COMPARING ROOT BALLS ON LAUREL OAK TRANSPLANTED FROM THE WILD WITH THOSE OF NURSERY AND CONTAINER GROWN TREES.

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Abstract. Laurel oak (*Quercus laurifolia*) was transplanted from 3.8 liter containers into a field nursery or into fabric containers and grown for 2 years. Root balls were then compared. Also compared were oaks collected with a tree spade from the wild. The root system on wild trees was dominated by a single tap root with a few lateral roots growing from the tap root and from the base of the trunk. The nursery trees did not have a single prominent tap root, but several large roots that grew straight or at a slight angle down beneath the trunk. In most cases, these vertically oriented roots originated from roots that had circled the bottom of the container prior to planting. There was no difference in weight of roots less than 5 mm diameter between field- and fabric container-grown trees, and root number and cross-sectional area were comparable among wild, field grown and fabric container-grown trees with the exception that wild trees had fewer roots and less cross-sectional area than did nursery-grown trees in the >5-10 mm root diameter class. Root:shoot ratio was similar for trees in all treatments.

Specifications for trees planted in urban areas are sometimes met with trees collected from the wild. Some of these are transplanted directly into landscapes, others are brought to a nursery holding area where they are hardened-off before planting into the landscape. Some landscape contractors are reluctant to accept collected trees because they believe these trees have an inferior root system compared to nursery-grown trees. However, there are no reports in the literature which make direct comparisons between collected and nursery-grown trees.

Despite the root pruning many trees receive in the nursery during production, root development within the root ball of field-grown trees can best be described as variable. There appears to be more variation among root balls of oak trees (10, 17) than among individuals of other species such as crape myrtle (*Lagerstroemia indica*), bald cypress (*Taxodium distichum*) (11) and Southern magnolia (9).

In only a few reports has root structure on trees grown in the field been compared with those grown in fabric containers. The response of trees to the fabric container appears to be species specific. There is one report of more, smaller-diameter roots in the root ball of fabric containers than in a traditional field-grown root ball (18). There are reports of increased root weight inside the harvested fabric root ball compared to a field-grown root ball (5, 14). Some species' root balls appear to be unaffected by the fabric (14). There is one report of reduced root weight in the fabric container root ball (4). The one consistent response of trees to fabric containers is an increase in root density within the fabric container root ball (5,12). The root system inside the root ball of trees collected from the wild has not been described.

There is no evidence linking increased root density within the root ball of fabric containers with reduced stress following transplanting or enhanced post-transplant shoot or trunk growth. In one study conducted to test transplantability, increased root dry weight in fabric-grown root balls compared to field-grown trees corresponded to an increase in regenerated roots 60 days later only in one of five species tested (6). On one species root regeneration was less on trees transplanted from fabric containers than from field soil. In another study, root regeneration on trees grown in fabric containers was greater than on field-grown trees for two of three species (13). Gilman and Harris (8)

Florida Agricultural Experiment Station Journal Series No. R-02105. Research supported in part by a grant from the ISA Research Trust.

found that laurel oak (*Quercus laurifolia*) trees from fabric containers regenerated the same amount of roots, but grew less in trunk diameter in the year after transplanting than trees transplanted from the field with a tree spade. Beeson and Gilman (2) found that transplanted fabric and field-grown slash pine trees established in the landscape at the same rate and that both established quicker than container-grown trees provided they received adequate irrigation. The present study was designed to compare the root system within the root ball of 1) fabric-container-grown, 2) field-grown and 3) trees collected from the wild.

Materials and Methods

Laurel oak (*Quercus laurifolia*) were planted from 3.8 liter containers in Nov. 1987 into an excessively-drained, medium-textured, sandy field soil in central Florida or into 36 cm diameter fabric containers (Gro-Bags, Root Control Inc., Oklahoma City, OK). Irrigation was applied daily to a 36 ft^2 area around each tree for two years until trees were harvested in Jan. 1990. Fertilization and pest control were conducted according to the current practices of the participating nursery where the study was conducted. Trees were not root pruned during the study. Five laurel oak, which were about the same height as the nursery-grown trees and were growing naturally in a sandy, non-managed open field nearby (collected trees) were selected in Jan. 1990 for comparison.

