Research Reports

Effect of Bioplex™ on Transplant Success and Recovery of Summer-dug Goldenraintree[1]

Jonathan D. Sammons and Daniel K. Struve[2]
Department of Horticulture and Crop Science
The Ohio State University, Columbus, OH 43210

Abstract

Biostimulants are intended to reduce stress associated with non-dormant (summer-dug) harvest of field-grown nursery stock; however, the effectiveness of biostimulant treatment is uncertain. We tested the effects of three application methods of Bioplex™ (a biostimulant) on transpiration rates, transplant survival, and recovery of field-grown goldenraintree (*Koelrueteria paniculata* Laxm.), which is considered difficult to transplant and is rarely summer dug. Bioplex™ was applied as a foliar spray, soil drench, or a combination of foliar spray and soil drench. Bioplex™ reduced transpiration rates of trees by 12% compared to untreated control trees. Root loss associated with digging reduced transpiration rates and had a greater effect on transpiration than any Bioplex™ treatment. Survival 12 months after transplanting was 100%. Bioplex™ treatments applied before digging had no effect on growth after transplanting. Transplanted trees had reduced caliper growth and shoot extension the season after transplant compared to non-dug controls. Although Bioplex™ reduced transpiration rates for three to five days after application in non-dug trees, there were no long-term benefits to survival or re-growth to summer transplanted trees.

Index words: summer digging, transpiration, transplant establishment, biostimulants.

Significance to the Nursery Industry

Biostimulants are marketed as a means to reduce transplant stress, but information on their effectiveness is mixed (3, 9, 14). In our study, Bioplex™ (a biostimulant) reduced transpiration rates of goldenraintree three to five days after application. Root loss associated with transplanting reduced transpiration and had a greater effect on transpiration than any pre-harvest Bioplex™ treatment. Bioplex™ treatment had no beneficial effect on recovery of summer dug goldenraintree. Survival 12 months after transplanting was 100%. If Bioplex™ is used, the most efficient application method is a foliar spray; significantly less (about ½) volume is needed to give a similar reduction in whole plant transpiration as with a soil drench. There was no advantage of a combination foliar and soil drench treatment combination over the foliar spray only treatment. The results suggest that handling at the nursery, during transportation and on the job site may affect transplant survival and re-growth more than the root-regeneration characteristics of the species.

Introduction

In northern temperate regions, late winter and early spring are the primary seasons to dig balled and burlapped (B&B) nursery stock. Often frozen soils, soils saturated from spring

[1]Received for publication August 4, 2004; in revised form January 12, 2005. Salaries and research support provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center, The Ohio State University, Columbus, OH. Manuscript No. HCS 05-03.

[2]Graduate student and Professor, respectively.

The *Journal of Environmental Horticulture* (ISSN 0738-2898) is published quarterly in March, June, September, and December by the Horticultural Research Institute, 1000 Vermont Avenue, NW, Suite 300, Washington, DC 20005. Subscription rate is $65.00 per year for scientists, educators and ANLA members; $95.00 per year for libraries and all others; add $25.00 for international (including Canada and Mexico) orders. Periodical postage paid at Washington, DC, and at additional mailing offices. POSTMASTER: Send address changes to Journal of Environmental Horticulture, 1000 Vermont Avenue, NW, Suite 300, Washington, DC 20005.

rains, or early warm weather shorten the digging season. If stock is not dug by bud break it remains in the field and represents lost spring sales. To extend the harvest season, some nurseries practice 'summer-digging.' Summer-dug plants are harvested between late summer and the first fall frosts. Although summer-digging procedures vary among nurseries, the general process includes: saturating the soil, applying an anti-desiccant, digging a larger diameter root ball (compared to that for dormant stock), and acclimating plants under shade and overhead irrigation for several days before shipping.

Summer-dug trees experience transplant shock. Some species, like green ash (*Fraxinus pennsylvanica*) wilt almost immediately after digging and partially defoliate during the acclimation procedures (personal observation). Transplant shock is 'the period between transplanting and the resumption of vigorous growth' (8); poor growth encountered during this period is due to internal water deficits (5, 8). Under typical summer conditions, transplant shock can be characterized as transplant-induced drought stress. Drought stress causes loss of turgor, reduction in growth, closure of stomata, and a decrease in photosynthesis and metabolic function (7). Therefore, reducing internal water deficits through increased water uptake, rapid root regeneration, or reduced transpirational water loss would reduce internal water stress and increase transplant success. However, reduction in transpirational water loss accomplished through stomatal closure could increase leaf temperatures and decrease photosynthetic gas exchange, which would reduce net photosynthesis and the accumulation of carbohydrate reserves.

