Research Updates

Microirrigation Affects Growth and Root Distribution of Trees in Fabric Containers

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Summary. Lagertroemia indica L. x *fauriei* Koehne ('Natchez' crape myrtle) crown width increased after 13 months as irrigation frequency increased from every 3 days to every day, and the irrigated area around the fabric container increased from 20% to 100% of the circular area within 20 cm beyond the container. Restricting irrigation to within the fabric container plus 20% of the area 20 cm beyond the container edge resulted in less height and width for crape myrtle, but had no effect on root growth, compared to irrigating 100% of area 20 cm beyond the container. Restricting the pattern of irrigation to the container plus 20% of the area 20 cm beyond the container resulted in greater free-root weight (roots < 5 mm in diameter) within the container for laurel oak *(Quercus laurifolia* Michx.) compared to irrigating the container plus 100% of the area 20 cm beyond the container. Height, width, and caliper of oak were not different among treatments.

Use of fabric containers (Gro-Bags™) for field production of landscape trees requires growers to adapt nursery practices to this developing technology. Trees are planted in fabric containers that are buried in field soil with the top inch of fabric exposed above ground. Roots are partially girdled as they grow through the fabric. Girdling confines most of the large-diameter roots inside the fabric and results in a smaller, lighter rootball than traditional balled-in-burlap harvested trees. Lighter rootballs in fabric containers are easier to handle in the nursery and during transplanting to the landscape.

Use of fabric containers in sandy soils makes irrigation particularly challenging. Well-drained sandy soils allow little lateral movement" of water, requiring irrigation of 50% to 60% of the root zone in agronomic crops (Smajstrla et al., 1987). Growers are concerned about irrigation placement for maximum tree growth in the nursery, and for establishment in the landscape after transplanting.

The response of trees to fabric containers appears to be species-dependent. Root weight inside fabric containers can be creater than inside traditional field-grown rootballs on comparably sized trees (Fuller and Meadows, 1987; Ingram et al., 1987). It has been suggested that there may be more roots and smaller roots in fabric container-grown rootballs than those inside a traditional field-grown rootball (Whitcomb, 1986). However, Gilman et al. (1992),Tilt et al. (1992), and Ingram et al. (1987) showed that, for most species, there was no difference in weight or distribution of roots within the rootball between a tree harvested in a fabric container and one harvested by traditional balled-in-burlap methods. Lower root weight within the fabric container has been reported in only one study (Chong et al., 1987). Due to the small size of the rootball, root density appears to be higher within fabric-container rootballs compared to balled-in-burlap rootballs (Fuller and Meadows, 1987; Gilman et al., 1992; Harris and Gilman, 1991).

Optimum irrigation placement has not been studied for trees produced in fabric containers; however, there are some data from trees produced in field soil without fabric containers. In a temperate climate, trickle irrigation placed 15 cm from the base of the trunk had no effect on root system depth in sugar maple *(Acer saccharum* Marsh.), honeylocust (*Gleditsia triacanthos* L.) and pin oak *(Quercus palustris* Muenchh.; Ponder and Kenworthy, 1976). Compared to an unirrigated control, trickle irrigation during the 3-year study resulted in increased tine-root weight within the rootball of pin oak and sugar maple, but not of honeylocust. On the other hand, live oak *(Q. virginiana* Mill.), red maple *(A. rubrum* L.), and Southern magnolia (Magnolia *grandiflora* L.), in sandy soil receiving low-volume drip irrigation from one drip emitter at the base of the trunk, had roots extending well beyond the branch dripline. There appeared to be no concentration of roots beneath the drip emitter. This was similar to root distribution on other species receiving occasional overhead irrigation (Gilman, 1988). There appears to be sufficient soil moisture for root growth well beyond the drip emitter in temperate climates (Gilman, 1988; Ponder and Kenworthy, 1976), although in desert climates there is a dramatic increase in root density beneath the drip emitter at the expense of root growth beyond the wetted zone (Goode et al., 1987).

The following research was conducted with 'Natchez' crape myrtle

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and laurel oak and was designed to: 1) determine the effects of microirrigation placement on root mass and distribution, and 2) compare shoot growth of treatments combining irrigation placement and frequency.

Materials and methods

This study was conducted in central Florida in an excessively well-drained Astatula fine sand (< 1% organic matter). Trees were transplanted from 11-liter (oak) or 3.7-liter (crape myrtle) containers into 46-cm-diameter fabric containers (Root Control, Inc., Oklahoma City) on 5 Apr. 1988. Trees were spaced 2 m apart within the row and 3 m between rows. Each plant was fertilized with 85 g of Osmocote 17N–6P–10K Plus Minors (Sierra Chemical Co., Milpitas, Calif.) top-dressed within the fabric container at planting and with 42.5 g of the same fertilizer applied to a 60-cm-diameter circle centered on the trunk the following August and in May 1989.

