EFFECT OF NURSERY PRODUCTION METHOD, IRRIGATION, AND INOCULATION WITH MYCORRHIZAE-FORMING FUNGI ON ESTABLISHMENT OF *QUERCUS VIRGINIANA*

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Abstract. Live oak (*Quercus virginiana*) trees were grown to about a 2.5 in. (6 cm) caliper in various container and field production systems, then transplanted to a landscape with and without mycorrhizae-forming spores under two irrigation regimes. Trees grew at nearly the same rate in the nurseries, regardless of production method. However, root distribution was altered. Low-profile, air root-pruning containers had less roots on the outside surface of the root ball than did traditional plastic containers. Application of mycorrhizae-forming fungi to the backfill soil at planting in a landscape had no impact on live oak the first 30 months after planting. However, nursery production method and irrigation frequency following planting had a huge influence on tree survival. Irrigating 2.5 in. (6 cm) caliper live oak for only 6 weeks after planting in spring in a slightly drier than normal year resulted in 43% tree death rate. Irrigating twice each week through the first summer after planting in spring kept all trees alive. Under limited irrigation conditions, trees from containers died sooner and more trees died than field-grown, B&B trees. Root-pruned, field-grown, B&B trees survived better than all others following transplanting. Trees planted from all nursery production methods survived and grew similarly, provided they were irrigated regularly through the first growing season. Under limited irrigation, landscape managers would obtain the most live trees by planting root-pruned, field-grown, B&B nursery stock.

Key Words. Planting; transplanting; container; field-grown; B&B; amendments.

Nursery container type appears to have an impact on post-transplant growth for seedling planting stock of certain species (Struve 1993) but may not affect larger-sized material typically planted in urban landscapes (Marshall and Gilman 1998). Irrigating newly planted trees improves their survivability and growth and can lead to better structural form (Gilman et al. 1998; Martin and Stutz 1994; Struve 1994). Freshly dug, field-grown, B&B holly (*Ilex attenuata* 'East Palatka') trees were more stressed and more likely to die than trees planted from containers if they were not well watered after transplanting (Harris and Gilman 1993). However, if regular irrigation is provided, laurel oak (*Quercus laurifolia*) and East Palatka holly trees from either production method experienced similar transplant stress (Gilman and Beeson 1996). More rapid root growth of well-watered, field-grown, B&B laurel oak trees resulted in faster establishment than trees planted from containers with artificial substrate. In addition, field-grown live oak trees may osmotically adjust when roots are severed, helping prepare them for the suboptimal soil moisture conditions common on many landscape sites (Beeson and Gilman 1992).

There are numerous studies showing that inoculation of pines and some hardwood seedlings with mycorrhizae-forming fungi at planting improves tree survival and growth on many cut-over forested sites and strip mines (Marx and Cordell 1989). There are few published studies on the effects of inoculating landscape-sized trees at planting. One showed that shoot growth of 7 gal (27 L) container-grown mesquite (*Prosopis alba*) was inhibited, and trunk diameter and root growth were unaffected by inoculating with mycorrhizal-forming fungi at planting (Martin and Stutz 1994). A second study showed that inoculating the backfill soil around the root ball of field-grown, 3 in. (8 cm) caliper silver linden (*Tilia tomentosa*) trees at planting had no effect on shoot growth 2 years after transplanting but increased shoot growth the third year by 11 in. (28 cm). There was little effect the fourth year after planting (Garbaye and Churin 1996). Over the 4-year study period, trunk diameter of trees receiving mycorrhizae-forming fungi increased by 0.1 in. (3 mm) compared to untreated trees. Foliage mineral content was affected only slightly by the treatment.

This study was designed to 1) determine the influence on live oak (*Quercus virginiana*) survival and growth of planting from different nursery production methods, incorporating mycorrhizae-forming fungi into the backfill soil, and irrigation management after planting; and 2) evaluate the costs of these practices to determine the most effective and/or least expensive way to establish live oak in the landscape.

MATERIALS AND METHODS

Tree Production

Live oak seedlings approximately 4 ft (1.2 m) tall in #3 (3 gal [11 L]) containers painted with SpinOut™ (Griffin Corp., Inc., Valdosta, GA) latex carrier, at a rate of 100 g/L, on the inside to minimize root circling were planted February 1995 into four different types of aboveground containers and into field soil. Forty trees were planted in each of the following #15 (15 gal [57 L]) container types in a 6 parts pine bark:3 parts peat:1 part sand media: black plastic, black plastic with SpinOut applied to the inside, an air root-pruning container with dimensions of 17 in. (43 cm) diameter × 16 in. (41 cm) deep (Accelerator™, HoldEm, Inc., West Palm Beach, FL), and a low-profile Accelerator with dimensions of 22 in. (56 cm) diameter × 12 in. (30 cm) deep. Trees were repotted in spring 1996 into #25 (25 gal [97 L]) containers of the same type as the #15 containers. Dimensions for the #25 containers were as follows: plastic and plastic with SpinOut—17 in. (43 cm) tall × 24 in. (61 cm) diameter; Accelerator—25 in. (63 cm) tall × 16 in. (41 cm) diameter; low-profile Accelerator—12 in. (30 cm) tall × 32 in. (81 cm) diameter. Trees were grown in a container nursery located in central Florida, U.S. (USDA hardiness zone 9a). All trees received daily irrigation during the growing season and regular irrigation at other times, as well as weed and pest control in accordance with standard nurssery practice in the southeastern United States.

