higher from conventionally grown transplants early in the season. Total number of fruit and total yield were not affected by transplant production method. Transplants grown in cupric hydroxide-treated trays were larger and had fewer roots emerging through the bottom of the trays than transplants grown in untreated trays. Cupric hydroxide treatment had no effect on tomato earliness, yield, or mean fruit size.

Many vegetable growers are using the float system to produce transplants. This technology was adopted from tobacco transplant growers, and most research and recommendations for transplant production with this system have

been reported for tobacco (Fowlkes, 1994; Isaacs and Foley, 1993; Smith et al., 1993; Thomas, 1993). The method involves planting seed into a growing medium in a plastic foam tray and floating the tray in a tank of nutrient solution. Commercial tanks are usually built of a wood frame ≈ 16 cm high lined with a double layer of black polyethylene plastic. Nutrient solutions consist of a complete water-soluble fertilizer that will supply ≈ 150 ppm nitrogen. Plant roots usually grow through the hole in the bottom of the tray into the nutrient solution. Plants grow very quickly in this system and should be removed from the tanks and hardened before field setting.

Copper-containing compounds have been found to inhibit spiraling of roots in container-grown ornamentals and other species (Arnold, 1995; Brass et al., 1996; Ruter, 1994; Svenson et al., 1995). Plants grown in copper-treated containers have better root distribution and produce more branching and more lateral root growth without massing of roots at the medium-pot interface.

Objectives of this study were to 1) compare float-system-grown with conventionally grown tomato transplants and 2) determine the effects of a copper hydroxide [$\text{Cu}(\text{OH})_2$] compound applied to the trays on tomato transplant growth, development, and subsequent field production of tomatoes.

Materials and methods

'Sunny' tomatoes were direct seeded into plastic foam planter trays (72 cells per tray, cells $5.1 \times 5.1 \times 7.6$

cm, cell volume 66 cm^3). One half of the cells of each tray had been painted previously with Spin Out, a latex paint formulation of 7.1% $\text{Cu}(\text{OH})_2$ (Griffin Corp., Valdosta, Ga).

Trays were either suspended on rails for conventional transplant production (Thomas, 1993) or placed in float tanks containing ≈ 77 L of nutrient solution in a greenhouse maintained at $\approx 28/21^\circ \text{C}$ (day/night). Conventional transplants were fertilized with solutions containing $4 \text{ g} \cdot \text{L}^{-1}$ of water-soluble fertilizer (20N-8.8P-16.6K). Two liters of the solution was applied to each tray at 3 and 4 weeks after seeding. Nutrients were provided to transplants in the float tanks by adding $0.45 \text{ g} \cdot \text{L}^{-1}$ of the same fertilizer formulation. The experimental design was a split plot with conventional or floated trays as main plots and control or $\text{Cu}(\text{OH})_2$ -treated cells as subplots. The study was replicated six times.

Trays were removed from the float tanks 21 d after seeding. The number of cells in each treatment that had roots emerging from the drainage holes were counted. All roots emerging from the drainage holes were removed at the point of emergence and fresh and dry weights were obtained. Trays from the floated plots were then suspended on rails for 13 d and treated like conventionally grown transplants, except that no fertilizer was applied. Water was applied only as needed for 3 d to harden

Fig. 1. Tomato transplants grown in float tanks (left) and by conventional means (right).

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Table 1. Fresh and dry weights of tomato transplant shoots, roots and number of emerged roots at field setting. Transplants were grown with conventional or float methods in untreated or $\text{Cu}(\text{OH})_2$ -treated plastic foam trays.

Treatment	Transplant top wt ^z		Emerged roots (no.) ^y	Emerged root wt	
	Fresh (g)	Dry (g)		Fresh (g)	Dry (g)
Transplant type (T)					
Conventional	14.9	3.4	---	---	---
Floated	23.4	5.7	---	---	---
LSD (0.05)	2.9	0.9	---	---	---
P > F	0.001	0.001	---	---	---
Cell treatment (C)					
Untreated	17.5	4.0	35	10.2	0.34
$\text{Cu}(\text{OH})_2$	20.9	5.2	11	4.3	0.15
LSD (0.05)	1.4	1.2	5	2.2	0.07
P > F	0.03	0.02	0.001	0.001	0.001
T × C	NS	NS	---	---	---

^zPlants excised at cotyledonary node; mean of five plants per treatment.

^yRoots that had emerged through the drain hole; cells per treatment = 36.

the plants before transplanting.

Field plots were established on 24 Apr. 1994, using plants from all transplant production treatments. Before transplanting, 673 kg·ha⁻¹ of 15N-6.6P-12.4K fertilizer was applied to a 45-cm band over the row and incorporated with a rotary tiller. A drip-irrigation line and black plastic mulch were installed in each plot. Tomato plants were transplanted by hand and spaced 0.25 m apart in rows 3.05 m apart with 10 plants per plot. The study was replicated six times.

