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Root Cell Volume Affects Growth of Compact-growth-habit Tomato Transplants

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Abstract **The influence of flat cell volume (cavity containing growing medium) on transplant growth and development of NC 13G-1, a compact-growth-habit, fresh-market tomato *(Lycopersicon esculentum* Mill.) breeding line, was compared to that of a normal growth habit line, NC 8288. Transplants of each line were produced in four cell volumes (3.3, 27, 37.1, and 80cm^3) for 5 weeks, evaluated and then transplanted to larger containers, and grown until anthesis. During the first 5 weeks after seeding, plant dry weight did not differ between the lines; however, plant height of NC 13G-1 was ≈60% of the height of NC 8288. For both lines, number of days from sowing to anthesis decreased as root cell volumes increased. For space-efficient production of large quantities of compact-growth-habit tomato transplants, flats with root cell volumes as small as 27 and 37 cm^3 can be used without greatly delaying anthesis.**

Labor costs for producing staked, fresh-market tomatoes are high because plants must be pruned, staked, and tied (Konsler and Gardner, 1990). Compared to determinate cultivars presently used in this system (Konsler and Gardner, 1990), compact-growth-habit (CGH) tomatoes have a short, spreading plant type because of two genetic traits: the brachytic gene, which shortens internode length by 50% to 60% (Burton et al., 1955), and the prostrate growth habit, which causes wide branch angles (Ozminkowski et al., 1990). The plant is ≈46 cm high and 60 cm in diameter, self-supporting, and holds its fruit and most foliage aboveground. The plant does not require pruning, staking, or tying, which should lower total production costs for the grower.

Gardner and Davis (1991) demonstrated that NC 13G-1, a CGH tomato breeding line, produced high early season marketable yields when grown in a high-density system with double rows and close in-row spacings (46 cm). A possible limitation to adopting this system however, is the vast amount of greenhouse space needed to produce the required number of transplants.

High-density flats are the basis for an economical system of producing large quantities of transplants because as plant density increases, average cost per transplant decreases (Marr and Jirak, 1990). A concern with using high-density flats is that small root cell volumes can delay plant maturity and result in small transplants that produce low early season yields (Marr and Jirak, 1990; Weston and Zandstra, 1986). For tomato transplants with normal growth habit, height, leaf area, shoot dry weight (Weston and Zandstra, 1986), and stem diameter (Marr and Jirak, 1990) increased with increasing root cell volume. Transplants produced in large cells also matured earlier (Marr and Jirak, 1990) and produced higher early yields (Weston and Zandstra, 1986).

We evaluated high-density flats for producing CGH tomato transplants in a study that was conducted twice in a greenhouse (Jan. to Apr. 1991 and Sept. 1991 to Jan. 1992) in Raleigh, N.C. Seeds of two tomato breeding lines, NC 13G-1, a CGH line, and NC 8288, an early maturing line with normal growth habit (Gardner, 1990), were sown, two per cell, into four sizes of flats (Speedling, Sun City, Fla.) filled with the peat-based Baccto Seedling/Propagation Mix (Michigan Peat Co., Houston). Flat sizes are identified by the manufacturer as 001A, 100A, 150, and 200 and correspond with cell water volumes of 3.3, 27.0, 37.1, and 80.0 cm^3, respectively. Seedlings were thinned to one per cell following emergence. Beginning 1 week after sowing, seedlings were fertilized twice weekly with 100 mg N/liter as 20N–4.4P–16.6K (W.R. Grace and Co., Cambridge, Mass.). Day/night temperatures were maintained at 27/18C. Flats were suspended 10 cm above the benches to facilitate air pruning of roots. The design was a split plot with root cell volume as the main plot and plant type as the subplot with five replications (half of each flat was sown with a single tomato line).

Five weeks after seeding, five randomly selected seedlings from each treatment were measured for height, cut off at the soil line, weighed (stems + leaves), dried for 48 h at 70C in a forced-air oven, and reweighed. Five more seedlings from each treatment were transplanted individually into 2.4-liter pots and grown under the same cultural regime as described above, except pots were not suspended and plants were fertilized three times weekly. The original split-plot design was used, but it was re-randomized. At first anthesis, each plant was cut at the soil line, and height, fresh weight, an-d dry weight were determined as described previously.

Analysis of variance indicated that there were no differences between the two studies. Therefore, data from both studies were combined and analyzed using PROC GLM, PROC REG, and PROC CORR of SAS (SAS Institute, Cary, N.C.). When plots of residual and predicted values displayed heterogeneity of variances, data were transformed into natural logs.

Five-week-old transplants. Shoot dry weight increased quadratically as root cell volume increased for NC 13G-1 and NC 8288 (Fig. 1A). There was no difference, however, in shoot dry weight between the two plant types at any cell volume. As root cell volume increased, transplant height also increased quadratically (Fig. 1B). NC 13G-1 transplants were only ≈60%the height of NC 8288 transplants and ranged in height from 3.6 to 8.9 cm for the smallest to the largest cell volumes, respectively.