Trees from the same #3 containers described above were planted into sandy field soil (Arrendondo fine sand) on 6 ft (1.8 m) centers in rows 10 ft (3 m) apart in Gainesville, Florida (USDA hardiness zone 8b), about 75 miles (120 km) north of the container nursery. Live oaks were grown on this site for the 2 years prior to this test, and the field was in pastureland for several decades before that. The natural soil horizon appeared to be mostly intact. Except on days when rainfall exceeded 0.5 in. (13 mm), they were irrigated according to standard industry practice to keep them vigorous. Irrigation was applied three times daily in the warm months.

Six months after planting, half the trees were root pruned. Roots on the north and south side of the root-pruned trees (50% of the root system) were cut with a sharp hand spade whose tip was angled slightly toward the trunk while inserted 12 in. (30 cm) deep into the soil 5 in. (13 cm) from the trunk. Twelve months after planting, the procedure was repeated on the east and west sides of the tree, but the spade was inserted 8 in. (20 cm) from the trunk. Eighteen months after planting, roots on the north and south sides of the tree (50% of the root system) were cut 12 in. from the trunk. Half the trees were not root pruned. All field-grown trees were dug in February 1997 with a 28 in. (71 cm) diameter tree spade (ANSI 1996) and placed into copper-treated burlap in 28 in. diameter × 20 in. (51 cm) deep wire baskets and placed back into the ground in the same hole they were dug from. Root balls were irrigated daily after they were dug. Survival was 100% and no dieback occurred. All trees in the study were trained to a dominant leader by shortening competing stems with drop-crotch cuts.

Five trees from each container type were randomly chosen near the end of the production phase of the study in April 1997. Roots were separated from the media and washed and dry root weight recorded for all roots greater than 2 mm (0.08 in.) diameter visible on the outside surface of the root ball. Roots in the top half of the root ball were separated from those in the bottom half. Tree height and trunk diameter 6 in. (15 cm) above soil surface were measured at the end of the production period, April 1997, on all trees in the study.

Landscape Transplanting

Twenty-eight trees from each container type were shipped to Gainesville April 14 through 16, 1997, and planted by April 16; 56 field-grown trees (28 root pruned; 28 not root pruned) that were placed in wire baskets in February 1997 were lifted from the ground and planted April 14 through 16. All trees were planted to the same soil type as the field-grown trees were produced in. Planting holes were twice the diameter of the root ball and slightly shallower. Trees were spaced in the field on 10 ft (3 m) centers. Half the trees from each production method received

MycorTree TreeSaver™ (Plant Health Care, Inc., Pittsburgh, PA) in the backfill soil around the root ball at planting and half did not. This material was shipped directly from the manufacturing plant several days prior to initiation of this experiment and was applied according to the manufacturer's directions: mix 8 oz (227 g) of the material with the backfill. This was done by placing the tree in the hole, half filling the hole around the root ball with backfill, applying half the MycorTree and turning it into the loose backfill with a shovel, adding the remaining backfill, then applying the remaining MycorTree and turning it into the loose backfill. All container trees were staked for 1 year to prevent them from shifting in the soil. Field-grown trees did not require staking.

All trees received 28 gal (100 L) of irrigation the first and second day after planting, no irrigation on days 3 and 4, 5 gal (18 L) on day 5, 3 in. (8 cm) of rain on day 7, and 15 gal (57 L) of irrigation on day 9. Thereafter, half the trees received irrigation twice per week through mid-October (summer irrigated); the other half received irrigation five times at 1-week intervals through the end of May 1997, then no irrigation (no summer irrigation). Trees received 2 gal (7.6 L) of water per caliper inch (2.54 cm) each time they were irrigated (2.5 in. caliper × 2 gal = 5 gal per tree). More than this was found to be wasteful and of no benefit to the tree (Gilman et. al. 1998). All irrigation was applied to the top of the root ball and a 2 in. (5 cm) tall soil berm constructed so all applied water soaked into the root ball. No mulch was applied. Beginning July 1997, trees received 4 lb of nitrogen per 1,000 ft^2 per year (20 g N/m^2/year) as ammonium nitrate applied to a 9 ft^2 (0.8 m^2) area around the trunk. Fertilizer was divided into two applications, one in July and one in January of each year. Rainfall in May was about normal at 2 in. (5 cm); June was below normal at 6 in. (15 cm). The summer of 1997 was slightly drier than normal.

