Arboriculture & Urban Forestry 2013. 39(1): 1–5

Anchorage Influence by Production Method and Root Pruning

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Abstract. The objectives were to 1) compare the post-planting anchorage of container-grown and field-grown (balled-and-burlapped) live oaks (*Quercus virginiana* Mill.), and 2) evaluate the effects of root pruning and post-planting irrigation placement on anchorage and growth. At seven months after planting, field-grown trees were approximately 50% better secured to the soil than trees from containers. However, removing the peripheral 5 cm of the container root ball at planting improved anchorage of container-grown trees by approximately 13% without reducing diameter growth or causing visible symptoms. Irrigation placement (applied directly on the root ball or to a wider area) had no effect on anchorage and growth. There appeared to be no benefit to irrigating the soil around the root ball during tree establishment in the fine sand soils that receive 120 mm annual rainfall.

Key Words. Anchorage; Container-grown Nursery Trees; Field-grown Nursery Trees; Landscape Planting; Lateral Stability; Root Ball Shaving.

The differences in root configuration and mass between container-grown and field-grown balled-and-burlapped trees may influence anchorage after planting. Trees averaging 80 mm in trunk diameter when transplanted from a field nursery were found to be better secured to the soil three years after planting than trees installed from smooth-sided containers (Gilman and Masters 2010). Number of roots growing straight from the trunk and across the root ball/landscape soil interface was most correlated with anchorage, and trees from containers had fewer of these roots. Anchorage evaluations have not been made on larger nursery stock.

Many trees are shifted from one container in the nursery to the next larger size without root pruning. The imprint left on the root system by each container is considered a defect caused by roots deflecting up, down, and around the container wall. The result can be few straight roots resulting in poor anchorage following planting (Harris et al. 1971; Salonius et al. 2000; Gilman and Wiese 2012). Root pruning when shifting from one container size to the next has improved root systems in containers. Pruning reduces circling, ascending, and descending roots, and creates large-diameter straight roots, especially toward the top of the root ball (Harris et al. 1971; Gilman et al. 2010b).

Gilman et al. (1996) showed that shallow slicing (2.5 cm deep) 11 L container root balls top-to-bottom on shrubs (*Ilex cornuta* Lindl. & Paxt. 'Burfordii') at planting into field soil resulted in a redistribution of roots, not an increase in roots compared with non-pruned controls. Lightly scoring or teasing the root ball periphery from slightly larger trees (*Tilia cordata* Mill., *Salix alba* L.) from 25 to 40 L containers also had no impact on number of roots growing into landscape soil (Welcherding et al. 2007). One study on *Quercus virginiana* Mill., 'SNDL', Cathedral Oak® trees that were 66 mm caliper at planting showed that shallow radial slicing of 170 L root balls (2.5 cm deep into the side surface) in several places top to bottom also failed to impact root growth (Gilman et al. 2010a) or lateral stability (anchorage) three years after planting (Gilman and Masters 2010). These experiences call into question the effectiveness of shallow root ball slicing at planting.

Further study suggested that pruning live oak root balls from 57 L containers by either deep (10–12 cm) radial slicing or shaving off the periphery at planting reduced the number of circling roots and improved tree anchorage after planting (Gilman and Wiese 2012). Improved anchorage was attributed to the presence of straight roots extending from the trunk and into landscape soil. These root pruning methods may prove effective at enhancing anchorage and establishment rate of a wide variety of species from containers of many different sizes.