At harvest (Jan. 1990), 5 collected and 5 field-grown trees were dug with a tree spade adjusted to make a root ball diameter in accordance with American Association of Nurserymen standards. Five fabric-grown trees were dug by hand and the fabric removed. Soil was washed from the roots, and roots were separated into diameter classes (0 - 1 mm, >1 - 2 mm, >2 - 5 mm, >5 - 10 mm, >10 mm). Roots larger than 5 mm diameter which intersected the perimeter of the root balls were counted, and their cross-sectional area was calculated with a Delta T area meter (Decagon Instruments, Pullman, WA). Root number and cross-sectional area were classified into the root-diameter classes >5 - 10 mm, >10 - 15mm, >15 - 20 mm, >20 - 25 mm, >25 - 30 mm and >30 mm. Tops (including trunk, branches and leaves) and roots were dried to constant weight, and caliper and height measured at harvest.

Results and Discussion

Trees collected from the wild were the same height as the nursery-grown trees, but had about 1 cm less trunk diameter (Table 1). Field-grown trees (5889 g) had more top (shoot) weight than collected trees (2548 g).

The root system on wild trees was dominated by a prominent tap root and few large, horizontally-oriented lateral roots growing from the tap root and from the base of the trunk (Figure 1). Tap roots often dominate the root system of young seedling-grown oaks in sandy, well-drained soil (7). Fine roots grew predominantly from the lateral roots, not from the tap root.

The field-grown nursery trees did not have a single prominent tap root, but several large roots grew straight or at a slight angle down beneath the trunk on most trees (Figure 2). In most cases these

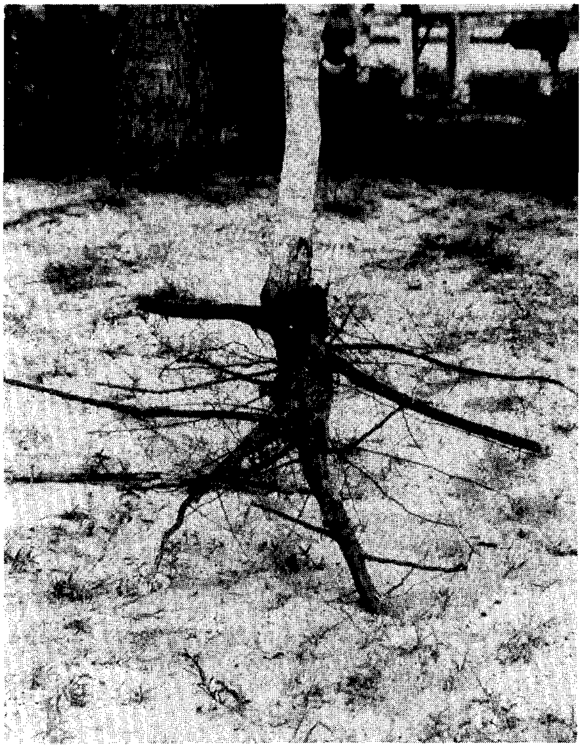

Figure 1. Root system inside the root ball of trees collected from the wild was dominated by a single tap root. Large, horizontal lateral roots and fine roots grew from the tap root close to the surface of the soil.

vertically-oriented roots originated from roots which had circled the bottom of the container prior to planting in the nursery. Vertically-oriented roots were generally larger in diameter than other roots. There were only a few fine roots growing from these deeper roots; most fine roots grew from the shallower horizontally-oriented laterals. The plastic bottom of the fabric containers prevented the development of roots deeper than the depth of the fabric container (36 cm) (Figure 3). Smaller-diameter, horizontally-oriented, lateral roots grew from the 'cage' of roots which formed at the edge of the container prior to planting into the nursery. The 'cage' was 15 cm deep and wide (which are the dimensions of the 3.8 liter nursery container from which trees were planted) and was formed when lateral roots circled the side and bottom of the container after hitting the container walls. As the trees grew in the nursery, these roots increased in diameter and grafted to each other as they touched, forming what appeared to be a braided cage of roots.