The study was installed as a 6 (nursery production methods) × 2 (post-transplant irrigation regimes) × 2 (mycorrhizae-forming fungi inoculation or no inoculation) factorial in a randomized complete block design with 7 blocks (6 × 2 × 2 ×7 = 168 trees). Trunk diameter at 6 in. (15 cm) above soil surface was measured monthly after transplanting. Tree height was measured when #3-sized trees were placed into the nursery containers or into the nursery field plots and again at the end of the nursery production period. After transplanting, stem xylem potential was recorded at regular intervals during entire days in a pressure chamber (Soil Moisture, Inc., Santa Barbara, CA) on freshly cut twigs from the sunny side of the canopy. The number of dead trees was recorded periodically in the first year after transplanting. The sum of the trunk diameters of all surviving trees was calculated for each production method. Analysis of variance and t-test were used to analyze data, with $P < 0.05$ considered significant, and means were separated using Duncan's Multiple Range Test.

The cost of 28 container-grown trees and 28 field-grown, B&B 2.25 to 2.5 in. (57 to 63 mm) caliper live oak trees; for transporting 28 trees for both production methods (assuming a 50 mi [80 km] distance between nursery and planting site); for installation (planting hole twice as wide and slightly shallower than the root ball) of 28 trees planted 25 ft (7.5 m) apart in a row in a former agricultural field; for staking container trees; for 8 oz (227 g) MycorTree TreeSaver mycorrhizae inoculum product and incorporation into backfill soil; and for application of irrigation with a water truck for both irrigation treatments were calculated by averaging three bids from landscape contractors. These figures were used to compare the cost of planting and establishing trees from each production method for each of the two irrigation frequencies described above with or without backfill inoculation with spores of mycorrhizae-forming fungi.

RESULTS AND DISCUSSION

Tree Production

The tree production method had a statistically significant but small impact on trunk diameter and tree height growth in the nurseries (Table 1). Both air root-pruning containers (ARP) produced trees that had greater trunk diameter than the traditional plastic container. Trunk diameter on root-pruned, field-grown trees increased slower than on field trees that were not root pruned, but there was no difference in height growth. Trees in ARP containers were taller than root-pruned, field-grown trees. Despite small differences in size, trees from all production methods at the end of the production period would be graded similarly by trade standards (Florida Dept. Agric. 1998; AAN 1996) so the small size differences, al-

Table 1. Trunk diameter, tree height, and circling root weight of live oak after 2 years growing in six different nursery production methods.

Production method	Trunk diameter (cm)	Tree height (m)	Circling[z] root weight (g)
Plastic container	5.8 b[y]	3.7 ab[y]	11.3 b
Plastic container with SpinOut	6.1 ab	3.7 a	8.9 ab
Air root-pruning (ARP) container	6.3 a	3.7 a	6.1 ab
Low-profile ARP container	6.3 a	3.9a	2.8 a
Root-pruned, field-grown, B&B	5.8 b	3.5 b	N/A[x]
Non-root-pruned, field-grown, B&B	6.3 a	3.7 ab	N/A

[z]Circling root weight was the total root weight of all roots > 2 mm (0.08 in.) diameter visible on the outside surface of the root ball averaged from five trees per production method.
[y]Means in a column followed by the same letter were not different at $P < 0.01$. Twenty-eight trees from each production method were mea sured for trunk diameter and tree height.
[x]Field-grown B&B trees had no circling root weight on the outside edge of the root ball.

though statistically significant, may be practically unimportant.

Dry weight of roots on the outside surface of the container root balls was significantly affected by container type. Trees in low-profile Accelerator containers had fewer roots on the outside surface of the root ball than trees in plastic containers (Table 1). Milbocker (1994) found similar results with low-profile containers, attributing this difference to increased distance of the container edge from the trunk. Fewer roots on the outside surface of the root ball could make this container production method a good choice for planting since there are likely to be fewer circling roots than in other containers. The lack of circling roots on the Accelerator was probably due to the vertical ribs in the container (Marshall and Gilman 1998). There were no differences in root weight on the outside surface of the root ball among the other container types. Studies with red maple (*Acer rubrum*) also showed that low-profile, air root-pruned containers and other alternative container designs reduced root circling compared to conventional plastic containers (Marshall and Gilman 1998). Root weight on the outside surface of the root ball in the top half of the root ball was the same as root weight in the bottom half for all container types (data not shown).

