Establishment and Growth of Begonias in the Landscape as Affected by Root Ball Condition at Transplanting[1]

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Abstract

Begonias (*Begonia semperflorens*) were transplanted into an open-sided clear polyethylene covered shelter to evaluate the effect of root ball condition on establishment and growth. Three root ball classes were evaluated: non root-bound (NRB; 6 week old plants), root-bound (RB; 10 week old plants), and root-bound with the bottom 1 cm of the root ball removed (RBM). Non root-bound plants had greater growth rates for both height and faster rates of accumulation for cumulative root dry mass and new root dry mass relative to the other treatments tested. Cumulative shoot dry mass, new shoot dry mass, and total biomass accumulation rates were slower among RB plants compared to other rootball conditions. Mean canopy size, shoot dry mass, and biomass of NRB were significantly less at transplant; however all parameters were comparable among treatments 12 weeks later. Final mean shoot to root ratios were lower for the NRB treatment relative to RBM. Results indicate smaller, NRB transplants establish faster in the landscape. Furthermore, rootball manipulation is not recommended as it had no significant effect on root establishment or canopy growth of this annual bedding plant in the landscape.

Key words: root ball slicing, transplanting.

Taxa used in this study: *Begonia semperflorens* Hook.

Significance to the Industry

Labor costs and availability are a major concern of the landscape services industry. Balance between labor constraints and recommended landscape practices must be achieved to ensure effective landscape management at a reasonable cost to both the consumer and supplier. Slicing rootballs of rootbound plants is often practiced to promote rapid root growth during establishment. Most of the evidence is anecdotal. Results of this study indicate root slicing is not effective for new root development or increased canopy growth of annual bedding plants. Furthermore, smaller, non-rootbound plants established at faster rates compared to root-bound and root-bound plants that had been manipulated. Rootball manipulation of *Begonia semperflorens* is inefficient labor utilization and thus is not recommended.

Introduction

A common practice among gardeners, but not landscapers, is to disrupt root-bound annuals during transplant by either vertically slicing the entire rootball or removing the lower portion of the root system (5, 11). Root ball slicing, root pruning or root removal is often recommended for root-bound herbaceous and woody ornamentals to promote new root development during establishment in the landscape, and eliminate circling roots that encourage stem girdling. Although root slicing is beneficial for reducing stem girdling, no evidence exists that the practice stimulates new root growth (11). Gilman et al. (11) reported a reduction in shoot dry mass in response to root slicing without daily irrigation. Similar results were reported for juniper (*Juniperus chinensis*) following vertical slicing of the rootball. However, root dry weight was significantly greater than non-sliced rootballs (6). Production methods that promote root pruning such as air-pruning and copper-impregnated containers have yielded mixed results following transplanting into landscapes (8, 17, 25). Brass et al. (7) reported increased root regeneration of red maple (*Acer rubrum*), yet Marshall and Gilman (17) found no effect. Bellett-Travers et al. (4) found shoot and root regeneration of common birch (*Betula pendula*) were inversely proportional to root removal prior to transplanting. Similar results were reported for amaranthus (*Amaranthus hypochondriacus* and *A. caudatus*) and oilseed rape (*Brassica napus*) transplants (3, 9). However, other authors reported either no effect or increased root regeneration following root removal prior to transplanting rice (*Oryza sativa*) (19, 20). Therefore, the objective of this study was to evaluate the effect of root ball condition of annual bedding plants at transplanting on shoot and root growth during landscape establishment and post-establishment.

Materials and Methods

Begonias were obtained from a commercial nursery in 0.72 liter containers and transplanted on March 1, 2004, into an excessively drained fine sand (Apopka fine sand series) in an open-sided clear polyethylene-covered shelter. Begonias were planted on 0.3 m (1 ft) centers in 1 m (3.3 ft) wide strips. Areas between strips were covered with 0.6 m (2 ft) wide strips of polypropylene ground cloth (BWI Companies, Inc., Apopka, FL) to inhibit weed growth. To evaluate effects of root ball condition on establishment and growth, three root ball classes were evaluated: non root-bound (NRB; control), root-bound (RB), and root-bound manipulated (RBM). Non root-bound plants were 6 weeks old and identified by presence of root tips just visible on the outside of the root ball. Root-bound plants had numerous roots circling the outside of the root ball and were 10 weeks old. Root-bound manipulated plants were identical to root-bound except the bottom 1.3 cm (0.5 in) of the root ball was removed.