There was no difference between field- and fabric-grown trees in the number and cross-sectional area of roots larger than 5 mm diameter located at the edge of the root ball (Table 2). Most roots were between 5 and 10 mm in diameter. Wild trees had fewer roots and less cross-sectional area than nursery-grown trees only in the >5 - 10 mm root diameter class. This could be explained by the lesser shoot weight on the wild trees (Table 1). Root number and cross-sectional area in all other root diameter classes were comparable among wild and nursery-grown trees. Carlson et al. (3) found that root morphology on seeded-in-

Figure 2. Root system inside the root ball of field-grown nursery trees showing a large number of horizontal lateral roots and some nearly vertical deep roots. Fine roots are located at the top right hand side of the root ball.

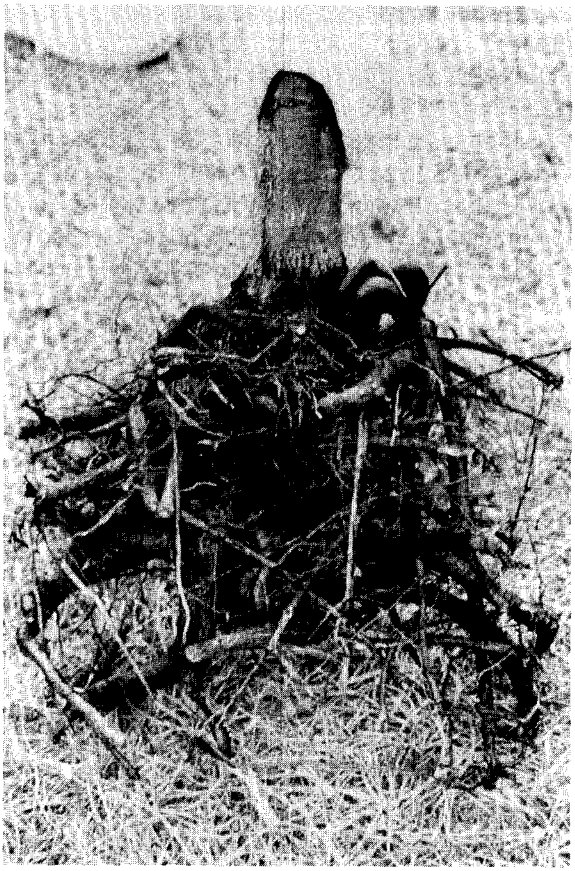

Figure 3. Root system inside the root ball of trees grown in fabric containers. Roots are oriented horizontally and fine roots are in the top portion of the root ball. The dense mass of tangled roots in the center of the root ball represents those roots which were growing inside the 3.8-liter container before the tree was planted in the nursery.

Table 1. Height, caliper, trunk and shoot weight, and weight of roots inside rootball for wild, nursery- and fabric-container-grown laurel oak.z

Measurement	Collected wild	Nursery grown	Fabric container-grown
Height (m)	3.66aw	3.62a	3.54a
Trunk caliper (cm)y	4.4a	5.6a	5.3a
Trunk and shoot dry weight (g)x	2548a	5889b	3752ab
Dry weight of roots within root ball (g)	674a	1279b	1269b
Shoot:root dry weight ratio	3.78a	4.60a	2.95a

z Each value in the table is the mean of 5 trees.
y Caliper measured at 15 cm from soil line.
x Total of trunk, shoots, branches and leaves.
w Means in a row followed by the different letters are significantly different from each other by Duncan's Multiple Range Test, $p<0.05$.

place trees was similar to that for trees planted in the nursery from containers.

