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Low-profile Containers for Nursery-grown Trees

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Abstract. ***Pyrus calleryana,*** **Decne, 'Aristocrat';** ***Cryptomeria japonica,*** **D. Don;** ***Populus maximowiczii,*** **Henry × 'Androscoggin' and** ***Koelreuteria bipinnata,*** **Franch. trees were grown in low-profile containers. The optimum height and width of these containers was 20 to 30 cm and 84 cm, respectively. Pine bark and mixtures containing 50% or more of pine bark were preferable to mixtures containing leaf mold for filling the containers because the former weigh less. Roots penetrated pine bark mixtures better than sphagnum peat mixtures and also retained their shape better during transplanting. When grown in low-profile containers, trees grew fibrous root systems; after transplanting, roots grew downwardly radial and trees were able to withstand extremely difficult landscape conditions.**

Trees develop poor root systems when grown in typical nursery containers, because roots circle within the container and protrude through drain holes (Whitcomb, 1986). This problem has been recognized in the development of alternative containers (Milbocker, 1978, 1979; Whitcomb, 1986).

Water depletion from container media after transplanting may also present a problem because a disproportionately large amount of water from the container medium moves to the surrounding soil if textural differences exist between the soil and growing medium (Costello and Paul, 1975; Nelms and Spomer, 1983). Therefore, early recovery and new growth depend heavily on a small amount of water and nutrients left within the original root mass. Absorption of available water depends on the rate of root spread (Watson and Himelick, 1982; Watson, 1987). Therefore, initial root ball diameter is also an important factor in recovery of the tree.

Most containers are constructed with a diameter about equal to the height. However, depths of larger containers (up to 60 cm depth) are much deeper than the zone occupied by the majority of roots grown by unconstricted trees (Torrey and Clarkson, 1975). Therefore, a less misshapen tree root system with better potential for survival might result from containers with the same volume of growing medium as conventional containers but spread over the greater width in a design called "low-profile container".

Lowering height and increasing the width of containers increases water retention (Spomer, 1974; Tilt et al., 1987; White and Mastelerz, 1966). Short containers reduced growth of holly, *Ilex cornuta* Lindl. and Paxt. 'Burfordii Nana'; euonymus *Euonymus japonica* Thunb. 'Microphylla'; and azalea *Rhododendron* x sp. 'Hershey's Red' (Keever et al., 1985) but they were shorter than low-profile containers. This report deals with the determination of container height and volume and the type of growing medium necessary for making the low-profile container useful for nursery stock production.

Container height (Test 1). The effect of different container heights on growth was determined by growing Aristocrat pear, and Androscoggin poplar trees in containers holding 17 liter of medium with heights of 10, 20, 30, and 40 cm. Each container was a standing tube constructed from 1.02-mm thickness (40 roil) polystyrene sheeting and placed on a 0. l-mm thickness (4 roil) polyethylene covering. The diameters were calculated to provide an equal volume for all container heights. The four treatments were arranged in a randomized complete-block design with three replicates. Each tree species was grown in a separate experimental design. Aristocrat pear trees were l-year grafted whips, 75 cm tall. The Androscoggin poplar were early spring rooted whips, 35 to 40 cm tall. Containers were filled with a 3 pine bark : 1 leaf mold mixture (v/v). This mixture is sufficiently coarse that it tolerates overwatering without saturation yet retains enough water to supply the tree for a day. Each container was fertilized on the surface with 24 g of 8- to 9-month slow-release 18-6–12 Osmocote (18N-2.6P-9.9K). Trees were planted 17 May 1982 and irrigated daily for an hour with sprinklers that supplied 5 cm of water, an amount adequate throughout the growing season for all trees regardless of container diameter. Trunk diameters at 15 cm above the surface were measured 1 Sept. 1982 and the data analyzed with an F test.

