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Effects of Container Dimension and Volume on Growth of Three Woody Ornamentals

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Additional index words. *Ilex cornuta* 'Burfordii Nana', dwarf Burford holly, *Euonymus japonica* 'Microphylla', dwarf Japanese euonymus, *Rhododendron* x sp., 'Hershey's Red' azalea

Abstract. **Dwarf Burford holly (*Ilex cornuta* Lindl. & Paxt. 'Burfordii Nana'), dwarf Japanese euonymus (*Euonymus japonica* Thunb. 'Microphylla'), and 'Hershey's Red' azalea (*Rhododendron* x sp.) were grown in containers in all combinations of 3 diameters (10.2, 15.2, and 20.3 cm) and 3 depths (7.6, 15.2, and 30.5 cm). Top growth of Burford holly, a species with coarse, lateral, and deep roots, increased as pot depth and width increased; root growth was increased in deep pots. Euonymus, a species with a densely branched, medium fine root system, increased in top growth as pot depth and width increased, although the response to pot depth was less than to width. Top growth of azalea, a fibrous and shallow-rooted species, increased as pot width increased but was not affected by pot depth. Root density of euonymus and azalea decreased as pot depth and width increased, whereas relative root depth of azalea was reduced in deep pots.**

Distribution of roots in soil is determined by both genetic and environmental factors (5); however, due to restrictive container walls, limited growth medium, and high water holding capacity of the media, root growth in containers differs from that in the field. Studies of seedling trees have shown a significant influence of container volume and shape on plant growth, with larger containers generally producing larger tree seedlings (1, 4, 6, 7, 8), except with slow-growing species (6). Containers designed specifically for growing trees are typically deeper than wide, sometimes by a ratio of as much as 10:1 (7). Numerous woody ornamental species are grown in nursery containers with a typical diameter/depth ratio of about 1:1.

Traditionally, there has been little regard for the plant's natural root distribution. Matching the container dimensions to the natural shape of the root distribution may stimulate both canopy and root growth. This study was initiated to investigate the influence of container width, depth, and volume on root and shoot growth of 3 woody ornamentals having different root growth characteristics. Plants included *Rhododendron* x 'Hershey's Red' (fibrous and shallow root system), *Ilex cornuta* 'Burfordii Nana' (coarse with both laterals and deep roots), and *Euonymus japonica* 'Microphylla' (medium fine and extensive root system).

Seventy-two uniform liners of each species were potted 31 May 1983, in a 1 peat:1 perlite, (v/v) growth medium amended with dolomitic limestone (4.7 kg m^{-3}), superphosphate (1.2 kg m^{-3}), gypsum (1.2 kg m^{-3}), and Esmigran (2.4 kg m^{-3}). Containers were made from white polyvinylchloride (PVC) pipe in all combinations of 3 diameters (10.2, 15.2, and 20.3 cm) and 3 depths (7.6, 15.2, and 30.5 cm). Container volumes ranged from 618 cc to 2472 cc in the 10.2-cm pots, from 1390 cc to 5562 cc in 15.2-cm pots, and from 2472 cc to 9887 cc in 20.3-cm pots. Bottoms of containers were covered with plastic netting. All plants were placed 46 cm apart on raised, wire benches in a double polyethylene greenhouse (15° to 27°C) and elevated to an equal pot height. Plants were fertilized weekly with a soluble 25N–2P–17K fertilizer applied to container capacity at the rate of 150 ppm N and irrigated as needed. The factorial experiment was arranged in a completely randomized design with 8 single-plant replicates per treatment within each species.

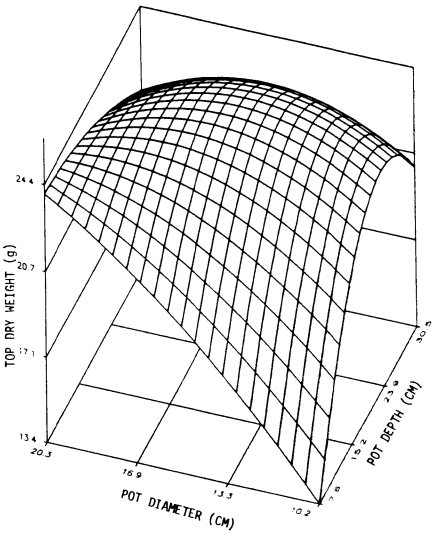

Fig. 1. Top dry weight for Burford holly grown in pots of 3 diameters and 3 depths (diameter × depth sign.).

Growth indices (height + width + width/3), relative root density, relative root depth (rooting depth/pot depth), and top dry weight were determined in Jan. 1984. Data were subjected to statistical analysis using an analysis of variance (ANOVA) and regression. Where intercepts differed among levels of a factor (diameter or depth), all levels were plotted, but equations are for the common regression. Response surfaces were shown where significant diameter × depth interactions occurred.