Each plot was managed with best management practices (5). Controlled-release fertilizer was uniformly broadcast in each bed area 30 days after transplanting at a standard rate of 0.91 kg N/100 m^2 (2 lbs N/1000 ft^2) of 15N–3.9P–9.9K Osmocote (Scotts Co., Marysville, OH). Irrigation was ap-

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plied daily at a rate of 1.3 cm (0.5 in) within each bed area with microirrigation spray stakes equipped with a strip spreader (Model Stake 31, Spreader Blue Series 7000, Dan Sprinklers, Kibbutz Dan, Israel). Spray stakes were situated in a linear pattern with each emitter 1.2 m (4 ft) apart and mounted 22.9 cm (9 in) above ground level. The Christssen Coefficient of Uniformity was a minimum of 0.49 prior to planting (12). Irrigation of each bed was controlled as a separate zone using an automated irrigation time clock (Model Sterling 12, Superior Controls Co., Inc., Valencia, CA). Irrigations began at 0500 h and were completed by 0600 h each day.

Growth indices and biomass. Beginning one week after transplant and continuing weekly throughout the experiment, one replicate of each treatment from each block was removed and shoot and root dry masses collected. Shoots were severed at the soil line and dried at 65C (149F) until constant dry weight was obtained. Soil was removed from roots, and roots were dried as described for shoots. Measurements of average canopy height, widest canopy width, and width perpendicular to widest width were recorded to calculate growth indices (growth index = height × width 1 × width 2). All plants were measured immediately after transplanting and at final harvest. At transplanting, a representative sample of eight plant replications of each root ball condition were measured and dried as described above to obtain initial values.

Data analysis. The experiment was conducted as a randomized complete block design with four blocks of single plant replicates. Growth data from weekly plant harvests, consisting of plant height, cumulative shoot dry mass, cumulative root dry mass, new shoot dry mass, new root dry mass, cumulative biomass, and shoot to root ratios were analyzed by regression, with three root ball classes and four replications. New shoot and root dry masses were calculated by subtracting initial shoot and root dry masses, respectively, from final shoot and root dry masses per sampling period. Slopes of resulting regression equations were compared by single-degree-of-freedom contrast (24). Growth index did not fit a linear response due to severe dieback that occurred prior to day 42 with normal growth resuming after day 42. Data from day 42 was not collected. Data were analyzed with segmented line analysis and orthogonal contrasts were used to determine treatment differences (1).

Initial and final plant height, growth index, root dry mass, and shoot dry mass data from week 12 plants were analyzed as a one-way ANOVA, with three root ball condition treatments and four replications. Where significant differences were indicated, mean separation was by Fisher's Protected