Stakes were installed between every other plant and support was provided using the Florida weave tying system. Plants were pruned to two stems. Plant height was measured at 2-week intervals for 8 weeks beginning on 11 May. Five random plants were measured in each plot. Irrigation was provided as needed and regular sprays of registered fungicides and insecticides were applied.

Pink or red fruit were harvested two times weekly for 5 weeks beginning on 6 July. Fruit were divided into four size categories based on fruit diameter: small (<6.1 cm), medium (6.2 to 6.7 cm), large (6.8 to 7.4 cm), and extra large (>7.5 cm). Number and weight of fruit in each size class were recorded for each harvest and fruit with rough or distorted blossom ends (catface) were counted. The harvests were divided arbitrarily into an early (6 July through 18 July) and a late (21 July through 8 Aug) portion. Data were analyzed by analysis of variance with mean separation by least significant difference procedures.

Results and discussion

Tomato transplants produced in the float tanks were larger (Fig. 1) and had significantly higher fresh and dry weights than conventionally grown transplants (Table 1), even though they were grown under the same conditions for the last 13 d before measurements were made. Conditions in the float tanks were optimal for rapid growth. Seedlings were not stressed for water at any time and, since the trays were buoyant and displaced only ≈1 cm of the nutrient solution, most of the medium was not excessively saturated.

A surface coating of $\text{Cu}(\text{OH})_2$ on the walls of the tray cells significantly increased transplant fresh and dry weight

(Table 1). Increased growth possibly resulted from greater lateral root penetration of the interior of the medium in the cells. Less root growth occurred in the medium-cell interface (Fig. 2) where roots normally grow to the exterior of the root media, encounter the cell surface, turn downward, and remain in the interface area until they emerge through the drainage hole.

Root growth through the drainage holes in the trays was reduced by $\text{Cu}(\text{OH})_2$ treatment (Table 1). The number and fresh and dry weights of emerged roots were lower from the portion of the trays treated with $\text{Cu}(\text{OH})_2$. Roots in untreated trays usually grew into the nutrient solution and became quite profuse. When trays are removed from float tanks for hardening, these roots are air pruned when trays were suspended on rails. In tobacco, loss of this portion of the root system was not detrimental to the transplant and did not affect yield (Smith and Boyette, 1996). Tomato roots that emerged from cells treated with $\text{Cu}(\text{OH})_2$ probably did so at random, since few roots followed the medium-cell interface to the bottom of the cell.

Tomato plants grown in the float system were larger than conventionally grown transplants when transplanted into the field (Table 1) and remained larger through 4.5 weeks after transplanting (Table 2). Beyond 4.5 weeks

Fig. 2. Root balls of tomato transplants grown in untreated tray cells (left) or with $\text{Cu}(\text{OH})_2$ -treated tray cells (right).

Table 2. Tomato plant heights 2.5 to 8.5 weeks after transplanting (WAT). Transplants were grown with conventional or float methods in untreated or Cu(OH)₂-treated plastic foam trays.

Treatment	Plant ht (cm) ^a			
	2.5 WAT	4.5 WAT	6.5 WAT	8.5 WAT
Transplant type				
Conventional	21	44	74	88
Floated	24	47	76	87
LSD (0.05)	2	2	NS	NS
P > F	0.01	0.01	0.06	0.58
Cell treatment				
Untreated	22	46	75	88
Cu(OH) ₂	23	46	75	88
LSD (0.05)	NS	NS	NS	NS
P > F	0.34	0.84	0.72	0.93
T × C	NS	NS	NS	NS

^aSoil surface to terminal growing point of the main stem.

after transplanting, no differences in height were found between plants grown in the two production systems. No differences in tomato plant height were found due to Cu(OH)₂ treatment.

The number and weight of small, medium, and large fruit harvested early in the season (6 July through 18 July) were significantly higher from tomato plants grown in the float system than to conventionally grown transplants (Table 3). Larger transplants have been found to require fewer days to anthesis (Kemble

et al., 1994) and produce higher early yield (Weston and Zandstra, 1986). Float-grown plants may have developed fruit buds earlier than conventionally grown plants and subsequently flowered and fruited earlier. Tobacco transplants grown in float tanks matured earlier than conventionally grown transplants, but no differences were found in leaf number or yield (Maksymowicz and Palmer, 1993). Late-season fruit numbers and yields (21 July through 8 Aug) in the small and medium size

categories from conventional transplants were not significantly different. Total fruit number and total yield of large tomatoes were significantly higher from float-system transplants. No differences in numbers of extra large tomatoes were found between transplant production methods. The Cu(OH)₂ treatment had no effect on fruit numbers or yield of any tomato fruit size (data not presented). Total early, late, and season-long fruit numbers and total yields were not significantly different due to transplant production method or to Cu(OH)₂ treatment (Table 4).