Top dry weight of Burford holly increased as both pot diameter and depth increased, with an interaction between diameter and depth (Fig. 1). The greatest response to pot diameter occurred at the shallow depths and to pot depth at the smallest diameters. In the wide or deep pots, increasing pot depth or

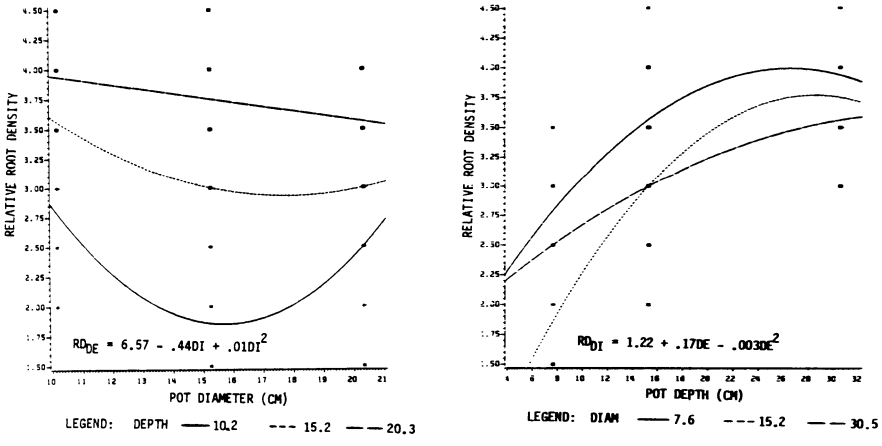

Fig. 2. Relative root density (1 = no roots on rootball surface, 3 = moderate density, 5 = dense matting) for Burford holly grown in pots of 3 depths as influenced by pot diameter and grown in pots of 3 diameters as influenced by pot depth. Equations are for the common regression.

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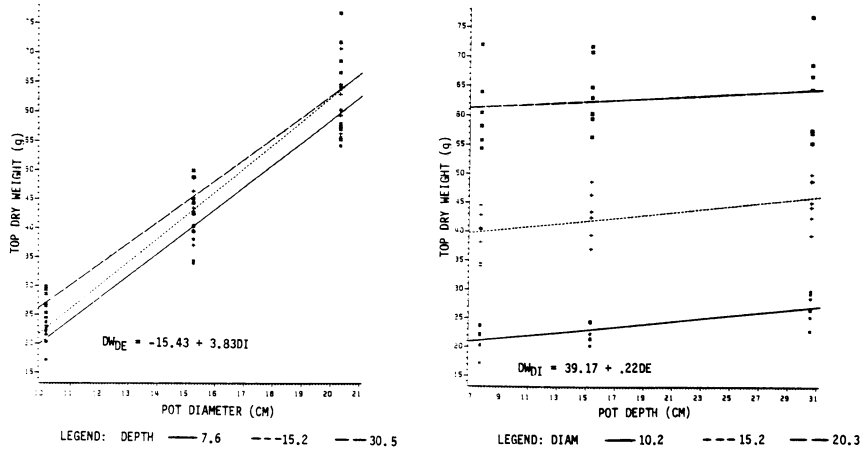

Fig. 3. Top dry weight for euonymus grown in pots of 3 depths as influenced by pot diameter and grown in pots of 3 diameters as influenced by pot depth. Equations are for the common regression.

diameter, respectively, had minimal influence on top dry weight. Growth index of holly increased linearly as pot diameter increased (GI_{DE} = 19.74 + 0.31DI) and increased between pot depths 7.6-cm and 15.2-cm before leveling off between 15.2-cm and 30.5-cm depths (GI_{DI} = 18.74 + 0.62DE − 0.01DE^2) (data not shown). Growth indices for plants in the 7.6-cm-deep pots and in the 10.2-cm-wide pots were less than those in pots wider or deeper regardless of pot depth and pot diameter, respectively. Increased growth, as pot diameter or pot depth were increased, also may be considered a response to an increased volume of growth medium. These results concur with those from other container volume studies (1, 2, 3, 4, 7, 8).

Relative root density of holly increased as pot depth increased except for a tapering off of root density as pot width and depth increased (Fig. 2). Roots reached the bottoms of pots of all depths. Root density was highest in the lower half of containers, except in pots 7.6 cm deep, reflecting the relatively deep rooting habit of Burford holly. Root density in 15.2-cm and 30.5-cm-deep pots increased as pot diameter decreased, whereas, in 7.6-cm-deep pots root density was restricted to a pot diameter of 15.2 cm and increased thereafter as pot diameter increased.

Top dry weight of euonymus increased linearly in response to both increased pot diameter (Fig. 3) and pot depth (Fig. 3) with a greater response from increased diameter ($slope_{DI}$ = 3.83, $slope_{DE}$ = 0.22). Growth index also increased linearly as pot diameter increased (GI_{DE} = 19.27 + 1.09DI); however, growth index was not influenced by pot depth (data not shown).