There is some evidence that the soil surface area to which a given volume of water is applied can influence root distribution, but the impact of application area on survival, establishment, and anchorage is not clear for large landscape-sized nursery stock. Gilman et al. (1994) planted laurel oak (*Quercus laurifolia* Michx.) and 'Natchez' crapemyrtle (*Lagerstroemia indica* × *fauriei* Koehne) from 10 L containers into an in-ground fabric container in a sandy soil with irrigation applied over varying soil surface areas. Confining the irrigation to the area within the fabric container resulted in more fine-root mass within the root ball on laurel oak but not crapemyrtle compared to applying water over a larger soil area. However, small diameter roots are not as important to anchorage as are large diameter roots (Coutts 1986; Gilman and Masters 2010). There was no impact of irrigation application area on root mass outside the root ball or distance between the trunk and the farthest root tips. Moreover, in all irrigation studies on newly-planted trees of the size commonly installed into landscapes, application of water only to the top of the root ball consistently results in quick establishment from rapid root growth (e.g., Gilman et al. 1994; Gilman et al. 2010a). Roots are not confined to the irrigated area attributable to ample soil moisture under mulch outside the root ball periphery (Stabler and Martin 2000).

The present study compared anchorage and growth of planted container-grown trees considerably larger than previously tested with that of similarly-sized trees transplanted from a field nursery. A second study was designed to compare anchorage and growth of 1) recently planted trees irrigated only on the root ball with that of trees receiving irrigation over a larger soil area, and 2) recently planted trees whose root balls were shaved or not at planting.

MATERIALS AND METHODS

Study One

Thousands of live oak (*Quercus virginiana* Mill., 'SNDL', PP#12015 Cathedral Oak) trees began as cuttings stuck into square 14 cm tall × 6.9 cm wide smooth-sided containers (Anderson Die and Manufacturing, Portland, Oregon, U.S., model 03AN-BAN2_7-8 × 5) in August 2001 at Skinners Nursery (Crescent City, Florida, U.S., USDA Hardiness Zone 8b). Trees were shifted into 3.8 L smooth-sided containers (20 cm tall × 18 cm top diameter, Nursery Supplies, Fairless Hills, Pennsylvania, U.S.) in May 2002, and into either 57 L Florida Cool Ring containers (41 cm tall × 44 cm top diameter, Florida Cool Ring, Lakeland, Florida) in March 2003 or into a field nursery (Myakka fine sand, non-hydric). Trees in 57 L containers were planted into 379 L containers (51 cm tall × 91 cm top diameter) Cool Ring containers in September 2004. Container substrate was 50:40:10 (New Florida peat: pine bark: sand, volume). New Florida peat is a compost of Florida peat and hardwood bark fines (Florida Potting Soil, Inc., Orlando, Florida). Fertilizer (18-5-10 controlled release, Harrell's Inc., Lakeland, Florida) was incorporated at 10.74 kg/m^3 into substrate prior to planting; additional fertilizer was periodically applied. Weeds were hand pulled from container substrate. Trees did not root out of pots and into the ground. All trees were pruned to one central leader twice annually.

Three matching trees with trunk diameters of exactly 14 cm (measured with a diameter tape 8 cm from substrate surface) were chosen from both the field and container plots. Field-grown trees were lifted from the nursery January 2008 with a 152 cm diameter tree spade and placed in copper-treated natural burlap inside a wire basket that matched the root ball dimensions. Woven black plastic nursery ground cloth fabricated as a sleeve to fit over the basket was placed into the hole dug by the spade, and the root ball with basket was lowered back into the hole inside the sleeve. The fabric prevents most roots from penetrating and growing into the soil outside the root ball facilitating easy lifting later. Certain segments of the wire basket were tightened around the root ball to maintain soil contact with roots. Trees were irrigated several times daily to maintain turgor as standard practice in the region until March 2008. This practice of digging field-grown trees several weeks to several months prior to landscape planting is known as "hardening-off," and results in trees that transplant reliably and with a high survival rate (Gilman 2001). It has been a common practice in the region for more than 20 years.

In March 2008, trees were planted 6 m apart into field soil several hundred m from where they were grown in the same nursery in a randomized complete block design with one tree from each treatment in each of three blocks. Holes were dug with a backhoe and the bottom was tamped by foot to standardize settling. The top of the root ball was positioned even with the soil surface. Once the root ball was placed in the hole, a 15 cm wide volume of undisturbed soil at the edge of hole was loosened and pushed into the hole. The rest was filled with soil that came out of the planting hole. Water was added to settle backfill soil before packing firmly with a person's foot. No berm or water ring was constructed around the root balls and no fertilizer was added during the study.