Biostimulant composition and the benefits following application to plants were listed in a previous paper (11). In a greenhouse study with non-dormant containerized red oak (*Quercus rubra* L.) seedlings, Bioplex™ (the most widely used biostimulant transplant aid by Ohio nursery managers) applications did not increase survival after severe root pruning (59% of the total root surface area was removed by pruning) or growth the following spring (11). However, it was not known if Bioplex™ applications where more severe root loss occurred (like that associated with field digging) and/or less benign environmental conditions, would increase transplant survival and speed establishment.

Therefore, we studied the effects of transplanting and biostimulant application on transpiration rate, transplant survival and recovery of goldenraintree. Goldenraintree was chosen because it is a coarse-rooted, difficult-to-transplant species that is rarely summer dug (4). Taxa with coarse root systems are difficult-to-transplant, in part, because they have few rapidly regenerating, intact root tips after harvest (12). Also, goldneraintree has a high leaf area-to-xylem diameter ratio, suggesting that under stress it may not be able to adequately supply water to the shoots (2). Consequently, it was expected that goldenraintrees with fully developed canopies would not be able to cope with putative internal water deficits caused by root loss at transplanting, thus making it a good candidate for a summer-digging study. Due to limitations of plant material and because Bioplex™ is the most widely used biostimulant by Ohio nursery managers, only one biostimulant product was evaluated.

Materials and Methods

Preparation of plant material. Forty-eight goldenraintrees were selected from a block of field-grown trees at the Waterman Agricultural and Natural Resources Research Laboratory (WANRRL) on the campus of The Ohio State University (OSU). The trees were transplanted from containers three years before (spring 1999) this study was conducted. Tree caliper was measured 15 cm (6 in) above the ground and trees assigned to one of four treatment groups so that similar numbers of trees with the same caliper occurred within each treatment group. On August 1, 2002, trees averaged 6.1 ± 1.4 cm (2.4 ± 0.5 in) in trunk caliper. The treatments (and number of trees per treatment) were: 1) Control, no Bioplex™ (n = 16); 2) Bioplex™ foliar application (n = 8); 3) Bioplex™ soil drench application (n = 8); and 4) a combination of Bioplex™ foliar and soil drench applications (n = 16).

Also, on August 1, leaf area and transpiration measurements were made. Three leaves were harvested from each tree and leaf area determined with a LI-3100 Area Meter (Li-Cor, Inc., Lincoln, NE). Transpiration rates of intact leaves were measured using a Li-1600 steady-state porometer (Li-Cor Inc., Lincoln, NE). Six trees from the control and foliar and soil drench combination treatment groups, and three trees from the foliar only and soil drench only treatment groups were measured throughout the study. Transpiration rates were measured on three randomly selected fully expanded leaflets (located in the outer canopy at varying heights) between 1200 and 1300 hours. Leaflets on different leaves were measured each time. Baseline transpiration readings were taken between August 1 and 3, 2002. At each reading, the three readings per tree were averaged to estimate mean transpiration per tree. Beginning on August 1, and daily until August 14, daily high and low temperatures, relative humidity and precipitation were recorded at a weather station located on the WANRRL.

After the baseline transpiration rates were established, trees were flood irrigated, approximately 9.5 liters/m^2 (2.5 gal/yd^2) per irrigation event, in the morning and afternoon for each of three days (August 4 to 6). Daily transpiration rates were measured as described earlier.

On August 7, trees received the Bioplex™ treatments according to label directions. Foliar treatments were applied using a 9.5 liter (2.5 gal) Hudson Leader Plus Sprayer (H.D. Hudson Manufacturing Company, Hastings, MN). Bioplex™ was mixed at 59 ml (2 oz) per 9.5 liters (2.5 gal) of water. The foliage was sprayed until runoff; we estimated the equivalent of 14.75 ml (0.5 oz) of undiluted Bioplex™ was applied per tree. Soil drench applications delivered 73 ml (2.5 oz) of Bioplex™ in 19 liters (5 gal) of water using plastic buckets with one 3.2 mm (0.125 in) diameter hole drilled in the container bottom. Control trees received 19 liters (5 gal) of water only as described for the soil drench treatment. Transpiration rates were measured on August 7 and 8 as described earlier.