Mean fruit size was affected by transplant production method only in the early part of the season (Table 4). Conventionally grown transplants produced significantly larger early fruit than transplants produced in the float system, possibly because float-grown plants produced more fruit. This increase in number of carbohydrate sinks would tend to make individual fruit smaller and result in lower mean fruit weight. The Cu(OH)₂ treatment had no effect on mean fruit size.

Catfacing was a noticeable problem throughout the planting, especially during the first part of the harvest season. The number of catfaced fruit was significantly lower in plants grown in

Table 3. Number and weight of small, medium, large, and extra large tomatoes grown using transplants produced with conventional or float methods.

Transplant type	Early ^z	Late ^z	Total	Early	Late	Total
	(no./ha × 1000)			(t·ha ⁻¹)		
Small fruit ^x						
Conventional	3.7	21.7	25.4	0.2	1.1	1.3
Floated	7.2	16.2	23.4	0.4	0.8	1.1
LSD (0.05)	2.8	NS	NS	0.15	0.30	NS
P > F	0.02	0.08	0.54	0.03	0.04	0.36
Medium fruit						
Conventional	4.1	10.0	14.1	0.3	0.7	1.0
Floated	7.3	8.4	15.7	0.6	0.6	1.2
LSD (0.05)	2.0	NS	NS	0.14	NS	NS
P > F	0.01	0.20	0.28	0.002	0.14	0.10
Large fruit						
Conventional	10.4	17.1	27.5	1.1	1.6	2.6
Floated	19.9	17.5	37.4	2.0	1.7	3.7
LSD (0.05)	7.6	NS	9.2	0.73	NS	0.84
P > F	0.02	0.88	0.04	0.02	0.70	0.02
Extra-large fruit						
Conventional	40.8	38.3	79.1	6.4	5.8	12.2
Floated	37.5	38.3	75.8	5.7	5.9	11.6
LSD (0.05)	NS	NS	NS	NS	NS	NS
P > F	0.27	0.97	0.28	0.14	0.85	0.31

^aEarly = 6 July through 18 July 1994.

^bLate = 21 July through 8 Aug. 1994.

^cSmall = <6.1 cm in diameter, medium = 6.2 to 6.7 cm in diameter, large = 6.7 to 7.5 cm in diameter, extra large = >7.5 cm in diameter.

Table 4. Total number and yield of tomatoes, mean fruit weight, and number of catfaced fruit. Tomatoes were grown using transplants produced with conventional or float methods in untreated or Cu(OH)₂-treated plastic foam trays.

Treatment	Total fruit (no./ha × 1000)			Total yield (t·ha ⁻¹)			Mean fruit wt (g)			Catfaced fruit (no./ha × 1000)
	Early ^a	Late ^b	Season	Early	Late	Season	Early	Late	Season	
Transplant type										
Conventional	59	87	146	8.0	9.1	17.1	271	209	234	19.3
Floated	72	81	153	8.6	8.9	17.5	240	221	230	16.0
LSD (0.05)	NS	NS	NS	NS	NS	NS	18	NS	NS	3.2
P > F	0.06	0.17	0.35	0.30	0.70	0.59	0.01	0.17	0.28	0.04
Tray cell treatment										
Check	64	84	148	8.2	8.8	17.0	258	210	231	16.7
Cu(OH) ₂	67	84	151	8.4	9.2	17.6	250	220	233	18.6
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P > F	0.57	0.96	0.63	0.78	0.53	0.46	0.35	0.27	0.82	0.24
T × C	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

^aEarly = 6 July through 18 July 1994.

^bLate = 21 July through 8 Aug. 1994.

the float system (Table 4). Wien and Turner (1994) found less catfacing in tomato clusters that had developed past a critically susceptible stage when exposed to induction temperatures of 16/10 °C (day/night). We experienced low air temperatures of ~8 °C for 3 consecutive nights during the first part of May. Transplants produced in the float system may have been more vigorous or fruit bud development may have been advanced to the point that fruit from these plants were less affected by low night temperatures and, consequently, exhibited less catfacing.

The float system is a viable alternative for producing tomato transplants. Higher early fruit yield is certainly a benefit of this method, since this is usually the period in the season when market prices are highest. Using the float system also eliminates all management decisions concerning when and how much to water the transplants. Applying Cu(OH)₂ to the trays reduced the number of roots emerging into the nutrient solution in the float tanks and had no adverse effect on tomato earliness and yield.

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