There was no difference between fabric- and field-grown trees in root weight for roots less than 5 mm diameter (Table 3). However, the root ball size on fabric container trees was about 50% smaller than that on field-grown trees, so there is less of a soil moisture reserve in the fabric container root ball. Increased frequency of irrigation is required to maintain trees transplanted from fabric containers(12). Wild trees had less root weight in each of the root-diameter classes than nursery-grown trees, but this was not surprising since the wild trees were somewhat smaller (i.e., had less shoot weight than field-grown trees - Table 1). However, wild trees had a shoot:root ratio similar to field- and fabric-grown trees, indicating that they may transplant equally well (Table 1).

Nursery-grown and wild trees had a deeper root system than fabric-grown trees since the root balls were both taller and wider. There were some roots in the deeper soil layers which may not dry as quickly as those in the shallower soil. This could help maintain a favorable water status inside the tree and give nursery grown and wild trees an advantage in a well-drained landscape soil where there is enough oxygen at the deeper soil depths for root growth. At transplanting, fabric-grown trees have a shallower root system because the root ball is not as tall as on tree spade-dug trees. Fabric-grown trees will require more frequent irrigation in the first weeks after transplanting than trees transplanted from other production methods (12). But fabric-grown trees could have an advantage in a high water table site or compacted soil where deep roots on nursery-grown and wild trees might suc-

Table 2. Number of roots and root cross-sectional area within root diameter classes at the perimeter of root balls from wild, nursery- and fabric-container-grown laurel oak.z

Root diameter class (mm)	Number of roots			Cross-sectional area (cm^2)y		
	Collected wild	Nursery grown	Fabric container	Collected wild	Nursery grown	Fabric container grown
>5 - 10	5.4ax	15.6b	16.4b	2.2a	6.6b	7.5b
>10 - 15	5.0	4.8	7.6	5.1	5.9	8.0
>15 - 20	1.4	2.0	2.0	3.0	4.4	4.3
>20 - 25	0.8	0.2	0.8	3.0	0.7	2.6
>25 - 30	0	0	0	0	0	0
>30	0.2	0.4	0	1.8	2.3	0

z Each value in the table is the mean of 5 trees.
y Sum of cross-sectional area at the perimeter of the root ball of roots in each root diameter class.
x Means in a row followed by different letters are significantly different fromeach other by Duncan's Multiple Range Test, $p < 0.05$. There were no differences among treatments in any other root-diameter classes.

Table 3. Weight of roots inside root ball within root diameter classes for wild, nursery- and fabric-container-grown laurel oak.

Root diameter class (mm)	Root dry weight (g)^z Collected wild	Nursery-grown	Fabric container-grown
0 - 1	5.3ay	7.2b	8.3b
>1 - 2	5.4a	7.3b	7.1b
>2 - 5	14.6a	36.8b	39.1b
>5 - 10	45.9a	103.7b	92.0b
>10	602.9a	1124.7b	1122.9b

z Each value in the table is the mean of 5 trees.
y Means in a row followed by the same letter are not significantly different from each other by Duncan's Multiple Range Test, $p<0.05$.

cumb to low oxygen.

Trees in the current study were not root pruned at any time during the production period. Some nurseries routinely root prune trees when they are growing in the nursery and this has been shown to increase fine root mass inside the root ball of field-grown live oak (*Quercus virginiana*) trees (10) and enhance tree growth after transplanting (9). Irrigation practices in the nursery can also have a dramatic impact on fine root mass inside the root ball. Confining irrigation to the area within the fabric container more than doubled the fine root density on laurel oak compared to trees irrigated over a larger area (15). Compared to a non-irrigated control, trickle irrigation increased fine-root weight within the root ball in pin oak and sugar maple, but not in honeylocust (16). The results of the current study may have been different if the trees were root pruned prior to transplanting, or if irrigation were managed differently in the nursery prior to transplanting.

