Field Production

Raúl Cabrera
Section Editor and Moderator

Root Pruning and Transplant Success for Cathedral Oak™ Live Oaks

Edward F. Gilman, Patti J. Anderson and Chris Harcheck
University of Florida, Environmental Horticulture Department, Gainesville, FL 32611-0675

Index Words: root pruning, tree transplanting, root ball, pruning fabric, field production, water stress

Significance to Industry: Some nursery trees produce large numbers of small diameter roots while others do not. Since small diameter roots are thought to be more important for water and mineral absorption than larger roots, we think that the proliferation of small roots after pruning may help reduce water stress and increase survival after transplant (Gilman, et al. 2002a; Kozlowski and Pallardy 1997). This study examined root pruning as a means to improve root ball quality and enhance digging survival.

Nature of Work: Recent studies of live oak root pruning during production found increased survival following transplanting on trees that were root pruning during production with a hand digging shovel or pruned with fabric placed under the liner (Gilman, et al. 2002b). This current study was designed to evaluate the effects of hand spade root pruning and root pruning fabric on morphology of the root system of cutting propagated live oaks and on stress after transplanting these field-grown trees.

On August 7-8, 2001, thirty #1 (3.7L) liners each of Cathedral OakTM live oak (*Quercus virginiana* Mill. 'SDLN' Cathedral OakTM, PP #12015) were planted in Alachua County, Florida, in a sandy soil (Arrendondo sand) and grown for 39 months. Liner root balls were sliced from top to bottom about 2.5 cm (1 in) deep in four places around the plant to sever any potentially circling roots. The experimental design was a randomized complete block design with 2 (fabric vs. no fabric) x 3 (root pruning treatments) = 6 total treatments with 5 blocks totaling 30 trees. Root pruning treatments included hand spade root pruning cutting all roots in the top 12 inches over four events during the last year of production only (2004), hand spade root pruning throughout production, and no root pruning. At each root pruning event, we root pruned by slicing a square-tipped 36 cm (14 in) balling shovel into the soil at an angle similar to that of a mechanical tree spade. Each pruning consisted of two one-eighth (12.5 percent) circumference segments, totaling 25 percent of root ball circumference. In the treatments with fabric, a 30.5 cm (12 in) square of proprietary knit fabric, made of interlocking polyester fibers designed to prevent enlargement of openings (Rootmaker Products Company, LLC, Huntsville, AL), was placed directly under the root ball at planting.

Final caliper, canopy spread, and total tree height were measured just prior to transplanting in November 2004. To compare the effects of root pruning on digging survival and stress, four blocks of 6 trees (4 x 6 = 24 trees total) were dug with an 91 cm (36 in) diameter hydraulic tree spade November 14, 2004, and moved within the same field about 15 m (50 ft) from the original site. After transplanting, we measured stress periodically for 50 days using a pressure bomb (Soil Moisture Inc, Santa Barbara, CA).

All transplanted trees were raised with a tractor between 50-60 days following transplanting to measure roots in the root ball. The number of roots in each of four diameter categories (3 to 5 mm, 5 mm to 1 cm, 1 to 2 cm, and > 2 cm) was recorded. Roots smaller than 3 mm were not counted for this study; they were included in dry weight measurements. Washed, intact root systems on 18 trees were marked at 27 cm (10.75 in) below the soil surface, half the depth of the deepest root ball. The root system was divided into upper and lower sections along this line, placed in separate bags by diameter categories (< 3 mm, and > 3mm), and dried at 70°C for 7 days.

Results and Discussion: After 39 months of production, we found no differences in the dry weight of roots in either the upper or lower root ball, when comparing trees growing with and without root pruning fabric. The relatively shallow rooting of this cultivar may account for the lack of significant differences, especially in the lower portion of the root ball (deeper than 27.3 cm). Root pruning throughout production increased the root dry weight of small diameter (<3mm) roots and reduced dry weight of large diameter (>3mm) roots in the upper half of the root ball. Root pruning throughout also increased the mean number of small diameter roots (Figure 1).

Pruning fabric under the liner reduced stress following digging, but only on two of the days when water stress was measured (data not shown). Root pruning with a digging shovel throughout production resulted in less stress after digging compared to trees not root pruned. We found that root pruning over two years reduced tree height, caliper, and canopy width. When comparing fabric pruning, multi year, and single year results, root pruning Cathedral Oak™ only in the last year of production appeared to be most efficient, resulting in the largest trees with only moderate stress after digging.

Literature Cited:

1. Gilman, E. F., A. Stodola, and M. D. Marshall. 2002a. Production techniques for HighriseTM and seedling live oak. J. Environ. Hort. 20:127-132.
2. Gilman, E. F., A. Stodola, and M. D. Marshall. 2002b. Root Pruning but not irrigation in the nursery affects live oak root balls and digging survival. J. Environ. Hort. 20:122-126.
3. Kozlowski, T.T. and S. G. Pallardy. 1997. Physiology of woody plants, 2nd edition. Academic Press, San Diego, California.

Figure 1. Mean number of roots per size class for spade pruning treatments. Note: Within a given size class, letters above the bars indicate significant differences (p<.05).