On August 9 the trees were either balled and burlapped or not. All trees in the Bioplex™ foliar and soil-drench treatments were transplanted. For the control and combination Bioplex™ foliar and soil-drench treatments, half of the trees within each group were balled and burlapped, half were not. Thus, untransplanted controls for Bioplex™ treated and untreated trees were available for comparison with Bioplex™ treated and untreated transplanted trees. All trees were dug with a 55.9 cm (22 in) CareTree mechanical tree spade (CareTree Systems, Inc., Columbus OH) attached to a skid steerer. Thus, some root balls were purposely undersized, less than 25.4 cm (10 in) root ball diameter per 2.54 cm (1 in) trunk caliper (1). Immediately following digging the root balls were covered with burlap, placed in truncated wire baskets, the burlap pinned, and the wire baskets laced and crimped. The trees were then transported 457 m (500 yd) to an enclosed structure at the WANRRL where they were stored in the dark for three days (August 9 to 11). While in storage the root balls were hand watered twice daily. Transpiration was measured daily on dug and non-dug trees.

On August 12, the trees were then transported 365 m (400 yd) to another site at the WANRRL and transplanted into a Crosby silt loam soil, with a pH of 6.5. The holes, on spacing of 1.2 m (4 ft) within rows and 3.0 m (10 ft) between rows, were pre-dug with same tree spade used to dig the trees. The trees were planted in a completely randomized design with eight single-tree replications per treatment. At transplanting the wire baskets and the burlap from the top half of the root balls were removed. The trees were mulched with composted wood chips (1.3 m [4 ft] dia. circle) and hand watered once (approximately 38 liters [10 gal] per tree). Transpiration rates for dug and non-dug trees were measured for three days (August 12 to 14) as described earlier.

Caliper and leaf area were measured in August 2003, as described earlier. Twig extension was also measured on three of the most vigorous branches per tree for the 2002 and 2003 growing seasons. Growth data for the 2003 growing season were expressed relative to that of the 2002 season.

Data analysis. The data were analyzed using the one-way ANOVA procedure within SPSS for the personal computer (SPSS, Inc. Chicago, IL). For the transpiration data, the three readings from individual leaves per plant were averaged and individual tree transpiration averages subject to ANOVA. Means were separated using the Student-Newman-Keuls test at $\alpha = 0.05$ level of significance.

Results and Discussion

During the three-day base-line period, the average high temperature was 35.1C (95.3F), the low 21.7C (71.0F), the RH 70.7%, and transpiration averaged 6.1 ± 2.5 µmol per m^2 per sec (Fig. 1). During the three-day pre-digging flood irrigation period, the average high temperature was 32.0C (89.7F), the low 20.0C (68.0F) and the RH 75.6%. Transpiration increased about 51% after irrigation. During the two-day Bioplex™ treatment period, the average high temperature was 27.0C (80.5F), the low 12.5 C (54F) and RH 66.5%. Transpiration after Bioplex™ application was not significantly lower compared to untreated trees for both days following application. Transpiration was undetectable on balled and burlapped trees during the dark acclimation period. The non-dug untreated trees transpired at 4.35 ± 0.77 µmol per m^2 per sec while Bioplex™ treated trees averaged 3.05 ± 0.72 µmol per m^2 per sec during the three-day acclimation period (August 9 to 11, Fig. 1). The average high temperature during this period was 32.4C (90.7F), the low 14.9C (58.7F), the RH 64.7%. Transpiration rates of the transplanted trees, whether treated with Bioplex™ or not were similar for the three days following transplant, but were lower than non-dug trees (Fig. 1). High temperatures during this period averaged 32.5C (90.7F), the low 7.0C (21.1F), and the RH 73.7%. On August 5 and 14, it rained 2.39 and 2.59 cm (0.94 and 1.02 in), respectively.

There was no mortality in 2002, or by August 2003. Transplanted trees (treatment groups 3 through 6) had similar caliper increase in 2003 (Table 1); but significantly lower caliper increase than non-dug trees (treatment groups 1 and 2).