Container volume (Test 2). The volume of a low-profile container needed to grow a landscape-sized tree (4- to 5-cm trunk diameter) was determined by growing Aristocrat pear trees, planted as 75-cm whips, in containers holding 56, 113, and 227 liter of growing medium. Containers were bottomless square boxes 15 cm high with inside dimensions of 61, 86, and 122 cm, respectively. Containers were placed on 0. l-mm-thick plastic sheeting. The three treatments were arranged in a randomized complete-block design and replicated three times. Each container was filled with a 3 pine bark : 1 leaf mold mix (v/v) and fertilized on the surface with 200 g of 8- to 9-month slow-release 18-6-12 Osmocote. One-half was applied at the mid-May 1984 planting, another half during July. Similar rates were applied in 1985. All

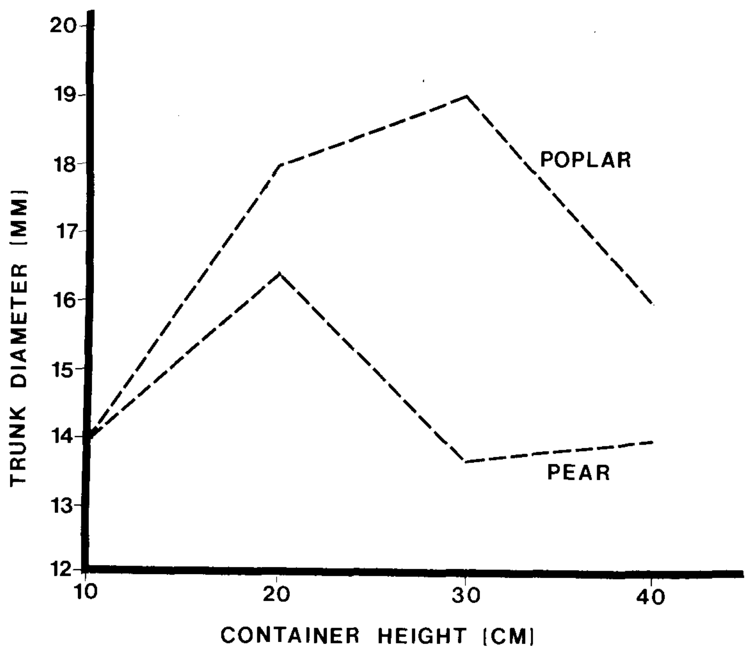

Fig. 1. Trunk diameter of 'Aristocrat pear' and Androscoggin poplar trees grown in four depths of growing medium. Poplar, F = 2.9*; pear, F = 5.0**. Standard deviation of the means = 2.0 mm.

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Fig. 2. Fibrous roots of an 'Aristocrat' pear tree grown in a 15-cm-tall and 83-cm-wide low profile container.

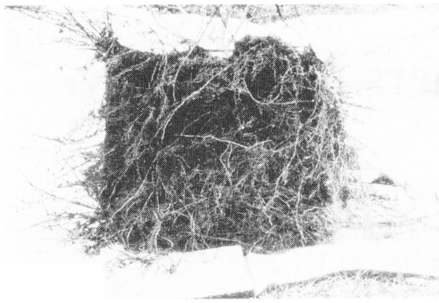

Fig. 3. Radial roots of an 'Aristocrat' pear tree (grown in a 15-cm-tall and 83-cm-wide low profile container) 1 year after being transplanted to field soil.

trees were irrigated daily for 0.5 h with sprinklers providing 24 mm of water, which was adequate for irrigating the 15-cm depth of the medium. Trunk diameters at 15 cm above the surface were measured after 2 years and the data were analyzed with an F test. Root systems were evaluated for root type and the presence of escaped roots.

Irrigated field planting (Test 3). Trees from Test 2 were transplanted to a field prepared as: 1) untilled grass sod; 2) field soil tilled to 15 cm deep; and 3) field soil tilled 15 cm deep and amended with ≈25% sphagnum peat. The soil type was Sassafras sandy loam. The block variance for trunk diameters was statistically nonsignificant; thus, the trees of each block were similar in size. Trees from a block of Test 2 were used for each transplanting treatment in this test, so that any variance caused by transplanting methods could be measured for significance.

Trees were transplanted in full leaf during mid-May 1986 and fertilized on the surface with 200 g of 8- to 9-month slow-release 18-6-12 Osmocote. Trees planted in the untilled treatment were placed on the sod as a severe test of survival and the remaining trees were planted to the original upper surface level of the container in the tilled soil. All trees were mulched with 5 to 10 cm of hardwood chips and irrigated daily with 2.4 cm of water provided by sprinklers. After one growing season, trunk diameters were remeasured and analyzed with an F test. Trees were carefully dug without destroying the root system and examined for root type and position.