Effect of Planting Depth on Tree Growth and Quality in Containers

Edward F. Gilman, Christopher Harchick and Patti J. Anderson
University of Florida, Environmental Horticulture Department, Gainesville, FL 32611-0675

Index Words: planting depth, landscape trees, live oak cultivar, Quercus virginiana, accelerator root pruning system, tree growth, Cathedral Oak™

Significance to Industry: Planting depth of trees in containers and in field nurseries has received little attention until recently. Arborists see trees declining after planting from what appears to be trees planted too deeply in the nursery root ball. When trees decline or die because of improper planting techniques money and/or customers may be lost. Depth of planting can have significant impacts on tree survival and growth. This study of planting depth provides information about the effects of planting one live oak cultivar in containers at differing root depths.

Nature of Work: Limited research on response of trees to planting depth has been carried out to substantiate recommendations based on observation of field conditions (e.g., Browne and Tilt 1992). In addition, there is little research to support the practice of planting palms at random depths to achieve uniform canopy heights in the landscape (Broschat 1985; Pittenger, et al. 2005). In this study, we examined the effects of planting depth on height and caliper of Cathedral OakTM live oak cultivars.

We transplanted cutting propagated Cathedral OakTM from 2.25 inch diameter containers into #3 AcceleratorTM plastic containers in May 2003. These trees were planted at five different depths measured from the point at which the top-most root met the trunk (Table 1).

Canopies were pruned in July 2003 and September 2003. In early May 2004, all trees were potted to #15 AcceleratorsTM. The top of the substrate in the #3 containers was placed even with the media surface in the #15 containers. An additional group of trees planted 2.5 in. deep into #3s were planted another 2.5 in. deep when potted into #15s, for a total depth of 5 in. below the media surface. Canopies were pruned again in May 2004 and September 2004. Caliper and height were measured in October 2004.

Results and Discussion: Overall, caliper decreased with increasing planting depth, with the exception that the first root of the slowest growing trees was planted with within 3⁄4 in. of the surface. Caliper in the first 18 months following planting was larger in trees planted 1.5 in. deep, than in trees 0.5 in.- 0.75 in. and 4.5 in. deep (Table 1). The slower growth of the shallowest planted trees may have been due to root desiccation for a short time after potting into the #3 containers. Tree height was not affected by planting depth.

Significant differences in trunk diameter of container grown Cathedral Oak™ liners suggest that planting depth can make a difference in the rate of growth. Research will continue to investigate the consequences of these differences on tree survival after planting to the landscape.

Literature Cited:

1. Browne, C. and K. Tilt. 1992. Effects of Planting Depth on Three Ornamental Trees. Southern Nursery Association Research Conference Proceedings 37:123-125.
2. Gilman, Edward F. 1997. Trees for the urban and suburban landscapes. Delmar Publishers, Albany, NY.
3. Broschat, TK. 1985. Planting depth affects survival, root growth, and nutrient content of transplanted pygmy date palms. Hort Science 30: 995-998.
4. Pittenger, D. R. D. R. Hodel, and A. J. Downer. 2005. Transplanting specimen palms: a review of common practices and research-based information. Hort Technology 15: 128– 132.

Table 1. Effect of liner planting depth on growth of live oak the first 18 months after potting into #15 containers.

Planting depth (distance (in) between top root and substrate surface)		caliper (in)	height (ft)
0.5-0.75	(120)*	1.02c	6.62
1.5	(44)	1.14a	6.86
2.5	(44)	1.10ab	6.65
3.5	(44)	1.07abc	6.66
4.5	(42)	1.03bc	6.45

*Means based on number trees (in parentheses) at each planting depth.

Means in a column followed by different letters are statistically different at P<0.05.

Evaluation of Cold Damage of Field-Grown Fruit Nursery Trees

D.E. Deyton[1], C.E. Sams[1], J.C. Cummins[1], D.W. Lockwood[1] and M. Halcomb[2]
[1]Department of Plant Sciences, The University of Tennessee, Knoxville, TN 37796,
[2]Agricultural Extension Service, The University of Tennessee, McMinnville, TN 37110

Index Words: Peach, *Prunus persica* (L.) Batsch, freeze, color scale, cambium, xylem

Significance to the Industry: We created a UT-Cambium/Xylem Browning chart (http://plantsciences.utk.edu/deyton/UTCambiumXylemBrowningChart.pdf) that can be used for future cold damage evaluations by nurserymen, extension personnel, researchers, etc. These trials show that low-chill requirement peach trees were damaged more by autumn freezes than the high chill cultivars. Very large June-budded trees were damaged more than smaller trees. Thus, if a freeze is expected, these trees should be dug first. The c/x browning can be evaluated within one to two days after the freeze if trees are kept at room temperatures. Trees exposed to freezes and having low c/x browning ratings (e.g., 'Redglobe') can grow normally the next year. However, more evaluations are needed to determine the cambium/xylem browning ratings that various peach cultivars, other fruits and ornamentals can tolerate and recover from.