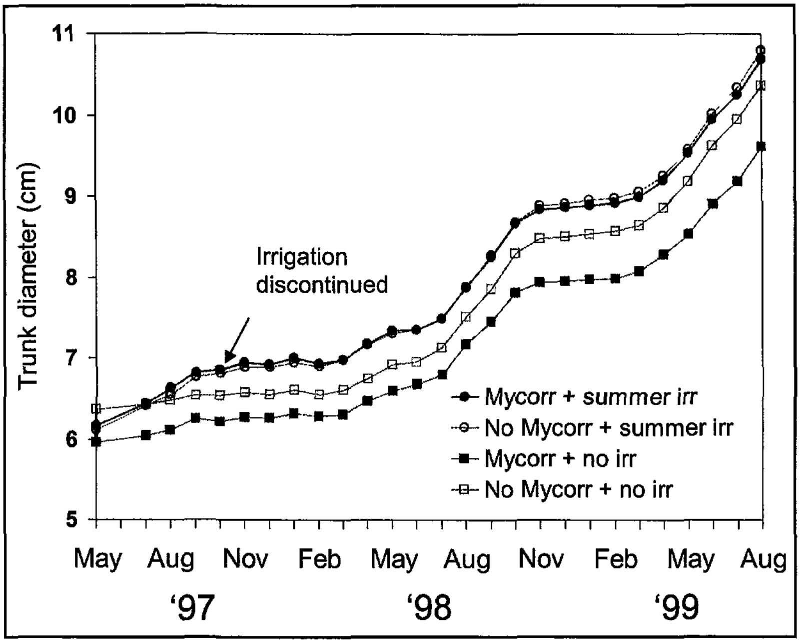
Landscape Transplanting

Inoculation with spores of mycorrhizae-forming fungi at transplanting had no impact on tree water stress (stem xylem potential; data not shown), no impact on tree survival (17 trees receiving mycorrhizae died and 18 in the non-mycorrhizae treatment died), and no impact on tree growth at any time during the 30 months after transplanting (Figure 1). In agreement with Martin and Stutz (1994), who found no impact of adding mycorrhizae at planting, there was no significant interaction between irrigation and mycorrhizae treatment. Garaye and Churin (1996) also found little effect on trunk diameter and shoot growth on 3 in. (8 cm) caliper silver linden from incorporation into backfill soil of mycorrhizae-forming spores at transplanting. In contrast, nursery production method and irrigation had a large and significant impact on water stress, tree death, and growth after transplanting.

Root-pruned, field-grown trees were significantly less stressed than trees from all container production methods at 830 hr and 1835 hr on May 2, about 2 weeks after transplanting (Figure 2). This was the first time trees were without water for 7 consecutive days. Trees were watered the evening of May 2. Both root-pruned and non-root-pruned field-grown trees were less stressed than all container-grown trees the second time trees were without water for 7 consecutive days (May 9). Perhaps containers would have performed better if a medium was employed other than the well-aerated, light media typically used in container production in the southeastern United States.

None of the 84 trees irrigated twice each week through the summer (summer irrigated) died during the first year after transplanting; 35 of the 84 trees (44%) irrigated for only 6 weeks after transplanting (no summer irrigation) died. Most dead trees were from containers: 55% of container-grown trees irrigated only 6 weeks died in the first year; whereas only 14% of field-grown trees died (Table 2). Perhaps trees from containers would have greater survival if a different growing medium with a higher water-holding capacity were employed. No trees that were root pruned three times during nursery field production died after

Figure 1. Trunk diameter on surviving trees measured monthly for 30 months following transplanting to the landscape with and without mycorrhizae-forming spore inoculation incorporated into backfill soil and with and without summer irrigation. Summer irrigation was applied in the first summer following transplanting (1997) only. Growth rate on summer-irrigated trees May through November 1997 was significantly greater ($P < 0.01$, t-test) than for nonirrigated trees. Each data point was the mean of 42 trees until trees began dying in July 1997.



transplanting to the landscape. Root pruning has been associated with increased survival of small forest seedlings (Benson and Shepard 1977), but until now no studies have reported increased survival from root pruning landscape-sized trees irrigated under typical stress conditions. Previous studies showed that field-grown, B&B trees that were not root pruned and not irrigated daily after digging were more likely to die than container-grown trees (Harris and Gilman 1993). Combining the current study with published research allows the conclusion that freshly dug, field-grown (in this sandy soil type) trees are most stressed and likely to die following transplanting; container-grown trees are intermediate; and root-pruned, field-grown B&B trees harvested 10 weeks prior to transplanting to the landscape are least stressed. The 10-week period used in this study may be longer than needed. This needs further clarification through additional research.

Irrigation was the only measured factor that affected growth rate of surviving transplanted trees. Irrigated trees were less stressed (had less negative xylem water potentials) than trees that did not receive irrigation through the summer (data not shown). Trees from all production methods irrigated throughout the first summer increased in trunk diameter faster than trees irrigated for only 6 weeks (Figure 1). After irrigation was discontinued in October 1997, trees grew at the same rate for the following 2 years regardless of previous irrigation treatment. Growth rate was rapid during the second and third growing season after transplanting—indicating that trees were established (Gilman and Beeson 1996). Trees did not increase in trunk diameter during the first dormant period but did so, although slowly, during the second dormant period.