A layer of hardwood wood chips 10 cm thick was applied as mulch to the root ball surface and adjacent soil in a 3 m diameter circular area around each tree. Mulch was absent in the 18 cm radius adjacent to the trunk. All vegetation was periodically killed with Glyphosate (isopropylamine salt, 41%) in a strip 4 m wide down each row with care to prevent spray on the trunk; vegetation between rows was mowed. Fifty-seven liters irrigation was applied daily through four Roberts Spray Stakes (Roberts Irrigation Products, Inc., San Marcos, Idaho, U.S.) positioned at the edge of the root ball spraying toward the trunk to encourage rapid growth; no irrigation was applied to the soil around the root ball. Trees were staked to stabilize them in wind. Stakes were removed in October 2008 and trees pulled with a winch to 15 degrees trunk tilt from vertical start position as described hereafter.

Study Two

In August 2003, thousands of Cathedral Oak trees began as cuttings in the same nursery as described for study one. Trees were shifted into the same 3.8 L smooth-sided containers as in study one in May 2004, and into 57 L Florida Cool Ring containers in May 2005. Trees were shifted into 254 L Florida Cool Ring containers (40 cm tall × 76 cm top diameter) in November 2006 using the same substrate and fertilizer regime as study one. In March 2009, 24 trees with exactly 8.9 cm trunk diameter (measured with a diameter tape 15 cm above substrate surface) and a mean height of 4.7 m were chosen from the group of thousands of trees. Twelve trees were root pruned (referred to as shaving, Gilman and Wiese 2012) with a reciprocating Tiger Saw (Porter-Cable, Inc., model 9748, Jackson, Tennessee, U.S.) by cutting tangent to the trunk to remove the entire periphery (approximately 5 cm) of the root ball (i.e., the sides and bottom). Although no data was collected on the diameter of the cut roots, most trees had cut roots up to about 2 cm in diameter at the periphery. The other 12 trees were not root pruned at planting. Trees were planted into the same field soil as study one in three rows of eight trees 4.9 m apart.

Half the trees in each root pruning treatment were irrigated with 44 L once daily. Water was applied only to the root ball surface through four Roberts Spray Stakes installed at the edge of the root ball directing water toward the trunk. The other half received twice the volume (88 L) through the same four stakes plus four more at the root ball edge which directed water outward away from the trunk onto the soil around the root ball. Total irrigated area for this treatment including the 76 cm diameter root ball was a circular 3 m^2. Plots were mulched and maintained as described for study one. Trunk diameter was again measured October 2009.

Evaluating anchorage

Tree trunks in both studies were pulled October 2008 (study one) or 2009 (study two) to evaluate anchorage (lateral stability) seven months after planting. An electronic inclinometer (model N4; Rieker Inc., Aston, Pennsylvania, U.S.) was mounted to a fabricated steel plate (5.1 cm × 7.6 cm) secured to the trunk base 8 cm from soil surface, which was above the swollen root flare. A 909 kg capacity load cell (study one) or 3,629 kg capacity load cell (study two) (SSM-AF-8000; Interface, Inc., Scottsdale, Arizona, U.S.) was used to record force and was placed in-line with the pulling cable attached to the trunk approximately 2 m from the ground. Trunks were pulled in the 90° azimuth (from north) direction with the cable parallel to ground at a rate of 2 $cm \cdot s^{-1}$ with an electric winch mounted to a tractor until the trunk tilted 15 degrees from vertical start position.