Nature of Work: Tennessee has historically been a major producer of nursery field-grown fruit trees. First-year field-grown nursery fruit trees, as well as ornamental trees, are sometimes exposed to damaging early autumn freezes prior to digging. Nurserymen are concerned how severe the damage is and if it will affect growth the following year. Previous researchers have reported that cambial browning after freeze damage was a reliable test of cherry tree viability (2) and peach tree survival (1). The objectives of this research were to develop a visual scale for nurserymen to rate tissue discoloration, to determine if cambium/xylem (c/x) browning was related to nursery tree size, to determine if the browning differed among cultivars, and to relate the browning to potential growth of trees.

Cold damage from freezes in the field: Field-grown, June-budded peach trees in a commercial nursery at McMinnville, Tenn. were exposed to an early autumn (5 Nov.) freeze (12°F) prior to being harvested (dug). We developed the UT-Cambium/Xylem Browning (UT-C/XB) chart based on a series of pictures taken of the c/x tissues of trees sampled from the nursery cooler (Fig. 1). In order to evaluate cold damage among different tree-size grades, five June-budded peach trees of 'Harbrite' and CVN-1BJ were sampled on 13 Dec. in the height grades of 12 to 17 in, 18 to 23 in, 24 to 29 in, 30 to 35 in, 36 to 47 in, and 48 to 60 in. Cuts were made on trunks at midpoint between the graft union and the apex, and 3 in above the graft union and c/x browning rated using the UT-C/XB chart. In order to evaluate if cold damage may vary among peach cultivars with differing chilling requirements, five trees per cultivar of ‘TropicSweet’ (175 chill h requirement), ‘Flordastar’ (225 h), ‘Flordaking’ (450 h),‘Idlewild’ (550 h), ‘La White’ (650 h), CVN-1BJ (750 h), ‘Harbrite’ (850 h), ‘Redhaven’ (950 h), and ‘La Premier’ (1050 h) were selected from the 36 to 48 in grade. The c/x browning was rated as above.

Cold damage from freezes in the laboratory: Controlled-freezing trials were conducted the following year to relate cold damage (c/x browning) to growth of trees the next year. Fifteen June-budded, field-grown (12 to18 in height) ‘Redglobe’/’Lovell’ (cultivar/rootstock) peach trees per cold treatment were exposed to controlled freezing conditions in mid-December The trees were placed in a programmable freezer and the temperatures lower at 5°F/h from 40°F to 21°F (exposure temperature in field before digging), 5, 0, -11, -22, or -31°F and held at the temperature treatment for 15 min. The roots were kept > 26°F. Trees were kept in cold storage and five trees were rated with the UT-C/XC chart at one and 65 days after cold treatment. The other five trees were planted in a field nursery on 30 Mar. and grown until 23 Nov. The trees were dug, oven dried, and root and shoot dry weights measured. The experiment was repeated in mid-January with ‘Juneprince’/’Lovell’ trees exposed to treatments of 16, 10, 5, 0, -11, -22, or -31°F.

Results and Discussion: *Cold damage from freezes in the field:* Bearing-age peach cultivars with less than 700 h chill requirements frequently suffer wintertime cold damage to fruit buds or springtime frost damage to flowers in the mid-South. However, we are unaware of reports that nursery trees of low-chill requirement cultivars are more susceptible to cold damage to trunks in the autumn than higher chill cultivars. In this trial, trees of peach cultivars with ≤ 450 h requirements had more c/x browning after the 12°F autumn freeze than cultivars with ≥ 500 h (Table 1). Cambial browning was very similar in all cultivars with ≥ 500 h requirements. Ratings taken in the mid-trunk (height) region were similar to those taken 3 inches above the graft union. The most vigorous June-budded trees (48 to 60 inches tall) had the highest c/x browning ratings. However, trees < 36 in did not differ in c/x ratings (Table 2).

Cold damage from freezes in the laboratory: The laboratory freeze trials evaluated c/x browning under more controlled temperatures and the effects on growth the next year. ‘Redglobe’ trees exposed to freezing conditions in December exhibited c/x browning the next day if kept at room temperature (Table 3). Temperatures as low as -11°F caused little or no browning at one day after treatment (DAT) or 65 DAT (in cool storage). Trees with low c/x ratings (≤ 1.6) grew equally well the next summer, but trees with c/x ratings ≥ 4 died. ‘Juneprince’ trees exposed ≥ -11°F also had c/x browning one DAT after cold treatment (Table 4). Trees exposed -22°F or -33°F had c/x ratings > 4 and failed to live through the following summer. The trees exposed to 0°F had very slight browning of the cambium one DAT (rating=1.2) and 40 DAT (rating=1.6), but failed to live through the next summer. We are uncertain if the tree deaths are associated with the cold damage or later factors in the field.

Literature Cited:

1. Cain, DW and R.L. Anderson. 1979. Relative freezing injury to 'Velvet', 'Redhaven', and 'Siberian C' peaches following controlled freezer tests at selected dates during two winters. J. Amer. Soc. Hort. Sci. 104:839-843.
2. Stergios, B.G. and G.S. Howell, Jr. 1973. Evaluation of viability tests for cold stressed plants. J. Amer. Soc. Hort. Sci. 98:325-330.