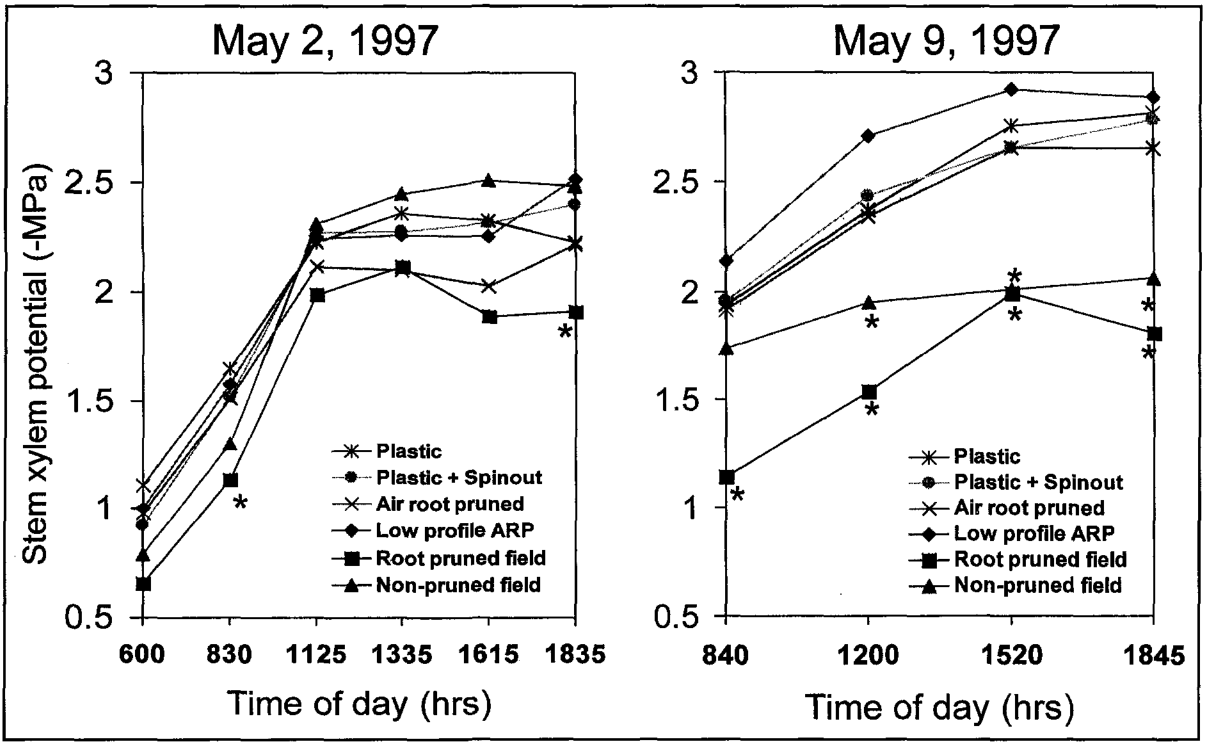
Surviving trees grew at the same rate following transplanting regardless of production method (Figure 3). Summing the trunk diameters of all living trees for each production method 30 months after transplanting provides another measure to compare treatments (Figure 4). Trees irrigated during the

Table 2. Number of dead trees[z] from each nursery production method in the no-summer-irrigation treatment 1 year after transplanting live oak to the landscape.[y]

Production method	Number of dead trees	Percent survival
Plastic container	6	57
Plastic container with SpinOut	8	43
Air root-pruning (ARP) container	7	50
Low-profile ARP container	10	29
Root-pruned, field-grown B&B	0	100
Non-root-pruned, field-grown B&B	4	71

[z]Fourteen trees were planted from each production method in the no-summer-irrigation treatment.
[y]All trees irrigated twice weekly through the first season after planting survived.

Figure 2. Stem xylem water potential for live oak trees in six nursery production methods 2 and 3 weeks after transplanting to the landscape. Each point is the mean of eight trees. Asterisk indicates that the data point is significantly different from trees growing in all container production methods at $P < 0.05$.



first summer and then left to grow without irrigation had the same total trunk diameter regardless of production method (Figure 4, left). However, without first-summer irrigation, root-pruned, field-grown trees had about twice the total trunk diameter of other production methods because some trees died from all the other five production methods (Figure 4, right). The low-profile containers had poor survival and low total trunk diameter perhaps due to the shallow nature of the root ball. Other studies also showed them to be slightly more stressed than other container types after planting to a landscape (Marshall and Gilman 1998). Perhaps the lack of roots on the outside of the root ball made them more susceptible to water stress.