Load cell and inclinometer measurements during pulling tests were sampled at 2 Hz using a 16-bit data acquisition system (National Instruments Corporation, Austin, Texas, U.S.) and displayed and archived in real-time on a laptop running LabView software (v: 7.0; National Instruments, Austin, Texas). Trunk diameter at the center of the inclinometer was measured with a diameter tape when each tree was pulled. Trunk bending stress at position of inclinometer was calculated as: (pulling force × distance from pulling point to inclinometer × trunk radius at inclinometer center) ÷ (0.25π × trunk radius^4) after James and Kane (2008).

Statistical analysis

Study one was designed and analyzed as a one-way ANOVA in a randomized complete block design with one replicate of both treatments in each of three blocks. Treatment differences in trunk diameter and bending stress required to pull trees to each angle increment (5, 10, 15 degrees) were compared using SAS PROC GLM (SAS Institute, Cary, North Carolina, U.S.). Study two was designed and analyzed as a two-way factorial in a randomized complete block design with one replicate of each treatment combination in each of six blocks (2 irrigation placements × 2 root pruning treatments × 6 blocks = 24 trees). Two-way analysis of variance in the SAS PROC GLM procedure was used to evaluate impact of main effects and interaction on trunk diameter and bending stress. The two main effects were root pruning and post-planting irrigation. Significant results were reported at $P < 0.05$ unless indicated.

RESULTS AND DISCUSSION

Trees from both the field and container nursery produced similar trunk diameter growth (1 cm) in the seven-month post-planting period of study one. Longer-term trials on smaller trees have shown that hardened-off trees from a field nursery are generally subject to less water stress and establish and grow somewhat faster than, or about at the same rate as, trees planted from containers (Beeson and Gilman 1992; Gilman et al. 2010a). However, trees planted from the field nursery in study one required significantly more bending stress to tilt trunks than trees planted from containers (Table 1). The approximate 50% increase in bending stress required to tilt trees from the field nursery to 10 or 15 degrees was similar to that on smaller trees (66 to 80 mm trunk caliper at planting) of the same cultivar (Gilman and Masters 2010). The better anchorage three years after planting field-grown trees in that study was associated with abundance of straight roots growing into the landscape soil, and greater mass of the mineral soil within the root ball (Gilman et al. 2010a). There is some evidence in the literature that the differences in anchorage between various root forms on trees planted from small (propagation) containers in the first few years after planting may disappear with time (Coutts et al. 1999). Longer-term studies are needed to evaluate this for trees planted from the much larger root balls common in the landscape trade.

All planted trees in study two survived and grew with no dieback or leaf drop occurring on any tree other than when associated with seasonal conditions (i.e., live oaks drop all their foliage in March just prior to new leaf emergence). Main effects will be discussed because the interaction between root pruning and irrigation was not statistically significant for bending stress or growth (Table 2). Root pruning at planting had no impact on subsequent trunk diameter growth compared to trees that were not root pruned ($P = 0.99$). Other researchers have found on much smaller trees that root pruning at planting, using various methods, had little or no effect on subsequent growth (Persson 1978; Gilman and Wiese 2012), reduced growth (Arnold 1996), or increased growth (Krasowski

Table 1. Effect of nursery production method on trunk diameter and bending stress required to pull trunks to various angles seven months after planting.

Production method	Trunk diameter[z] (cm)	Bending stress to 5 degrees (kN/m^2)	Bending stress to 10 degrees (kN/m^2)	Bending stress to 15 degrees (kN/m^2)
Field	15.2 (0.62) a[y]	27155 (5236) a	35703 (7092) a	37285 (4473) a
Container	14.8 (0.7) a	20363 (1216) a	23117 (1372) b	23641 (2160) b

[z] Trunk diameter was 14.0 cm at planting seven months earlier.
[y] Means (with S.E.) compared within columns ($P < 0.05$), based on three trees per treatment.

Table 2. Analysis of variance of trunk diameter and bending stress required to pull trees to various trunk angles seven months after planting.