Fig. 1. UT-Cambium/Xylem Browning chart. Pictures are of peach trees that exhibited varying degrees of browning after exposure to 12°F on 5 Nov.

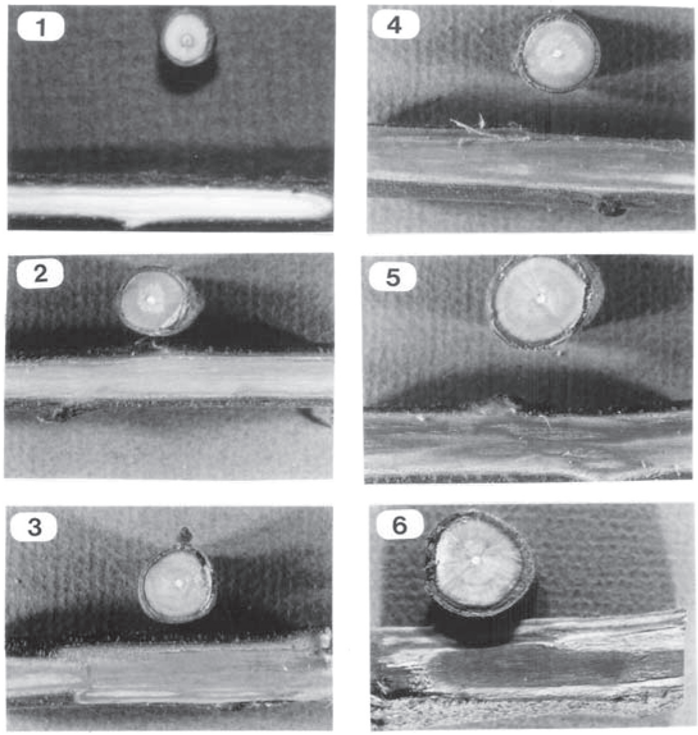


Table 1. Cold damage to cambium/xylem tissues of nursery field-grown, June-budded peach cultivars exposed to 12°F prior to digging.

Cultivar	Chilling requirement (hour < 45°F)	Cold damage rating of cambium/xylem[Z]
La Premier	1000	3.1 c[Y]
Redhaven	900	2.2 ab
Harbrite	850	2.5 bc
CVN-1BJ	750	2.1 ab
La White	650	2.0 a
Idlewild	550	2.6 bc
Flordaking	450	4.8 d
Flordastar	225	4.6 d
TropicSweet	175	5.1 d

[Z] Rated with UT-Cambium/Xylem Browning chart on 16 Dec., 40 days after the freeze.

[Y] Each value is the mean of 10 ratings. Mean separation by Duncan's multiple range test, values followed by the same letter are not significantly different at $P \leq 0.05$.

Table 2. Cold damage to cambium/xylem tissues of June-budded CVN-1BJ and 'Harbrite' peach trees exposed to 12°F prior to digging.

Tree grade height (inch)	Trunk diameter (in)[Z]	Cold damage rating of cambium/xylem[Y]
12 to 17	0.14[X]	2.0 c
18 to 23	0.18 e	2.0 c
24 to 29	0.24 d	2.0 c
30 to 35	0.29 c	2.1 bc
36 to 47	0.37 b	2.2 b
48 to 60	0.50 a	3.3 a

[Z] Measured three inches above the graft union.

[Y] Rated with UT-Cambium/Xylem Browning chart on 16 Dec., 40 days after the freeze.

[X] Mean separation by Duncan's multiple range test, values in a column followed by the same letter are not significantly different at $P \leq 0.05$.

Table 3. The effects of freezes in mid-December in the laboratory on cambium/xylem browning and growth of 'Redglobe'/'Lovell' peach trees the next year.

Temperature	Cambium/xylem browning[Z]		Cumulative tree dry wt. (g)[Y]	
(°F)	1 DAT x	65 DAT	Stem	Stem + roots
21	1.0 c[V]	1.2 b	403 a	724 a
5	1.0 c	1.2 b	399 a	802 a
0	1.0 c	1.0 b	350 a	643 a
-11	1.6 c	-----	428 a	722 a
-22	4.0 b	5.6 a	(dead)	(dead)
-31	5.4 a	6.0 a	(dead)	(dead)

[Z]Rated with UT-Cambium/Xylem Browning chart.

[Y]Trees were planted 30 Mar. and grown until 24 Nov.

[X]Days after treatment.

[V]Mean separation by Duncan's multiple range test. Values in a column followed by the same letter are not significantly different at P ≤ 0.05.

Table 4. The effects of freezes in mid-January in the laboratory on cambium/xylem browning and growth of 'Juneprince'/'Lovell' peach trees the next year.