Cost to purchase, install, and irrigate after planting container trees was slightly higher than for field-grown trees because field-grown trees were less expensive to purchase and they did not require staking to hold them firmly in the soil (Table 3). This pricing structure will vary depending on the region. After the first wind storm following planting, it was evident that container-grown trees required stakes to prevent them from blowing over. Irrigating throughout the summer for 6 months was more expensive than irrigating for only 6 weeks. The cost per live tree (cost to purchase, install, and irrigate divided by the number of live trees) 1 year after planting with irrigation throughout the first summer was identical for all container ($445) and field ($383) production methods because all trees irrigated throughout the first summer survived (Table 4). Cost per live tree varied for the no-summer-irrigation treatment because different numbers of trees died from each production method (Table 2). Since more trees died from the low-profile Accelerators, the cost per live tree 1 year after planting was greatest ($1,176) (Table 4). Since no trees died after transplanting from the root-pruned, field-grown treatment, the cost per live tree 1 year later was least ($274). Planting field-grown trees that were root pruned regularly in the nursery and dug 10 weeks prior to transplanting to the landscape provided the lowest cost per live tree.

Figure 3. Trunk diameter measured each month on all surviving trees from six nursery production methods for 30 months following transplanting to the landscape. Each data point was the mean of 28 trees until trees began dying in July 1997.

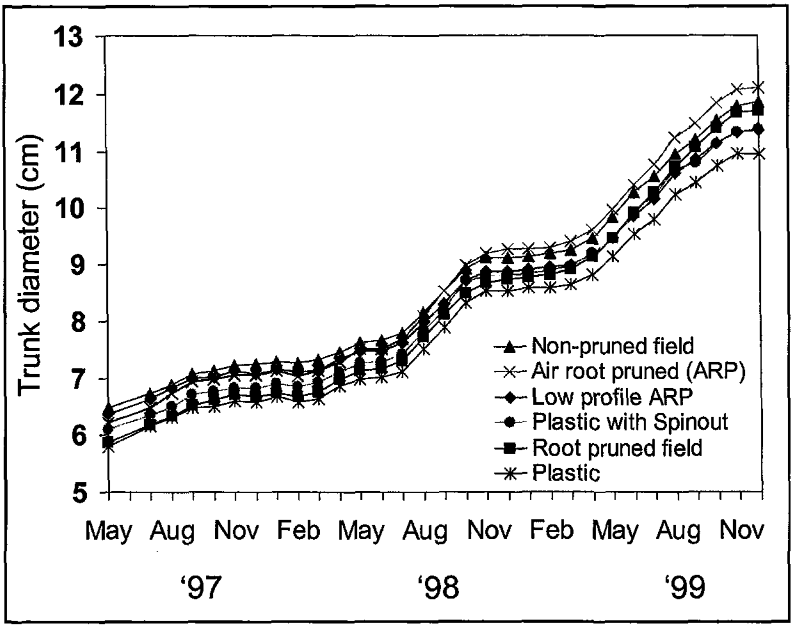


Figure 4. Sum of trunk diameter of surviving trees for each nursery production method 30 months following transplanting to the landscape for summer irrigated and nonirrigated live oak.