Growing media (Test 4). Appropriate media for low-profile containers were determined by mixing pine bark with 25% increments of sphagnum peat or leaf mold (v/v) to form nine mixtures consisting of: 1) 100% bark; 2) 75% bark, 25% peat; 3) 50% bark, 50% peat; 4) 25% bark, 75% peat; 5) 100% peat; 6) 75% bark, 25% leaf mold; 7) 50% bark, 50% leaf mold; 8) 25% bark, 75% leaf mold; 9) 100% leaf mold. Field soil was leveled and rows of containers were formed by laying a 122-cm-width of 0.15-mm-thick (6 roil) plastic sheeting. Plastic sheeting of 0.1-mm thickness was determined to be too thin in Test 2. Bottomless boxes 86 cm square and 15 cm high were placed 30 cm apart on top of the plastic sheeting. Each container was filled with 113 liter of a mixture. Treatments were arranged in a randomized complete-block design with four replicates. The design was repeated for each of the species. *(Cryptomeria* and *Koelreuteria). Cryptomeria* plants were 15- to 20-cm rooted cuttings and the *Koekeuteria* were 50- to 76-cm seedlings. One plant was planted in each container during mid-May 1986. Plants were fertilized each year for 2 years with 100 g of 8- to 9-month slow-release 18-6-12 Osmocote and were irrigated daily with ≈ 4 liter of water per plant applied as drip irrigation. At the end of the second growing season, trunk diameters were measured and data were analyzed with an F test. Root systems were examined for circling roots and for sufficient penetration of the growing medium so that the root mass could be lifted without breaking or falling apart.

Nonirrigated field planting (Test 5). At the end of the second growing season, two replicates of the *Cryptomeria* trees were used to measure survival under extreme landscape situations as compared to survival of the remaining two replications under typical garden center conditions (trees remained in their containers). Trees subjected to extreme landscape conditions were placed on packed untilled soil without supplemental irrigation and mulched with wood chips to a depth of 5 cm above the root mass. The other half was sprinkler-irrigated daily with 24 mm water. All trees were fertilized during early May 1988 at rates used on Test 4. Roots were evaluated and trunk diameters were remeasured after one growing season. Data were compared by using a t test.

Container height. Aristocrat pear and Androscoggin poplar trees grew significantly thicker trunks in the 20- and 30-cm-deep containers, respectively, than in the others (Fig. 1). The small difference between poplar grown in 20- and 30-cm-high containers showed that they could be grown under a wider range of depths than pear. The poor performance of trees growing in the 40-cm-high containers indicates that the 20- and 30-cm container heights have merit over the taller one. The poorer performance of trees growing in the 10-cm-high containers indicates. that very shallow containers can limit tree growth, possibly because the corresponding increase in surface area permitted more surface drying and shallow depth encouraged water saturation (Spomer, 1974), which limited the volume of medium suitable for supporting roots. Roots did not grow in the upper 2 cm of the medium in any containers. These results verified, under nursery conditions, the research of Tilt et al. (1987) and showed that the most advantageous height for low-profile containers was 20 cm with a possible 30-cm height for growing species, such as poplar, that tolerate water more readily.

Container size. As the width of the container increased, Aristocrat pear trees grew larger, but not proportionately. In the smallest container (56 liter) the average trunk cross-sectional area was 8 cm^2. Cross-sectional area was used because small changes in trunk diameter are associated with larger changes in top size as the tree becomes larger. Doubling the container size to 113 liter increased the trunk cross-sectional area by 27%, to 10.2 cm^2 (difference significant at $P = 0.05$). Doubling container size again, to 227 liter, increased the trunk size 18%. (difference nonsignificant). The smaller tree in the smallest container indicates that container size limited the size of these trees, whereas nonsignificantly larger trees in the largest container indicates that these trees could have grown bigger trees if given more time. While the smallest trees were marginally acceptable for landscaping, the larger trees were suitable. The root systems of all trees were fibrous, did not circle the container, and permeated the. entire volume of the container (Fig. 2), with the exception of an occasional escaped root. Roots that escaped (as large as 1 cm in diameter) were not fibrous. The root systems in the largest containers were not dense enough to hold the growing medium together. Thus, 113-liter containers appear to be the proper size for growing pear trees 2 years.