Temperature	Cambium/xylem browning[Z]		Cumulative tree dry wt. (g)[Y]	
(°F)	1 DAT[X]	40 DAT	Shoot	Shoot + roots
16	1.0 c[V]	1.2 c	558 a	975 a
10	1.0 c	1.0 c	397 a	695 a
5	1.0 c	1.2 c	383 a	800 a
0	1.2 c	1.6 c	(dead)	(dead)
-11	2.6 b	3.6 b	(dead)	(dead)
-22	4.2 a	5.6 a	(dead)	(dead)
-31	4.8 a	5.8 a	(dead)	(dead)

[Z]Rated with UT-Cambium/Xylem Browning chart.

[Y]Trees were planted 30 Mar. and grown until 24 Nov.

[X]Days after treatment. V Mean separation by Duncan's multiple range test. Values in a column followed by the same letter are not significantly different at P ≤ 0.05.

Response of Two Field-grown Redbud Varieties to Three Reference Evapotranspiration Based Irrigation Regimes

Thayne Montague
Texas Tech University, Dept. Plant and Soil Science, Lubbock, TX 79409-2122

Index words: Eastern redbud, *Cercis canadensis*, Reference Evapotranspiration, Irrigation

Significance to Industry: For many nurseries, water conservation is a top priority. However, while reducing the amount of water used in nursery production is crucial, little data exists which quantifies the amount of water needed to produce field-grown trees or methodology to estimate tree water requirements. This research suggests that calculating irrigation levels based upon estimated tree root area and reference evapotranspiration may provide sufficient water for growth, yet avoid over irrigating and wasting resources. In addition, this research indicates irrigation volume will influence gas exchange and growth of field-grown redbud trees, but that proper irrigation volume can conserve water and produce satisfactory growth.

Nature of Work: Drought and depleted water tables have increased the number of ordinances (often without regard to plant water requirements) in many municipalities and irrigation districts. These ordinances often limit the amount of water nurseries can use to irrigate trees (1). Even though research on water conservation in nurseries is currently ongoing (3), little research has been conducted to inform growers, municipalities, and irrigation districts of the amount of water required to produce field-grown (FG) tree species (2). To help determine the influence of limited irrigation on FG tree species, this research investigated gas exchange and growth of two FG redbud tree varieties subjected to three reference evapotranspiration based irrigation regimes in a semi-arid climate.

Research was conducted at a field nursery in Lubbock, TX. Selected redbud varieties were: Texas redbud (*Cercis canadensis texensis*) and Mexican redbud (*C. canadensis mexicana*). During Spring 2002, nine containerized (3 gal) trees of each species were planted in rows. Irrigation regimes were based upon estimated soil surface area above the tree's root system (in^2) and local reference evapotranspiration (ETo (in)). During the dormant period after each growing season root area was estimated by removing soil from several trees. Climatic data was collected from an on site weather station. Irrigation regimes were: 100, 60, and 30% of ETo (high, medium, and low, respectively). Trees were irrigated through a drip irrigation system. Each tree had 3, 2, or 1 emitters (1 gal hr^{-1}) placed at the base of the tree and trees were irrigated an equal amount of time twice each week. If precipitation occurred, precipitation accumulation was subtracted from ETo. Trees were not fertilized during the experiment. During the 2002 growing season, all trees were irrigated at 100% ETo. Irrigation treatments began Spring 2003. On several occasions each growing season

(2003 and 2004) gas exchange data (pre-dawn leaf water potential and mid-day stomatal conductance) were collected. Growth data (trunk caliper increase, shoot elongation, and total leaf area) were collected at the end of each growing season. All data were subjected to ANOVA appropriate for a randomized block design. If treatment differences were found, means were separated by Fisher's LSD. Because of similarity of data between growing seasons, only 2004 data will be presented.

Results and Discussion: Climatic data during the growing season indicate precipitation totaled 6.3 inches and ETo totaled 28.4 inches. For each irrigation treatment, total irrigation volume applied to each tree ranged from to 153 gallons (low irrigation regime) to 462 gallons (high irrigation regime).

Pre-dawn leaf water potential and mid-day stomatal conductance measurements during the growing season were variable. For Texas redbud, pre-dawn leaf water potential measurements indicate trees under the low and medium irrigation treatments were under greater stress (more negative pre-dawn leaf water potential) than trees under the high irrigation treatment on only two occasions. In addition, stomatal conductance data indicates Texas redbud trees under low irrigation frequently had means similar to trees under the medium and high irrigation treatments. For Mexican redbud, pre-dawn leaf water potential for high irrigation trees was generally less negative than pre-dawn leaf water potential for trees receiving the low and medium irrigation treatments. However, trees receiving the medium irrigation treatment frequently had greater stomatal conductance when compared to trees receiving low and high irrigation treatments.

Data indicate irrigation treatment also influenced growth of each redbud variety. When compared to the low and medium irrigation treatments, shoot growth, caliper increase, and leaf area of Texas redbud trees receiving the high irrigation treatment had greater growth (Fig. 1). However, similar growth trends were not found for Mexican redbud. For each growth parameter, Mexican redbud trees receiving the medium irrigation treatment had similar growth when compared to trees receiving the high irrigation treatment and generally greater growth than trees receiving the low irrigation treatment (Fig. 2).