Source of variation	Trunk diameter (cm)	Bending stress to 5 degrees (kN/m^2)	Bending stress to 10 degrees (kN/m^2)	Bending stress to 15 degrees (kN/m^2)
Root pruning	ns[z]	ns	**	ns
Irrigation	**	ns	ns	ns
Root pruning ×irrigation	ns	ns	ns	ns

[z] Mean (with S.E.) for the non-significant (ns) sources of variations.
Note: Asterisks (**) indicate statistically significant at $P < 0.05$.

Table 3. Effect of root pruning at planting on bending stress required to pull trunks to various trunk angles seven months later.

Root pruning	Bending stress to 5 degrees (kN/m^2)	Bending stress to 10 degrees (kN/m^2)	Bending stress to 15 degrees (kN/m^2)
Yes	32953 (1276) a[z]	42851 (1692) a	45681 (2134) a
No	29531 (1852) a	37597 (1361) b	41882 (2419) a

[z] Means (with S.E.) compared within a column ($P < 0.03$), based on 12 trees per treatment.

and Owens 2000). Tree size, cultural conditions, soil, weather, species, and other factors likely account for the variety of results.

Root pruning at planting improved anchorage as shown by the approximate 13% increase in bending stress required to pull trunks to 10 degrees (Table 3). There was no difference when trees were pulled to 5 ($P = 0.1$) or 15 ($P = 0.31$) degrees. This suggests that there may be an enhancement of anchorage as a result of root pruning (described as shaving) at planting as found by Gilman and Wiese (2012) on smaller trees (57 L) of the same species. Shaving the root ball increased stability without reducing survival, crown appearance (not measured), or growth (Table 2). Shaving has also been shown to remove most circling roots at the periphery of the root ball (Gilman and Wiese 2012), thus reducing the likelihood of developing stem girdling roots in the future.

Trees had a statistically (Table 2) larger trunk diameter (107 mm) when irrigation was directed only onto the root ball surface than when irrigation was applied to the root ball plus the area around it (104 mm). The difference in size was obviously very small and probably not biologically significant or meaningful. There was no apparent explanation for the increase in trunk growth associated with less irrigation unless the soil remained too wet, which is not common in this soil type. Water was never seen standing in the field and similar studies showed either more growth (Stabler and Martin 2000; Montague et al. 2007) or no impact of increasing irrigation volume (Gilman et al. 1998; Wiese et al. 2009). Bending stress was also not impacted by irrigation (Table 2).

Although irrigation placement was confounded with irrigation volume in the current study (i.e., double the volume was applied in the larger application area), Gilman et al. (2002) found that neither irrigation placement (close to the trunk versus over a larger area) nor volume affected growth or post-digging survival. Beeson and Gilman (1995) also found that irrigation placement had no impact on shoot or trunk growth or root mass (roots < 10 mm diameter) within or beyond the irrigated soil area. All shrub species tested also generated roots in the soil well beyond the irrigated zone when water was applied only on the root ball (Shober et al. 2009). Along with the current data, these studies collectively support the notion that irrigation application outside the root ball has little impact on growth rate or anchorage of woody plants in this soil type. Research in other regions is incomplete, making it difficult to extrapolate results to other soil types and climates. Results might have been different in drier weather, for different species, or in a drier climate in sites without irrigation.

CONCLUSIONS

Trees with a 14 cm trunk diameter from a field nursery were better anchored to the soil seven months after planting than identically sized trees from containers. However, anchorage can be improved by shaving off the periphery of the container root ball at planting without sacrificing survival or trunk diameter growth. Longer-term studies are encouraged on large trees to determine if results from these short-term studies apply in the long run. Irrigation placement had little impact on growth or anchorage after planting.

LITERATURE CITED

Arnold, M.A. 1996. Mechanical correction and chemical avoidance of circling roots differentially affect post-transplant root regeneration and field establishment of container-grown Shumard oak. Journal of American Society Horticultural Science 121:258–263.

Beeson, Jr., R.C., and E.F. Gilman. 1992. Diurnal water stress during landscape establishment of slash pine differs among three production methods. Journal of Arboriculture 18:281–287.