At anthesis. Root cell volume continued to have a dramatic effect on plant growth and flowering following transplanting. Although there were no differences in number of days from sowing to anthesis between the two plant types at any cell volume, for both plant types, as cell volume increased, days from sowing to anthesis decreased quadratically (Fig. 1C). There was a 16- and 15-day difference between the largest and smallest cell volumes for NC 13G-1 and NC 8288, respectively. At anthesis, shoot dry weight decreased quadratically, but minimally, with increasing root cell volumes for both plant types (Fig. 1A). Both plant types reached anthesis ≈19and 33 days after transplanting in the largest and smallest cells, respectively. As a result, plants from small cells had more time to grow and were larger before reaching anthesis than plants from large cells. For each cell volume, the CGH plants weighed less than the plants with normal growth habit (Fig, 1A). At anthesis, NC 8288 plants had a mean height of 37 cm, whereas NC 13G-1 plants were only 51% of

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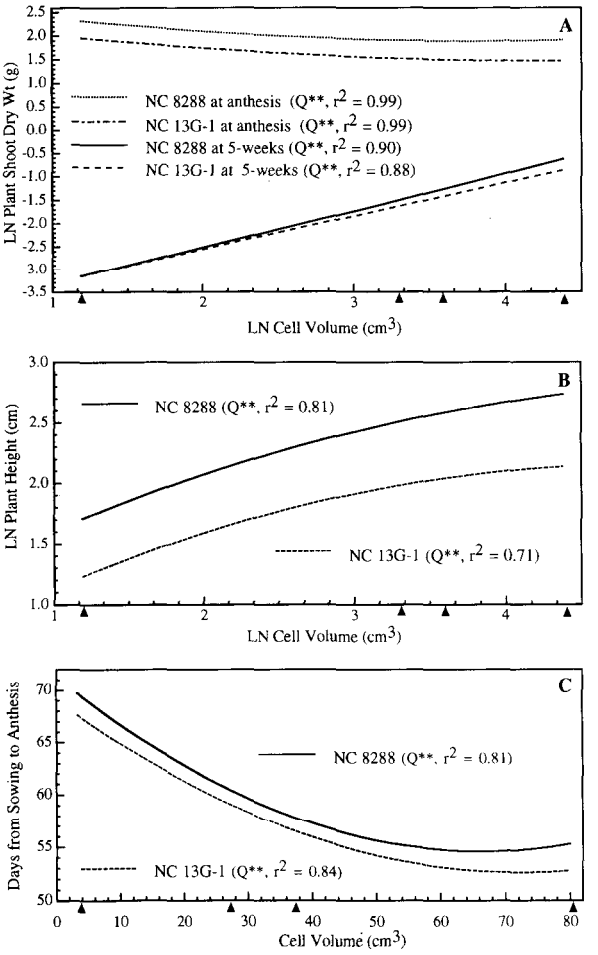

Fig. 1. Response of a tomato with compact growth habit, NC 13G-1, and a tomato with normal growth habit, NC 8288, to changes in transplant root volume. **(A)** Shoot dry weight 5 weeks after transplanting and at anthesis; **(B)** height 5 weeks after transplanting; and **(C)** days from sowing to anthesis. Data from both studies were combined. For A and B, data were transformed into natural logs. Cell volumes are indicated by a Δ on the transformed x-axis. Q** represents a quadratic response significantat $P \leq 0.01$.

this height (19 cm). Height within each plant type, however, was similar across all cell volumes (data not presented), indicating that by anthesis, plants tended to reach an equivalent height despite differences in shoot dry weights.

Use of CGH tomatoes by the tomato industry would eliminate many of the labor-intensive cultural practices required for staked tomatoes. Also, when grown in high-density, double-row plantings, CGH tomatoes produce high yields early in the season (Gardner and Davis, 1991) when market prices are usually high (Davis and Estes, 1993). Transplant costs for high-density plantings can be reduced by growing transplants in high-density flats (Marr and Jirak, 1990). In our study, flowering of CGH tomatoes was delayed >2 weeks by growing transplants at 2542 plants/m^2 with 3.3-cm^3 cells rather than at 308 plants/m^2 with 80-cm^3 cells. This delay in flowering would substantially reduce early season yields. Flats with 27-cm^3 cells (862 plants/m^2) and 37.1-cm^3 cells (547 plants/m^2) delayed anthesis only 7 and 5 days, respectively, compared to the 80-cm^3 cells. Flats with these two cell volumes likely allow for economical, space-efficient production of a large number of CGH tomato transplants, without a substantial delay in anthesis.

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