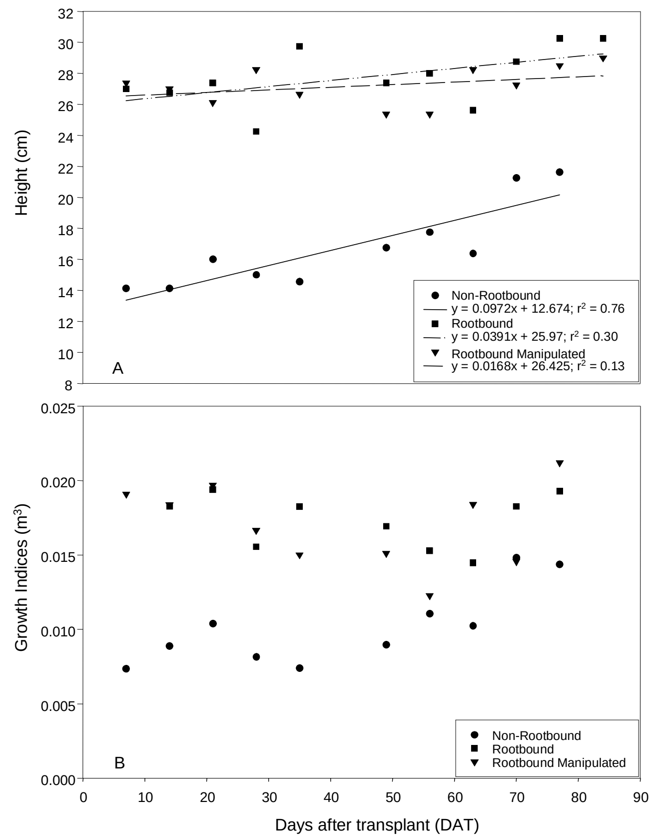

Fig. 1. A. Increases in height as a function of days after transplant, B. increases in growth indices during the first 42 days after transplant and increases in growth indices over the last 42 days of the experiment. Each point is the mean of four plants.

Least Significant Difference (F-Protected LSD, 24). All analyses were conducted using SAS (Vers. 8.1, 23).

Results and Discussion

Canopy size and height. Non root-bound plants had greater growth rates for height (Fig. 1A) relative to other treatments tested ($P < 0.05$). No differences in rate were found between RB and RBM plants ($P > 0.05$). Non root-bound plants grew 2 and 4.5 times faster in height, respectively (Fig. 1A), than RB and RBM. Initially, NRB plants were smaller than RB or RBM treatments ($P < 0.0001$; Table 1). Despite faster growth rates, NRB plants could not compensate and remained shorter than other treatments throughout the experiment (Fig. 1A; Table 2).

Table 1. Mean initial growth measurements for begonias subjected to three rootball conditions (non root-bound, root-bound, and root-bound manipulated).

Treatment	Growth index (m^3)[z]	Height (cm)	Shoot dry mass (g)	Root dry mass (g)	Biomass (g)	Shoot to root ratios
Non root-bound	0.010b[yx]	14.1b	4.87b	0.55a	5.42b	8.90a
Root-bound	0.024a	27.0a	8.12a	0.64a	8.75a	12.91a
Root-bound manipulated	0.019ab	27.4a	8.34a	0.77a	9.11a	11.55a
p-value	$P < 0.05$	$P < 0.0001$	$P < 0.01$	$P > 0.05$	$P < 0.01$	$P > 0.05$

[z]Growth index = height × width 1 × width 2.

[y]Means representative of 4 single plant replicates.

[x]Mean separations within a column with the different letters are significantly different according to Fisher's Protected Least Significant Difference, $P = 0.05$.

Table 2. Mean final growth measurements for begonias subjected to three rootball conditions (non root-bound, root-bound, and root-bound manipulated).

Treatment	Growth index (m^3)[z]	Height (cm)	Shoot to root ratios	New shoot to new root ratios
Non root-bound	0.011a[yx]	16.9b	10.6b	11.4b
Root-bound	0.018a	30.3a	12.4ab	11.9b
Root-bound manipulated	0.014a	29.0a	14.6a	21.5a
p-value	$P > 0.05$	$P < 0.0001$	$P < 0.05$	$P < 0.05$

[z]Growth index = height × width 1 × width 2.

[y]Means representative of 4 single plant replicates.

[x]Mean separations within a column with the different letters are significantly different according to Fisher's Protected Least Significant Difference, $P = 0.05$.

Approximately 21 days after transplant (DAT), dieback occurred among all treatments. Data from a nearby weather station suggest that uncommonly high wind speeds (maximum wind speeds > 32 kph at 10 m) and loose particulate matter resulted in injury. There was no indication of disease or insect damage. Canopy size decreased for the initial 35 days of the experiment. However, no negative impacts on biomass production were found (Fig. 2A–C). Plants from all treatments began to recover at 49 DAT and exhibited positive increases in canopy size for the remainder of the experiment (Fig. 1B). Growth indices were similar among treatments prior to day 42 and after day 42 of the experiment (data not shown).