Beeson, Jr., R.C., and E.F. Gilman. 1995. Irrigation and fertilizer placement affect root and canopy growth of trees produced in in-ground fabric containers. Journal of Environmental Horticulture 13:133–136.

Coutts, M.P. 1986. Components of tree stability in Sitka spruce on peaty, gley soil. Forestry 59:173–197.

Coutts, M.P., C.C.N. Nielson, and B.C. Nicoll. 1999. The development of symmetry, rigidity, and anchorage in the structural root system of conifers. Plant and Soil 217:1–15.

Gilman, E.F. 2001. Effect of nursery production method, irrigation, and inoculation with mycorrhizae-forming fungi on establishment of *Quercus virginiana*. Journal of Arboriculture 27:30–39.

Gilman, E.F., A. Stodola, and M.D. Marshall. 2002. Root pruning but not irrigation in the nursery affects live oak root balls and digging survival. Journal of Environmental Horticulture 20:122–126.

Gilman, E.F., and C. Wiese. 2012. Root pruning at planting and planting depth in the nursery impact root system morphology and anchorage. Arboriculture & Urban Forestry 38(5):229–236.

Gilman, E.F., and F.J. Masters. 2010. Effect of tree size, root pruning, and production method on root growth and lateral ability of *Quercus virginiana*. Arboriculture & Urban Forestry 36:281–291.

Gilman, E.F., C. Harchick, and M. Paz. 2010a. Effect of tree size, root pruning, and production method on establishment of *Quercus virginiana*. Arboriculture & Urban Forestry 36:183–190.

Gilman, E.F., G.W. Knox, C. Neal, and U. Yadav. 1994. Micro-irrigation affects growth and root distribution of trees in fabric containers. HortTechnology 4:43–45.

Gilman, E.F., M. Paz, and C. Harchick. 2010b. Root ball shaving improves root systems on seven species in containers. Journal of Environmental Horticulture 28:13–18.

Gilman, E.F., R.J. Black, and B. Dehgan. 1998. Irrigation volume and frequency and tree size affect establishment rate. Journal of Arboriculture 24:1–9.

Gilman, E.F., T.H. Yeager, and D. Weigle. 1996. Fertilizer, irrigation and root ball slicing affects Burford holly growth after planting. Journal of Environmental Horticulture 14:105–110.

Harris, R.W., W.B. Davis, N.W. Stice, and D. Long. 1971. Influence of transplanting time in nursery production. Journal of American Society Horticulture Science 96:109–110.

James, K.R, and B. Kane. 2008. Precision digital instruments to measure dynamic wind loads on trees during storms. Agricultural and Forest Meteorology 148:1055–1061.

Krasowski, M.J., and J.N. Owens. 2000. Morphological and physical attributes of root systems and seedlings growth in three different *Picea glauca* reforestation stock. Canadian Journal of Forestry Research 30:1669–1681.

Montague, T., C. McKenney, M. Mauer, and B. Winn. 2007. Influence of irrigation volume and mulch on establishment of select shrub species. Arboriculture & Urban Forestry 33:202–209.

Persson, P. 1978. Some possible methods of influencing the root development of containerized tree seedlings. Proceedings of the Symposium on Root Form of Planted Trees, Victoria, BC, Canada. May 16–19. pp. 295–300.

Salonius, P., Beaton, K., and B. Roze. 2000. Effects of cell size and spacing on root density and field performance of container-reared black spruce. Information Report M-X-208E, Canadian Forest Service, Atlantic Forestry Centre, Frederickton, New Brunswick, Canada.

Shober, A.L., K. Moore, S.M. Scheiber, E.F. Gilman, M. Paz, M. Brennan, and S. Vvapari. 2009. Post-transplant irrigation frequency affects growth of container-grown sweet viburnum in three hardiness zones. HortScience 44:1683–1687.

Stabler, L.B., and C.A. Martin. 2000. Irrigation regimens differently affect growth and water use efficiency of two southwest landscape plants. Journal of Environmental Horticulture 18:66–70.