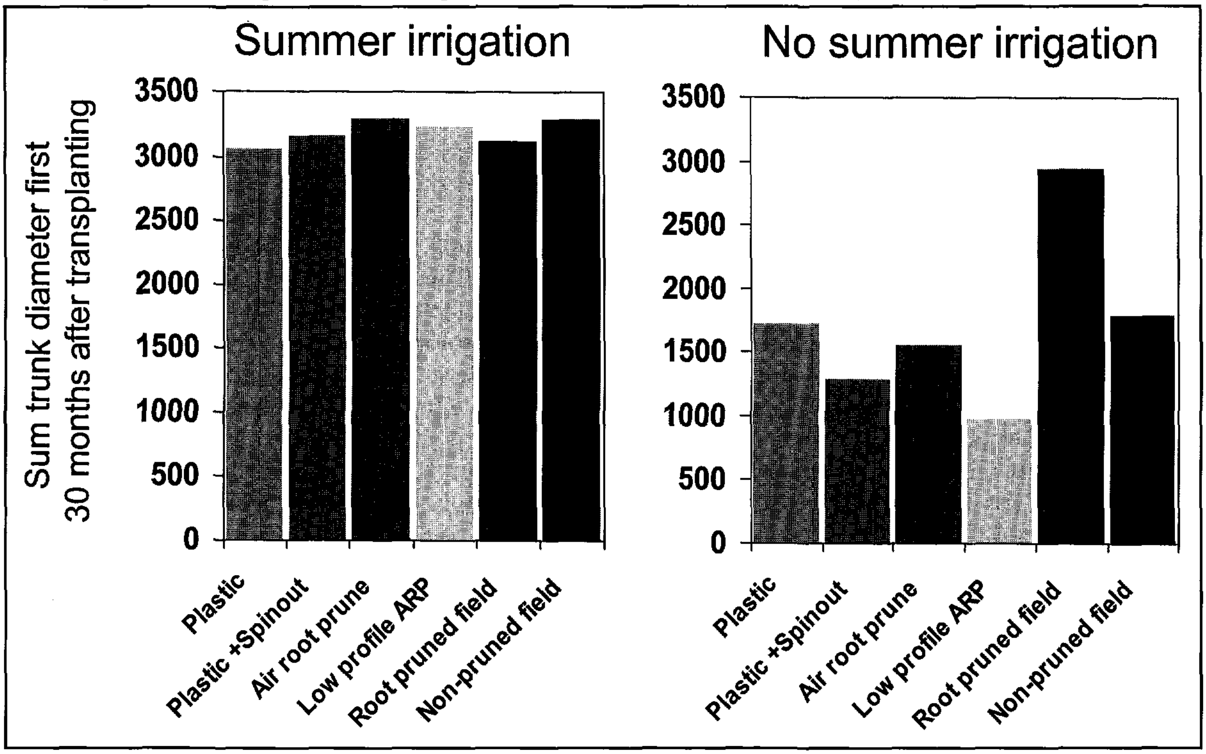


Table 3. Cost per tree[z] to purchase, install, and irrigate 2.5 in. (6 cm) caliper live oak in a landscape.

	Cost	
Production method	Summer irrigation[y]	No summer irrigation[x]
Container-grown trees	$445	$336
Field-grown, B&B trees	$383	$274

[z]The following represent costs per tree (U.S. dollars): container-grown tree—$144; field-grown tree—$107; transporting trees 50 mi (80 km) and planting them—$145; staking container tree—$25; irrigating for 6 months twice weekly—$131; irrigating for 6 weeks, once per week—$22; MycorTree soil amendment—$8. Numbers based on average of three contractors' prices. Applying MycorTree to backfill had no impact on any measured parameter so it was not included in this cost analysis.
[y]Trees irrigated four times in first 9 days then twice weekly for 6 months. Five gal (18 L) water was applied to the top of the root ball at each irrigation.
[x]Trees irrigated four times in first 9 days then once per week for 5 weeks. Five gal (18 L) water was applied to the top of the root ball at each irrigation.

Table 4. Cost[z] per live 2.5 in. (6 cm) caliper live oak tree from six nursery production methods and under two landscape irrigation regimes.

	Cost per live tree	
Production method	Summer irrigation[y]	No summer irrigation[x]
Plastic container	$445	$588
Plastic container with SpinOut	$445	$784
Air root-pruning (ARP) container	$445	$672
Low-profile ARP container	$445	$1,176
Root-pruned, field-grown B&B	$383	$274
Non-root-pruned, field-grown B&B	$383	$383

[z]Cost (U.S. dollars) of purchasing, installing, and irrigating 14 trees divided by number of live trees (see Table 2) 1 year after transplanting.
[y]Trees irrigated four times in 9 days then twice weekly for 6 months (summer irrigation) or 5 weeks (no summer irrigation). Five gal (18 L) water was applied to the top of the root ball at each irrigation.

CONCLUSIONS

1. Trees grew at nearly the same rate in the nurseries regardless of production method. Low-profile, air root-pruned containers had fewer roots on the outside surface of the root ball than did traditional plastic containers.
2. Application of mycorrhizae-forming fungi to the backfill soil at transplanting had no impact on post-transplant stress, growth, or survival the first 30 months after planting.
3. Nursery production method had no impact on post-transplant survival and growth provided trees were irrigated through the first growing season following transplanting. In contrast, under limited irrigation conditions root-pruned, field-grown, B&B trees that were dug and held in the nursery for 10 weeks prior to transplanting to a landscape had the greatest survival of all production methods following transplanting; trees from containers died in greater numbers (55%) and sooner than field-grown, B&B trees (14%). Following transplanting to the landscape, growth rate of surviving trees was not affected by nursery production method.
4. Under limited irrigation conditions, planting field-grown, B&B trees that were root pruned regularly in the nursery and dug 10 weeks prior to transplanting to the landscape provided the most live trees per dollar.
5. The least expensive way to obtain live *Quercus virginiana* trees in a landscape in hardiness zone 8b one year after transplanting was to install root-pruned, field-grown, B&B trees dug at least 10 weeks prior to planting, incorporate nothing into the backfill except the original soil, and irrigate them for 6 weeks after transplanting. Transplanting from containers with the typical media used today by the industry would be more expensive due to increased tree mortality unless frequent irrigation was provided. Transplanting freshly dug, B&B trees is likely to be most expensive due to very high mortality rate.