Irrigated field planting. Transplanting on the irrigated soil surface or into amended and unamended irrigated soils resulted in no statistical differences in trunk diameter. Trunk diameters measured 15 cm above the soil surface averaged 4.6 cm (63%) larger than before transplanting. The significant differences that were due to container size before transplanting were still evident at the end of the growing season. Even though these trees were transplanted fully leafed, only those where escaped roots were cut at the surface of the sheeting wilted. Trees with escaped roots were about equally distributed throughout the experiment, which minimized this factor as a source of variation between treatments. This type of tree was considered easy to transplant, based upon its quick recovery and 63% increase in trunk diameter even when planted on the soil surface. When redug, all trees had radial roots (Fig. 3) inclined slightly downward from the perimeter of the old root mass. The fibrous root systems of trees grown in low-profile containers were changing to root systems with fewer but coarser roots similar to those of naturally grown trees.

Growing media. Increasing amounts of leaf mold in pine bark significantly improved growth of *Cryptomeria* and *Koelreuteria* until the proportion reached 75% (Fig. 4). The addition of sphagnum peat was not beneficial. Mixtures with 50% or more of leaf mold produced root masses that were too heavy to

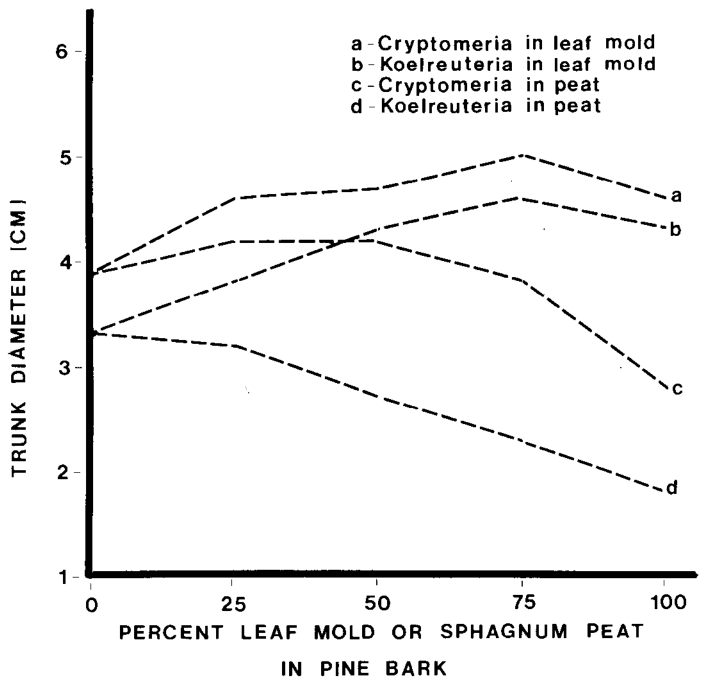

Fig. 4. Trunk diameters of *Cryptomeria* and *Koelreuteria* grown in media composed of 25% increments of leaf mold or sphagnum peat in pine bark. Standard deviation of the means = 0.3 cm.

handle manually without risk of root damage even though they grew the largest trees. Root masses grown in these heavy media tended to bend downward at the edges or break when trees were picked up by the trunk. Mixtures with 50% or more of sphagnum peat produced poor root systems that separated from the growing medium when the trees were lifted by the trunk. Media containing > 50% peat or leaf mold were unacceptable for use in low-profile containers because of poor growth and excessive weight, respectively, Pine bark alone, or when mixed with 25% peat or leaf mold, produced the best quality trees, those with root systems that completely permeated the growing medium and were light enough to be handled without root breakage.

Nonirrigated field planting. Transplanted *Cryptomeria* trees survived when transplanted on the surface of packed soil without supplemental irrigation but grew more slowly than those irrigated without transplanting. Natural rainfall for the 120-day season was 360 mm with only 30 mm falling during June. Irrigated trees increased an average of 138 cm in height and 2.2 cm in trunk diameter; nonirrigated trees increased an average of 36 cm in height and 0.9 cm trunk diameter. Differences in heights and trunk diameters were significant (t = 9.26** and 2.58*, respectively). No needlebum was evident and many of the roots of transplanted trees had entered the compacted soil after one season of growth.

Conclusion. The best container height was 20 to 30 cm. To grow a tree to landscape size, 113 liter of growing medium was needed, thus requiring a container 86 cm wide. Trees grown in 75% to 100% pine bark and fertilized with 100 g 18–6–12 Osmocote per year were capable of developing a solid root mass in 2 years that one could handle without roots separating from the growing medium.

Trees grown in low-profile containers all survived transplanting even when transplanted on packed soil, similar to the worst landscape site, and without irrigation. A proliferation of white roots on the underside of the root mass and the large area of contact with the soil probably are responsible for the transplanting success.

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