Welcherding, P.J., C.P. Giblin, J.H. Gillman, D, L. Hanson, and G. Johnson. 2007. Mechanical root-disruption practices and their effect on circling roots of pot-bound *Tilia cordata* Mill. And *Salix alba* L. 'Niobe'. Arboriculture & Urban Forestry 33:43–47.

Wiese, C., A. Shober, E.F. Gilman, M. Paz, K. Moore, M. Scheiber, and M.M. Brennan. 2009. Effects of irrigation frequency during establishment on growth of *Ilex cornuta* 'Burford Nana' and *Pittosporum tobira* 'Variegata'. HortScience 44:1–6.

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Résumé. Les objectifs étaient 1) de comparer la qualité de l'ancrage post-plantation de chênes verts (*Quercus virginiana* Mill.) produits en pot et en champs (i.e. en mottes), ainsi que 2) d'évaluer les effets du type de taille des racines et d'irrigation post-plantation sur la qualité de l'ancrage et de croissance. Sept mois après la plantation, les arbres produits en champs étaient environ 50% mieux ancrés dans le sol que ceux en pot. Cependant, enlever lors de la plantation une couche périphérique de 5 cm d'épaisseur de racines sur la motte des arbres produits en pot permettait d'améliorer l'ancrage de 13% tout en évitant des pertes de croissance ou l'apparition de symptômes visibles de stress. Le type d'irrigation (appliquée directement sur la motte de racines ou sur une surface plus large) n'avait aucun effet sur l'ancrage ou la croissance. Il est apparu qu'il n'y a pas de bénéfice particulier à obtenir en irrigant le sol autour de la motte de racines durant la période de plantation lorsqu'on est en présence de sols sablonneux fins qui reçoivent 120 mm de précipitations annuelles.

Zusammenfassung. Die Ziele waren erstens der Vergleich der Wurzelverankerung nach der Pflanzung bei getopften und im Freiland gezogenen Eichen (*Quercus virginiana* Mill.) und zweitens eine Bewertung der Einflusses von Wurzelrückschnitt und Bewässerung nach der Verpflanzung auf die Verankerung und Wachstum. Im siebten Monat nach der Pflanzung waren die feld-gezogenen Bäume schätzungsweise 50% besser im Boden verankert als die container-gezogenen Bäume. Wenn jedoch die oberen 5 cm Boden von dem Wurzelballe des container-gezogenen Baumes entfernt wird, verbessert sich die Verankerung dieser Bäume um ca. 13 % ohne Reduzierung des Wachstums oder anderer visueller Symptome. Das Bewässerungsschema (direkt auf den Wurzelballen oder auf eine größere Fläche) hatte keinen Einfluss auf Verankerung oder Wachstum. Das Bewässern des Bodens um den Wurzelballen während der Pflanzung in Böden aus feinem Sand mit einer jährlichen Regenfallrate von 120 mm schien keinen Vorteil zu bringen.

Resumen. Los objetivos fueron: 1) comparar el anclaje post trasplante de encinos (*Quercus virginiana* Mill.) crecidos en contenedor y en bola con arpilla en el campo y 2) evaluar los efectos de la poda de raíz y riego después del trasplante. A siete meses después de la plantación, los árboles crecidos en el campo estuvieron 50% mejor anclados al suelo que los árboles de contenedor. Sin embargo, la remoción de 5 cm de la periferia de las raíces de la bola al momento de la plantación mejoró el anclaje de los árboles de contenedor en aproximadamente 13%, sin reducir el crecimiento en diámetro o causar síntomas visibles. El emplazamiento del riego (aplicado directamente en la bola de raíces o a un área más amplia) no tuvo afectó el anclaje y crecimiento. Parece ser benéfico el riego del suelo alrededor de la bola de raíces durante el establecimiento del árbol en suelos finos arenosos que reciben 120 mm de lluvia anual.