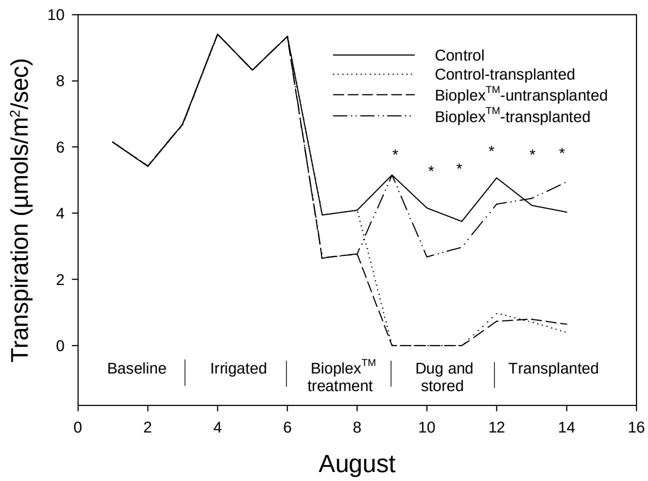

Fig. 1. Transpiration of goldenraintree plants before and after Bioplex™ application, balling and burlapping, dark storage, and transplanting. Transpiration readings were made on field-grown plants before (August 1 to 3) and after (August 4 to 6) irrigation. Bioplex™ applications were made on August 7; the plants were balled and burlapped on August 9. Dug plants were stored in the dark from August 9 to 12, and transplanted to field plots on August 12. Control and Bioplex™ treated but untransplanted, plants remained in the original field plots. Transpiration readings from the three Bioplex™ applications methods (foliar spray, soil drench, and foliar spray and soil drench combination) were averaged because there were no statistical differences among the treatments. Each value is the mean of three leaflets on each of three trees. The * denote statistical differences between control and Bioplex™ undug trees (August 9 to August 11) and between transplanted and untransplanted trees (August 12 to 14).

Average leaf area was similar for all treatment groups in 2003, but less than in 2002 (Table 1). Non-dug trees had greater twig extension in the 2003 growing season than that occurring in the 2002 season and greater extension growth in 2003 than transplanted trees (Table 1).

The objective of this research was to determine the effects of transplanting and biostimulant application on transpiration rates, survival and post-transplant growth of field-grown goldenraintree. A product and application method that would reduce short-term water loss is potentially beneficial to initial survival. Any benefits to long-term survival are uncertain, as reduced transpiration is associated with stomatal closure and reduced net photosynthesis. It is doubtful that long-term reduction in net photosynthesis would benefit transplant establishment.

On August 7 and 8 (after Bioplex™ application, but before digging) there were no differences in transpiration between treated and untreated trees. However, for non-dug plants, those treated with Bioplex™ had significantly lower transpiration rates between August 9 and 11. After August 12, there were no differences in transpiration rates between non-dug Bioplex™ treated and untreated trees. For transplanted trees, transpiration rates were lower for three days (August 12 to14) after transplanting than for those not dug, whether the transplanted trees were treated or not with Bioplex™. Thus, root loss associated with digging, had a greater affect on reducing transpiration rate than any Bioplex™ application method. In this study, transpiration rates were decreased by biostimulant application, dissimilar to previous studies (3, 6, 10, 13, 14). However, Bioplex™

Table 1. **Caliper, leaf area, and shoot extension of goldenraintree in 2002 and the change in 2003 relative to 2002, one year after August transplanting, or not, of goldenraintree as affected by Bioplex™ treatment.**

Treatment combination		Caliper (mm)		Leaf area (cm^2)		Shoot extension (cm^2)	
Bioplex™ treatment[z]	**Transplanted**	**2002**	**Change in 2003**	**2002**	**Change in 2003**	**2002**	**Change in 2003**
None	No	62a[y]	17.8a	152.8a	–48.3a	26.1a	6.4a
Foliar spray and Soil drench	No	60a	21.1a	168.3a	–41.9a	24.6a	8.1a
None	Yes	63a	9.4b	131.2a	–16.9a	27.2a	–0.6b
Foliar spray	Yes	60a	5.3b	163.6a	–64.9a	27.3a	–5.3b
Soil drench	Yes	60a	8.7b	157.3a	–49.7a	29.1a	–1.0b
Foliar spray and Soil drench	Yes	59a	6.1b	126.5a	–49.1a	24.0a	–0.9b

[z]Seedlings given the foliar spray were sprayed with Bioplex™ until run-off delivering 14.75 ml of undiluted Bioplex™ solution; soil drench treated seedlings received 73 ml undiluted Bioplex™; or seedlings were given a combination of soil drench and foliar spray. Control seedlings received no Bioplex™ applications nor were they transplanted.

[y]Means within the same columns followed by different letters are significantly different according to Student-Newman-Kuels at the $\alpha \leq 0.05$ significance level. Each caliper value is the mean of eight trees, each leaf and shoot value is the mean of 24 leaves or shoots (three leaves or shoots in each of eight trees).

decreased whole-plant transpiration in non-root pruned red oak seedlings under greenhouse conditions (11).

The most striking finding was that despite undersized rootballs and summer-digging, goldenraintrees survived transplanting, showed minimal signs of drought stress, and resumed growth at near pre-digging rates. Balok and St. Hilaire (2) found goldenraintree to have relatively thick cuticular wax, which could explain the minimal wilting and defoliation observed in our study. The results suggest that poor transplant survival and re-growth of summer-harvested trees may be caused by stresses other than biological limitations associated with root regeneration. The trees in this study were transported only short distances and held above ground for a short time. Stress associated with transportation to, and maintenance at, the job site may be greater causes of poor transplant survival than root regeneration characteristics of the species. Careful plant handling procedures by nursery producers, shippers and landscape contractors might reduce transplant losses and speed establishment.

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