All plants were irrigated inside the fabric container at a rate of 2.5 cm every other day for the first 4 weeks after planting before experimental irrigation treatments began. Six trees of each species were not irrigated after the initial 4-week irrigation period. Treatments were arranged in factorial combinations (3 × 3) obligation frequency (1.3 cm every day, 2.5 cm every 2 days, or 2.5 cm every 3 days) with irrigation placement (irrigation within the container plus either 20%, 45%, or 100% of the circular area 20 cm beyond the edge of the fabric container) facilitated by nozzle positioning. Irrigation placement was achieved with one 0.27 -liter·min^{-1}, one 0.49-liter·min–1, or two 0.24 -liter·min–1 mini-sprayers (Spot-Spitters, Roberts Irrigation Products), respectively. Cumulative rainfall at the test plot from Apr. 1988 through Sept. 1989 was 1.51 m. (0.7 m below normal for central Florida). Treatments were arranged in a randomized complete-block design with one replication per treatment in each of six blocks for both species.

Root systems from three trees of both species receiving no irrigation, or 1.3 cm irrigation daily within the container plus 20% of the circular area 20 cm beyond the fabric container (container +20%), or 1.3 cm irrigation daily applied within the container plus 100% of the circular area 20 cm beyond the fabric container (container + 100%)(total of 18 trees) were harvested at the end of the study (26 and 27 Sept. 1989). In addition to harvesting roots within the fabric container, all roots were harvested outside the container from 90° wedges (centered at the trunk) on the north and south sides of each fabric container (two wedges). This represented 50% of the root system outside the container. Total root weight outside the fabric container was estimated by multiplying this value by two. Maximum root extension from the trunk was recorded within each harvested wedge and means were compared using Dunnett's test. Root systems were separated into four root-diameter classes, dried, and weighed. Diameter classes were: <2 mm, 2 to <5 mm, 5 to <10 mm, and >10 mm. Percentage weights of all roots on the tree that were inside the fabric containers were calculated for each diameter class.

Height, crown width, and trunk diameter were measured for all trees at the beginning of study and subtracted from measurements made 13 months later to determine growth increase. Tree height was distance between the ground and the highest point on the tree. Crown width was recorded as the average of the widest crown diameter and perpendicular width. Trunk diameter was recorded 15 cm above the ground. Only the largest trunk on multi-trunked crape myrtles was measured.

Results

Root tips of nonirrigated crape myrtle extended an average of 1.0 m from the trunk, significantly shorter ($P < 0.05$) than for plants irrigated with 1.3 cm daily inside the container+ 20% (1.16 m), or irrigated with 1.3 cm daily inside the container+ 100%(1.26 m). For laurel oak, maximum root extension was not different due to irrigation placement with 1.3 cm in the container +20% or in the container + 100% or not irrigating (mean distance = 0.7 m for all three treatments).

Irrigation placement affected the distribution of the root system of laurel oak, but not crape myrtle. Laurel oak irrigated within the container + 20% had more fine roots (0- to < 2-mm- and 2 to <5 -mm-diameter classes) in the container than the other two treatments (Table 1). Trees irrigated within the fabric container + 20% also had the largest percentage (61%) of fine roots (0 to <2 mm in diameter) on the entire root system located within the fabric container. Both crape myrtle irrigated treatments had more fine-root weight than the nonirrigated trees (Table 2), but applying the irrigation within the container + 20% did not result in the greatest fine-root weight in the rootball, as it did for laurel oak. For roots. outside the container, irrigated crape myrtle and oak trees had greater weight partitioned to roots with diameters <5 mm compared to nonirrigated trees (data not shown).

The percentage of total-tree root weight (all root diameter classes combined) harvested within the fabric container was not different as a result of irrigation placement. About 69% of crape myrtle and 92% (data not shown) of the total weight of laurel oak root systems was within the fabric container. Past studies revealed that ≈50% of the total-tree root weight was harvested for trees grown in fabric containers (Harris and Gilman, 1991). A higher percentage may have been harvested in this study because trees were harvested 6 to 12 months before they would have been considered salable. During this time, more roots would have grown outside of the container, thus reducing the amount of roots harvested in the container. However, past research (E.F.G., unpublished data) and this study indicate that a much smaller fraction of the fine roots was harvested within the fabric container compared

Table 1. *Dry weight of laurel oak roots within the fabric container rootball after 18 months of irrigation with 1.3 cm daily.*