This research indicates irrigation volume can influence gas exchange and growth of these FG, redbud varieties. However, it is interesting to note that the greatest gas exchange and growth was not necessarily associated with trees receiving the greatest amount of irrigation volume. Therefore, it appears for some tree species, irrigation volume may be reduced and produce similar growth when compared to trees receiving greater irrigation volume. In addition, it appears the influence of irrigation volume on growth of these FG trees is plant structure and species specific. Data also suggests irrigation of FG trees based upon soil surface root area and local ETo measurements may be a means to conserve irrigation water and produce FG trees with acceptable growth. However, continued research on the influence of reduced irrigation on FG tree species is needed.

Literature Cited:

1. Mathers, H.M., T. H. Yeager, and L. T. Case. 2005. Improving irrigation water use in container nurseries. HortTechnology. 15:8-12.
2. Montague, T., R. Kjelgren, R. Allen, and D. Wester. 2004. Water loss estimates for five recently transplanted landscape tree species in a semi-arid climate. J. Environ. Hort. 22:189-196.
3. Warren, S.L. and T. E. Bilderback. 2005. More plant per gallon: Getting more out of your water. HortTechnology. 15:14-18.

Figure 1. Shoot growth, caliper increase, and total leaf area for field-grown Texas redbud trees subjected to three irrigations regimes (100, 66, and 33% reference ET (high, medium, and low, respectively). Different letters within growth data indicate significant effects of irrigation regime (P ≤ 0.05).

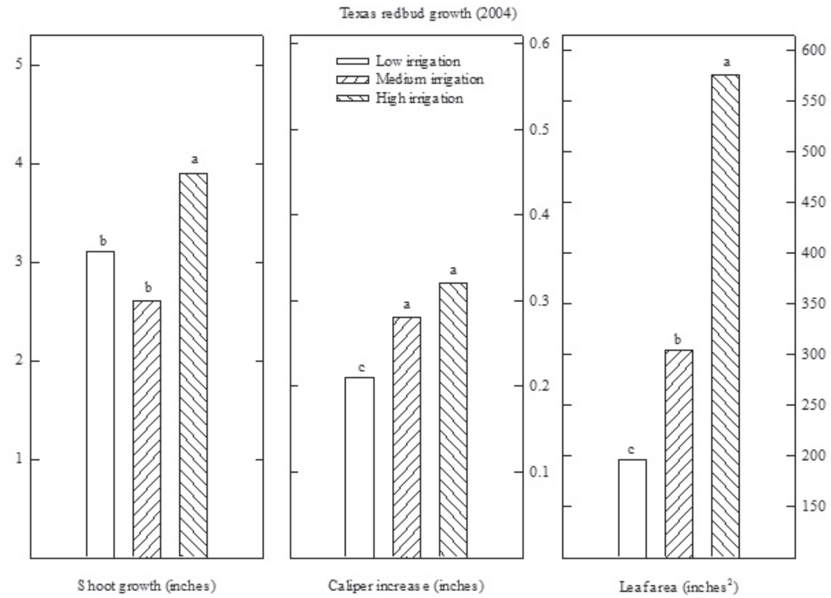
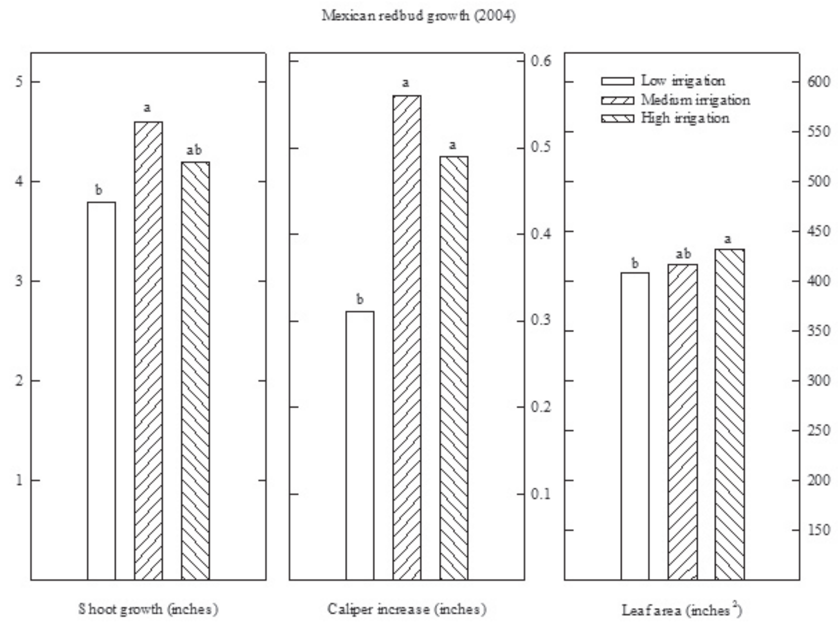


Figure 2. Shoot growth, caliper increase, and total leaf area for field-grown Mexican redbud trees subjected to three irrigations regimes (100, 66, and 33% reference ET (high, medium, and low, respectively). Different letters within growth data indicate significant effects of irrigation regime ($P \leq 0.05$).