Biomass. Lower rates of cumulative shoot dry mass accumulation were found among RB plants relative to other root ball conditions ($P < 0.05$; Fig. 2A). New shoot dry mass development rates were greater among NRB and RBM plants compared to the RB treatment ($P < 0.05$; Fig. 3A). Root-bound plants accumulated total shoot dry mass 32 and 29% slower than NRB or RBM treatments, respectively (Fig. 2A). Non-root-bound plants accumulated new shoot dry mass 1.6 and 1.3 times faster than RB and RBM treatments, respectively (Fig. 3A). NRB and RBM were similar for both parameters. Root-bound and RBM plants had greater cumulative mean shoot dry mass than NRB plants at transplant ($P < 0.01$; Table 1). However, different shoot dry mass accumula-

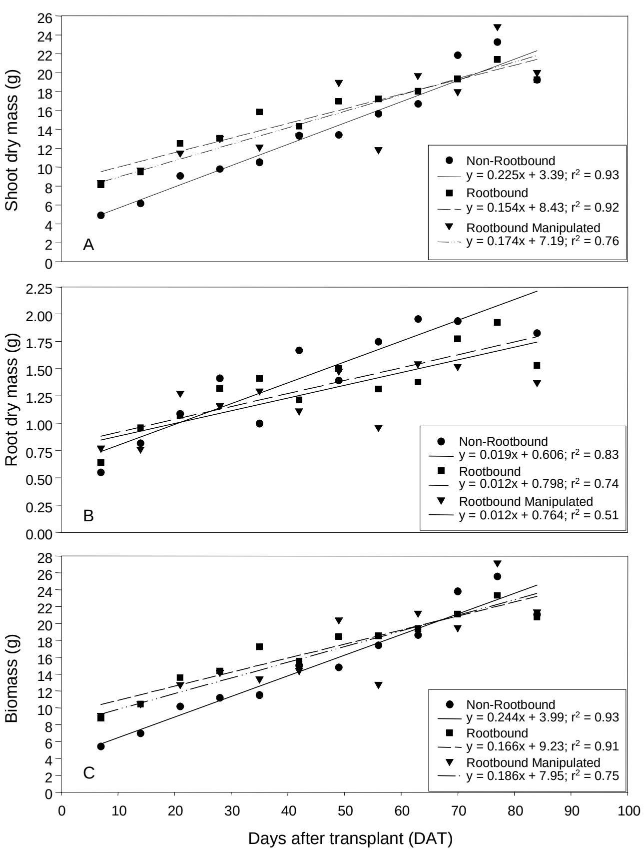

Fig. 2. Increases in A. total shoot dry weight, B. total root dry weight, and C. total biomass as a function of days after transplant. Each point is the mean of four plants.