Irrigation placement	Root diameter class (mm) 0 to <2	2 to <5	5 to <10	>10
	Dry wt (mg)			
Not irrigated	22.1 (51[z])	56.5 (73)	169.8 (97)	1016.5 (100)
Irrigated inside[y] container + 20%	51.9 (61)	77.7 (74)	159.9 (87)	1467.2 (100)
Irrigated inside[y] container + 100%	18.7 (44)	56.2 (64)	147.4 (91)	1727.6 (100)
LSD 5%	12	11	31	487

[z]*Percentage of all roots on the tree that were inside the fabric container for this diameter class.*
[y]*Irrigation covered soil within the fabric container plus the indicated percentage of the circular area 20 cm beyond the edge of the container.*

Table 1. *Dry weight of 'Natchez' crape myrtle roots within the fabric container rootball after 18 months of irrigation with 1.3 cm daily.*

Irrigation placement	Root diameter class (mm) 0 to <2	2 to <5	5 to <10	>10
	Dry wt (mg)			
Not irrigated	118.2 (53[z])	138.5 (84)	216.4 (100)	464.0 (100)
Irrigated inside[y] container + 20%	222.9 (48)	227.1 (77)	232.3 (100)	919.7 (100)
Irrigated inside[y] container + 100%	224.3 (42)	255.2 (75)	194.1 (100)	997.8 (100)
LSD 5%	71	68	57	149

[z]*Percentage of all roots on the tree that were inside the fabric container for this diameter class.*
[y]*Irrigation covered soil within the fabric container plus the indicated percentage of the circular area 20 cm beyond the edge of the container.*

to the large-diameter roots.

There was no interaction between placement and frequency for crape myrtle and laurel oak trunk caliper, height, and crown width. Trunk caliper, tree height, and crown width of laurel oak were smaller for nonirrigated trees than for irrigated trees (data not shown), and there were no trunk caliper, tree height, or crown width differences among treatments when data were averaged over irrigation placements or frequencies.

Averaged over frequency or placement, irrigation resulted in a significant increase in crape myrtle height, width, and caliper (Table 3). Irrigation placement within the container + 100% resulted in greater crape myrtle width than irrigation of smaller areas. Irrigation frequency of 1.3 cm every day resulted in wider plants than 2.5 cm every 2 days or 2.5 cm every 3 days. Calipers were not different due to irrigation frequency.

Table 3. *Height width, and caliper increase of 'Natchez' crape myrtle 13 months after initiating treatment.*

Irrigation treatment	Height (cm)	Width (cm)	Caliper[z] (cm)
Irrigation placement	*Averaged over frequency*		
Not irrigated	66.8[y]	80.3	2.93
Container + 20%[x]	75.2	100.3	3.41
Container + 45%	79.8	99.6	3.55
Container + 100%	84.1	109.1	3.69
LSD 5%	5.0	7.0	0.28
Irrigation frequency	*Averaged over placement*		
Not irrigated	66.8[y]	80.3	2.93
1.3 cm/day	83.0	109.9	3.68
2.5 cm/2 days	78.1	97.8	3.54
2.5 cm/3 days	78.0	101.3	3.42
LSD 5%	5.0	7.0	0.28

[z]*Caliper was measured on the largest trunk only.*
[y]*Numbers are the means of six plants for the unirrigated treatment and 18 plants for the other treatments.*
[x]*Irrigation covered soil within the fabric container plus the indicated percentages of the circular area 20 cm beyond the edge of the container. Note: Interaction between placement and frequency not significant.*

Discussion and conclusion

Total dryweight of laurel oak roots found within and outside the fabric container was not different due to irrigation placement. However, when irrgation was confined to the area within the fabric container + 20%, there was more be root weight in the fabric container (roots < 5 mm in diameter) than on trees not irrigated or irrigated within the container + 100%. Oak crown width, height, and trunk caliper did not increase as irrigated area or irrigation frequency increased, but crown width, height, and trunk caliper were smallest for the nonirrigated control. Therefore, restricting irrigation to within the container may be useful in reducing water use in the nursery, increasing the fine-root : shoot ratio, and it could result in increased transplant survival and posttransplant growth.

Irrigating within the container + 100% increased crape myrtle plant height and width compared to irrigating within the fabric container + 20%. Because root weights (roots <10 mm in diameter) within the container were not different, the root : shoot ratio would be increased. However, the root: shoot ratio may not be the most-important plant attribute contributing to successful transplant survival and growth. Differences in distribution of roots among diameter classes may be more crucial for transplant success (Gilman and Kane, 1990). Plants with fibrous root systems may have improved plant survival after transplanting (Fare et al., 1985). These results indicate species-specificity in response to irrigation placement and frequency, and suggest that water use and shoot and root growth might be optimized by irrigation management.

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