Field Caliper Tree Production Using Retractable Roof GreenHouse Grown Liners

Hannah M. Mathers, Luke T. Case,
Elizabeth Grosskurth and Michele Bigger
Ohio State University, Columbus, Ohio 43210-1096

Index Words: Nursery, bareroot liners, container production

Significance to Industry: Retractable roof greenhouses (RRG's) (as flat-roof or peaked-roof curtain houses) offer a number of production and marketing advantages compared to conventional container production. RRG's have been found to increase plant water use efficiency (WUE) and nitrogen use efficiency (4), increase growth (1, 4), cut production times of certain crops in half (2) reduce wind throw problems and extend growing seasons (4). They have also proven their utility in producing superior containerized tree liners (3, 4). The RRG grown containerized liners offer a feasible alternative to field bareroot liner production based on price, availability and niche markets such as coarse-rooted, difficult-to-transplant and native taxa. Additionally, data indicates RRG grown tree liners accelerate field caliper tree production in Midwestern states, when planted in October out of 3 gallon containers versus bareroot liners.

Nature of Work: At Ohio State University (OSU) Waterman Farm, Columbus, OH four species of tree liners were out-planted from three environments. A soil test was conducted in September, 2003 all nutrients were in the surplus (P and K), high (Mg) to medium range (Ca) with the exception of nitrogen. Soil pH was 7.5, CEC was 13.1 and organic matter percent was 4.7. In May 2004, 48g/tree or 100 lb N/ac of 34-0-0 was applied. 34-0-0 was also applied April 11, 2005 at 42g/tree and June 6, 2005 for a total of 171 lb N/ac. A Netafim USA (Fresno, CA) In-Line Dripperline Assembly was set-up to apply water on an as needed basis. The three environments where liners had been produced were a peaked RRG (Cravo Equipment, Ltd., Brantford, ON, Canada) in 11.4 L classic Spinout® treated containers (Nursery Supplies, Inc., Fairless Hills, PA), filled with a 60% pine bark, 25% peat moss, 7% composted sludge (from the City of Akron, OH), 7% haydite and 1% sand substrate (Willoway Nurseries, Inc., Avon, OH), a combination heated greenhouse-outdoor (CHGO) production environment also in 11.4 L containers at OSU, Columbus, OH and bareroot liners from nursery fields, Canby, OR. The OSU liners had been produced according to the methods described by Stoven et al. (4). The OSU liners were planted in the field in October 5, 2003 and bareroot liners were planted (when traditionally available for planting in Ohio) April 26, 2004. All plants were trained to 2 m tall bamboo stakes (A.M. Leonard, Inc., Piqua, OH) installed at planting. In cases where height exceeded 2 m – 2 stakes were attached together. The four species evaluated are, *Acer xfreemanii* 'Jeffersred' (Autumn Blaze™ red maple), *Malus* 'Prairifire' (Prairifire crabapple), *Cercis canadensis* (Eastern redbud) and *Quercus rubra* (red oak). Growth measures of height and caliper (taken at 15.24 cm) were recorded at planting and June and September 2004. Measures will continue to be collected each June and September for 2005-07. Average initial heights and calipers for redbud, maple, crabs and oaks out-planted from the RRG were (264.6 cm, 14.8

mm), (265 cm, 15.6 mm), (184.2 cm, 11.6 mm), (69.6 cm, 9.4 mm), respectively. Average initial heights and calipers for redbud, maple, crabs and oaks out-planted from the CHGO production environment were (221.7 cm, 14.8 mm), (249.6 cm, 17.7 mm), (189.2 cm, 11.8 mm), (50 cm, 8.2 mm), respectively. Average initial heights and calipers for redbud, crabapples, and oaks out-planted as bareroot liners in April were (187.1 cm, 18.2 mm), (132.5 cm, 10.7 mm), (225.4 cm, 15.8 mm), respectively. There were no initial measures taken for the maples. The redbud, maple and oak bareroot liners had (less height, greater caliper), (less height, less caliper) and (greater height, greater caliper) at planting versus the RRG or CHGO production environment, respectively. In early November, all the RRG and combination environment trees were pruned according to normal nursery practices. Heading back cuts on the central leader were preformed on OSU liners with excessive height and growth straight cards were used to reestablish the central leader in the spring. No pruning was done to bareroot liners at time of planting. Perennial ryegrass was seeded in the fall of 2003 between the rows and mowed as required. Row spacing between-rows is 12 ft and in-row 6ft. Height, caliper and change (Δ) in height and caliper from June to October, 2004 data were subjected to ANOVA using the GLM procedure within SAS® (SAS Institute, Inc., Cary, NC, 2000). Fisher's least significance difference test were used to compare means a $P < 0.05$ was used (SAS© Institute Inc.). The Type II Sum of Squares analyses was performed and graphs were produced in Excel. All factors were considered fixed effects; therefore all terms were tested for significance against the error mean square.