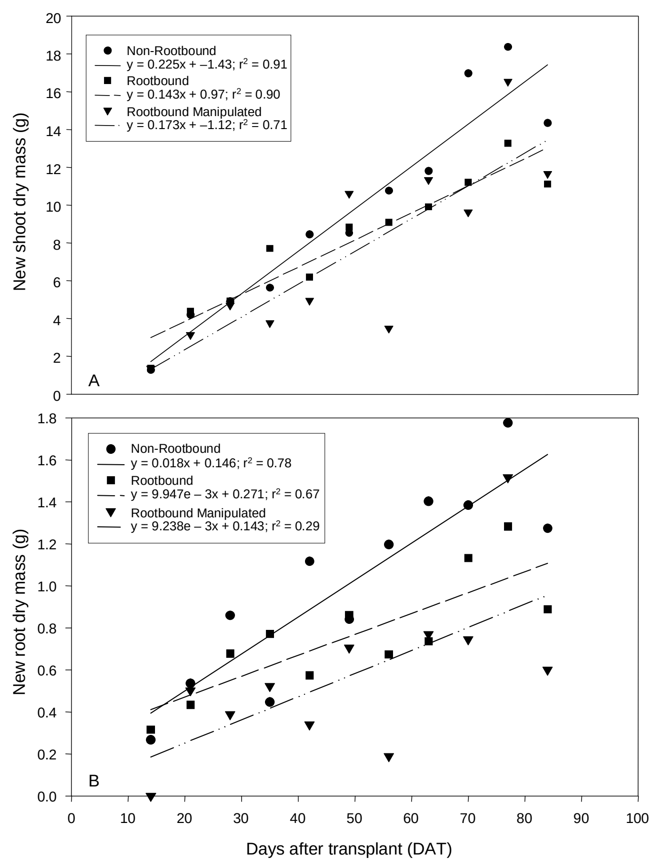

Fig. 3. A Increases in new shoot growth extending from the original canopy and B. increases in new root growth extending from the original root ball as a function of days after transplant. Each point is the mean of four plants.

tion rates resulted in no differences in either new shoot dry mass or cumulative dry mass production among treatments by final harvest ($P > 0.05$; data not shown).

Differences in cumulative root dry mass accumulation were found among treatments with NRB increasing at rates 1.6 times faster than other treatments tested ($P < 0.0001$; Fig. 2B). Similar results were found for new root production rates. Relative to RB and RBM treatments, NRB plants produced new roots at faster rates of 1.75 and 1.6 times, respectively ($P < 0.05$; Fig. 3B). No differences in cumulative root dry mass or new root dry mass accumulation rates were found between RB and RBM plants ($P > 0.05$). There were no differences among treatments for initial and final cumulative root dry mass despite differences in accumulation rates (Table 1; data not shown).

Cumulative biomass accumulation was similar to root development rates with greater increases among NRB plants relative to other treatments ($P < 0.05$; Fig. 2C). Root-bound and RBM plants accumulated biomass 32 and 24% slower, respectively, than the NRB treatment. Root-bound manipulated biomass production was 11% faster than RB, however, differences were non-significant ($P > 0.05$). Although biomass of NRB plants was smaller at transplant ($P < 0.01$), there were no differences by final harvest ($P > 0.05$; Tables 1 and 2). Similar results were found for canopy size (Tables 1 and 2). The absence of differences among treatments after 12 weeks is attributed to faster growth rates of NRB plants.

Results suggest landscape establishment was faster for NRB plants relative to other rootball conditions. Size has been found to affect the rate of establishment for both herbaceous and woody ornamentals. Latimer (16) examined effects of container size and shape on landscape performance of marigold (*Tagetes erecta*) seedlings. Marigolds produced in smaller volume cells had significantly less leaf area and root and shoot biomass than seedlings produced in larger cells; however, shoot biomass increases were greater for smaller cells following transplanting. Gilman et al. (10) reported faster growth for smaller nursery trees compared to larger trees after transplant. Differences were attributed to rapid balancing of shoot to root ratios. Similar results were reported by Watson (26).

Additional evidence is provided by differences in shoot to root ratios. Although, differences in mean shoot to root ratios between NRB and RB were not significant ($P > 0.05$), ratios were lower for NRB. Ratios were significantly lower for NRB plants relative to RBM , ($P < 0.05$; Table 2) and RBM and RB were similar ($P > 0.05$). Results were similar for new shoot to new root ratios (Table 2). Balances between leaf area and root systems must be achieved to prevent reductions in gas exchange and subsequent growth (10, 18, 27). Increased water stress has been associated with slower root growth during establishment (2, 10, 18). Lower shoot to root ratios indicate greater extension of root system relative to plant canopy and an expansion of soil volume available for nutrient and water uptake (15, 18, 28). Rapid development of sufficient root systems to compensate for transpirational water losses is essential for landscape establishment (18). Although, smaller sized, non-root-bound plants could potentially result in faster establishment and reduced irrigation requirements, consumers prefer larger canopy sizes (15, 22). Given the short term nature of annuals in the landscape, benefits of non-rootbound plants may be more applicable to semi-woody and woody ornamentals.

Finally, despite reports of increased root growth of herbaceous and woody species following root pruning (6, 20, 21), rootball manipulation is not recommended for begonia, as it had no effect on canopy growth or root establishment in the landscape. Labor accounts for 30–40% of total operational costs in the green industry (13, 14), and this practice is an inefficient utilization of labor.

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