There appears to be no best method of tree production. Those choosing trees from a nursery and maintaining them after transplanting must take production practices at the nursery, the site conditions and post-planting irrigation capabilities into account when selecting among tree production methods. Future studies should compare the irrigation requirements and post-transplant growth of trees transplanted from the various tree production methods.

Conclusions

1) Laurel oak trees collected with a tree spade from a non-managed, naturally regenerated field had a similar shoot:root ratio as trees grown in fabric containers or those planted directly into field soil in a managed nursery.

2) Root balls of field-grown trees were nearly identical to those grown in fabric containers except that fabric-grown root balls were about 50% smaller and are easier to handle in the landscape. But because of the smaller size of the root ball, there is probably less reserve water in the fabric container root ball than in the larger-sized root ball of the field-grown tree. If water is not applied regularly following transplanting, trees from fabric containers undergo more water stress than field- or plastic container-grown trees (12).

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Resumé. Le chêne à feuilles de laurier (*Quercus laurifolia*) en pots de 3.8 litres était transplanté en pépinière au champ ou en conteneurs préfabriqués et laissé en croissance pour deux ans. Les masses de racines étaient par la suite comparées. Etaient aussi comparés des chênes en milieu naturel recueillis au moyen d'une déplanteuse. Le système racinaire des arbres sauvages était dominé par un pivot racinaire simple avec quelques racines latérales croissant depuis le pivot et depuis la base du tronc. Les arbres en pépinière n'avaient pas de pivot simple proéminent, mais plusieurs grosses racines qui croissaient directement ou à un angle faible à la verticale au-dessous du tronc. Dans la plupart des cas, ces racines veticales avaient pour origine des racines qui tournaient dans le fond du pot antérieurement à la plantation. Il y avait aucune différence entre les arbres de pépinière et de conteneurs en regard de las masse en racines de moins de 5 mm de diamètre; quant à leur nombre et à leur surface en coupe transversale, ils étaient comparables tant pour les arbres sauvages, en pépinière et en conteneurs avec l'exception que les arbres sauvages possédaient moins de racines de 5 (non inclus) à 10 mm de diamètre et leur surface in coupe était inférieure à celles des arbres en pépinière. Le ratio racines:pousses était semblable pour tous les arbres au cours des recherches.

Zusammenfassung. Lobeereichen (*Quercus laurifolia*) wurden aus 3,8 l Containern umgepflanzt in Industriecontainer oder in Baumschulquartiere, um nach zwie Jahren die Wurzellballen zu untersuchen. Verglichen wurden diese Bäume mit Eichen, die mit dem Spaten im Wald ausgegraben wurden. Das Wurzelsystem dieser Waldbäume zeigte eine einzelne, dominante Hauptwurzel. Dazu kamen noch einige laterale Wurzeln, ausgehend von der Hauptwurzel oder dem Stammfuß. Die Bäume aus den Baumschulquartieren hatten keine einzelne Hauptwurzel, sondern einige große, nach unten wachsende Wurzeln oder solche, die mit einem leichten Winkel vom Wurzelstock wegwachsen. In den meisten Fällen hatten diese vertikal orientierten Wurzeln ihren Ursprung an denen, die sich vor dem Pflanzen kreisförmig gebogen am Containerboden befunden haben. Es gab keine Gewichtsunterschiede bei Wurzeln mit weniger als 5 mm Durchmesser zwischen Quartier- und Industriecontainerbäumen. Die Anzahl und Querschnittsfläche der Wurzeln waren bei Wald-, Quartier- und Industriecontainerbäumen ähnlich. Lediglich die Waldbäume hatten in der Klasse der Wurzeln mit 5-10 mm Druchmesser weniger Wurzeln und geringere Querschnittsflächen als die Quartierbäume. Das Verhältnis Wurzel/Trieb war bei den drei Varianten etwa gleich.