Results and Discussion: The only tree mortality occurred in the oaks with five of 12 bareroot liners having died by September 2004 (42%). One of 12 oaks died out of the CHGO production environment (8%) and there were no deaths with RRG liners (0%). Delta caliper was significant for the main effects of environment and species at $P>0.0001$, environment X species was significant at $P = 0.06$, so will not be presented. The RRG (Cravo) grown liners produced significantly greater caliper increases in the field from June to September 2004 versus the bareroot liners, producing an average increase, across species of 6 mm (0.24 in); however, this difference was not significantly different than the liners obtained from the CHGO environment (Fig.1). The main effects of species and environment were significant for September height ($P>0.001$) (data not shown) and caliper (P= 0.1, 0.0001); however, environment X species interaction for both measures was also significant so only the interactions will be presented. With the exception of oak, the RRG (Cravo) grown liners, had the largest calipers and height in September 2004 versus the bareroot liners; however, this difference was not significantly different than the liners obtained from the CHGO environment, again with the exception of oak (Fig.2 and 3, respectively). The oak grown bareroot in Oregon had larger caliper and height growth (Fig.2 and 3); however, keep in mind only 58% survived so this slight growth increased would not offset loss revenue at a production nursery.

Literature Cited:

1. Lowe, S.B., H. M. Mathers and D.K. Struve. 2005. High temperature stress in containers and the influence of environment, pot type, media and species. HortTechnology (in review).
2. Mathers, H.M. 2001. The future is in retractables: Nursery stock production in retractable roof greenhouses. The Buckeye. Aug. p. 16-17, 19 and 31.
3. Mathers, H., D. Struve and A. Stoven. 2002. Tree liner production in Ohio. The Buckeye. Nov. p. 14-17.
4. Stoven, A. A., H. M. Mathers and D.K. Struve. 2005. Fertilizer method affects growth, nutrient and water use efficiency of container-grown tree liners in two production environments. HortScience (in review).

Figure. 1. Field caliper increase during the period from planting October 2003 and April 2004 to September 2004 pooled over species for liners produced from three production environments. The abbreviations RRG and CHGO signify retractable roof greenhouse and combination heated greenhouse-outdoor, respectively. Different letters signify least significant difference (LSD) P = 0.05.

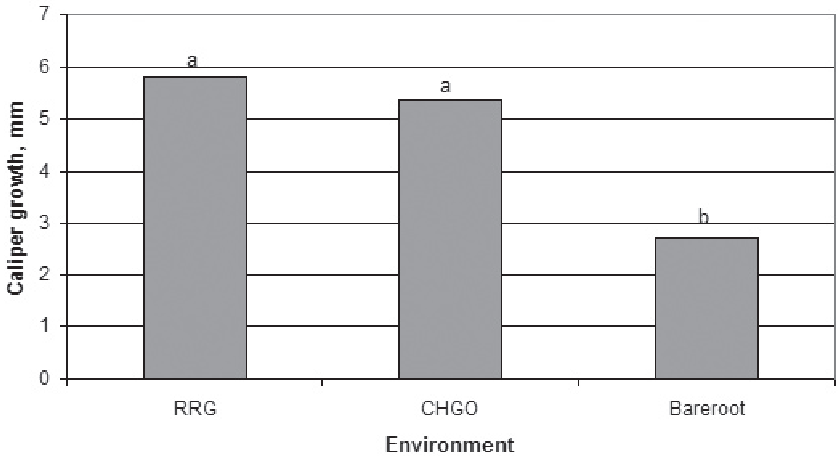


Figure. 2. Field caliper measures in September 2004 for four species of liners produced from three production environments. The abbreviations RRG and CHGO signify retractable roof greenhouse and combination heated greenhouse-outdoor, respectively. Different letters signify least significant difference (LSD) P = 0.05.

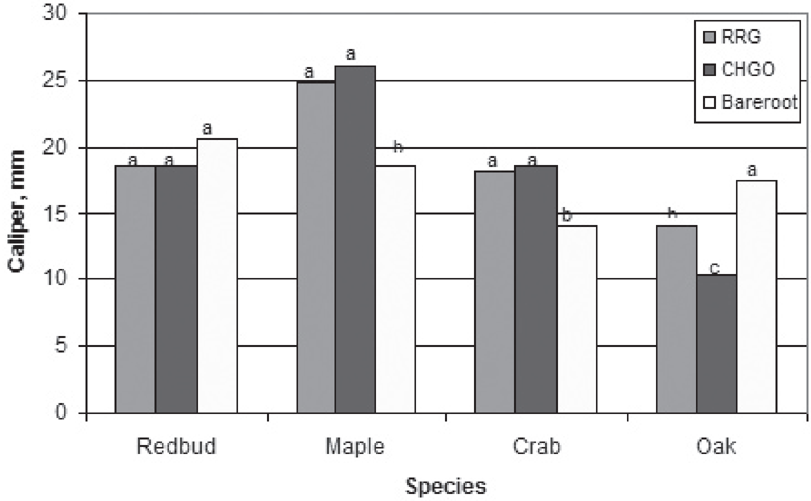


Figure. 3. Field height measures in September 2004 for four species of liners produced from three production environments. The abbreviations RRG and CHGO signify retractable roof greenhouse and combination heated greenhouse-outdoor, respectively. Different letters signify least significant difference (LSD) P = 0.05.