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Résumé. Des chênes verts ont poussé à une vitesse similaire en pépinières, peu importe la méthode de production. Des contenants à profil bas permettant la taille à l'air libre des racines avaient moins de racines sur le pourtour extérieur de la motte que les productions traditionnelles en contenants de plastique. L'application de mycorrhizes au terreau de remplissage au moment de la transplantation en pleine terre n'a pas eu d'impact sur le chêne vert durant les premiers 30 mois après la plantation. Néanmoins, la méthode de production ainsi que la fréquence d'irrigation après la plantation avaient une influence considérable sur la survie de l'arbre. Le taux de croissance des arbres ayant survécu à la transplantation en pleine terre n'était pas affecté par le type de méthode de production. L'irrigation des chênes verts de 5 cm de diamètre sur une période de seulement 6 semaines après leur plantation au printemps d'une année un peu plus sèche que la normale a provoqué la mort de 43% des sujets. L'irrigation deux fois par semaine durant le premier été après une plantation printanière a permis de maintenir tous les arbres en vie. Sous des conditions limitées d'irrigation, les arbres en contenants sont morts plus rapidement et en nombres plus élevés que ceux en mottes produits en plein champ. Les arbres en motte produits en champ qui ont fait l'objet d'un cernage des racines ont mieux survécu que tous les autres une fois la transplantation réalisée. Les arbres provenant de différentes méthodes de production ont survécu et ont poussé de façon similaire en autant qu'ils étaient irrigués régulièrement durant la première saison de croissance. Sous des conditions limitées d'irrigation, les gestionnaires d'espaces verts obtiendront un meilleur taux de survie et une meilleure reprise en plantant des arbres en mottes produits en champ dont les racines auront été cernées.

Zusammenfassung. Lebenseichen haben unabhängig von der Produktuionsweise in den Baumschulen ähnliche Wachstumsraten. Niedrig profilierte Pflanzbehälter, die einen Wurzelrückschnitt ermöglichen, haben weniger Wurzeln auf der Außenseite des Wurzelballens als die traditionellen Plastikcontainer. Die Applikation von Mycorrhiza-produzierenden Pilzen bei dem Füllboden nach der Aussetzung der Pflanzen im Felde hatte für die folgenden 30 Monate keinen Einfluß. Dennoch hat die Baumschulproduktionsmethode und die Bewässerungsrate nach dem Verpflanzen einen großen Einfluß auf das Überleben. Die Wachstumsrate der überlebenden Bäume nach der Transplantation wurde nicht durch die Produktionsmethode beeinflußt. Die Bewässerung von Lebenseichen mit einem Durchmesser von 5 cm für einen Zeitraum von nur 6 Wochen nach der Verpflanzung im Frühjahr in einem insgesamt etwas trockenen Jahr führte zu einem Ausfall von 43 %. Eine zweimalige Bewässerung pro Woche während des ersten Sommers ließ alle Bäume überleben. Unter begrenzten Bewässerungsbedingungen starben die Bäume aus den Containern schneller und es starben auch mehr Exemplare als bei den anderen Produktionsmethoden. Die im Feld gewachsenen, ballierten Bäume mit Wurzelrückschnitt überlebten besser als alle anderen. Unter regelmäßiger Bewässerung während der ersten Pflanzsaison wuchsen und entwickelten sich alle Bäume gleich. Bei begrenzter Bewässerung würde man die größte Überlebensrate und Entwicklung bei feldgezogenen, ballierten Pflanzen mit Wurzelrückschnitt erhalten.

Resumen. Se llevaron a cabo dos experimentos para probar la hipótesis de que los árboles capaces de establecerse en suelos urbanos tendrán una mejor tolerancia promedio a una mayor impedancia mecánica y resistencia de los suelos compactados. Un experimento probó la habilidad de las raíces de los brinzales de *Corymbia maculata* (Sin. *Eucalyptus maculata*), *Lophostemon confertus*, *Corymbia ficifolia* (Sin. *Eucalyptus ficifolia*) y *Agonis flexuosa*, para penetrar suelos franco arenosos compactados con densidades aparentes de 1.4 y 1.8 mg/m3 al 13% de contenido de humedad gravimétrica. Mientras las raíces de todos los árboles fueron capaces de penetrar los suelos de mayor densidad, la profundidad total de penetración se redujo en un 60% en las cuatro especies. El experimento dos probó la habilidad de *Corymbia maculata* y *Corymbia ficifolia* para penetrar suelo compactado a densidades aparentes de 1.4, 1.6 y 1.8 mg/m3 a dos niveles de humedad, 7 y 10% respectivamente. Al 7% de humedad, ambas especies fueron capaces de penetrar el suelo compactado a 1.4 y 1.6 mg/m3, pero ninguna fue capaz de hacerlo para suelos compactados a 1.8 mg/m3. Al 10% de humedad, las dos especies fueron capaces de penetrar suelo compactado a 1.4 y 1.6 mg/m3. También lo hicieron para suelo de 1.8 mg/m3. Sin embargo, con significativamente menos profundidad de penetración que para las dos densidades más bajas.