Relative root density of euonymus was greatest in the narrow, shallow pots and, in contrast to Burford holly, decreased as pot depth increased (Fig. 4), although roots of euonymus reached the bottoms of pots of all depths. Root density also decreased as pot diameter increased.

Top dry weight (Fig.5) and growth index (GI_{DE} = 13.33 + 0.56DI) (data not shown) of azalea increased linearly in response to increased pot diameter while pot depth had no effect. Magnitudes of change in growth index in response to increased pot diameter were much greater for azalea and euonymus than with Burford holly, indicating an increased response to pot diameter with shallow-rooted species. Relative root density of azalea, like euonymus, was greatest in the narrow, shallow pots and decreased as pot depth increased (Fig. 6), most rapidly in the widest pots. This root growth pattern contrasts with that observed with Burford holly and reflects the shallow, natural root distribution of azalea. Root density also decreased as pot diameter increased, although the response was less rapid than to pot depth. Roots of azalea did not reach bottoms of all pots, but, instead, relative root depth decreased quadratically as pot depth increased (Fig. 7). Relative root depth decreased only slightly as pot diameter increased; however, root depth was much less in 30.5-cm-deep pots compared to shallow pots (Fig. 7).

Burford holly, a species with both lateral and deep roots, exhibited increased canopy growth as pot depth and width increased, and increased root growth in deep pots. Canopy growth of euonymus, a species with a medium fine, extensive root system, increased as container depth and width increased, although less in deep containers. Canopy growth of fibrous and shallow-rooted plants of azalea was increased in wide containers but was not affected by pot depth. Root density of euonymus and azalea decreased as pot width and depth increased, while rooting depth of azalea was less in deep pots than in shallow. Increased growth when natural root growth patterns are matched with the shape of the container agrees with Biran and Eliassaf (2). Although additional volume of growth medium in wide and deep pots must be considered a major contributor to plant response, these results suggest it is beneficial to grow shallow-rooted species in shallow, broad containers and deep-rooted species in pots deeper than standard nursery pots.

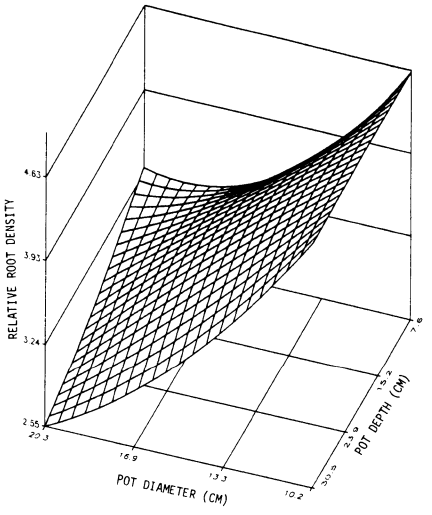

Fig. 4. Relative root density (1 = no roots on rootball surface, 3 = moderate density, 5 = dense matting) for euonymus grown in pots of 3 diameters and 3 depths (diameter × depth sign.).

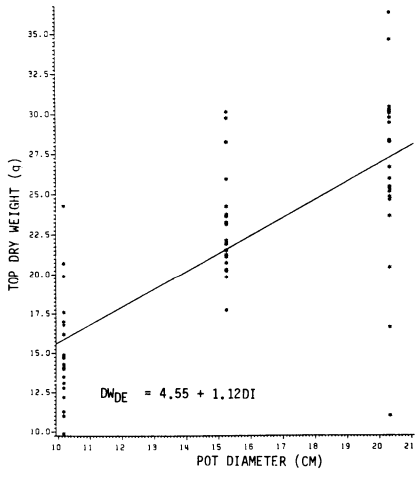

Fig. 5. Top dry weight (grams) for azalea grown in pots of 3 depths as influenced by pot diameter.

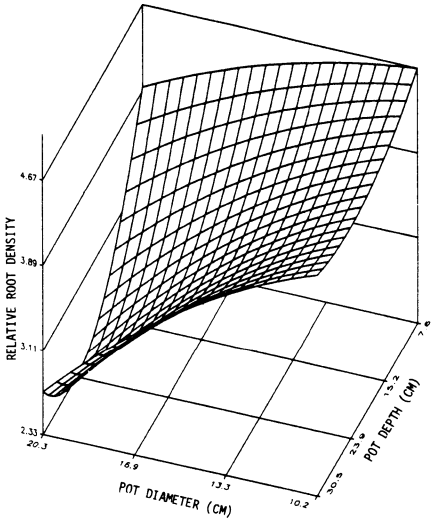

Fig. 6. Relative root density (1 = no roots on rootball surface, 3 = moderate density, 5 = dense matting) for azalea grown in pots of 3 diameters and 3 depths (diameter × depth sign.).

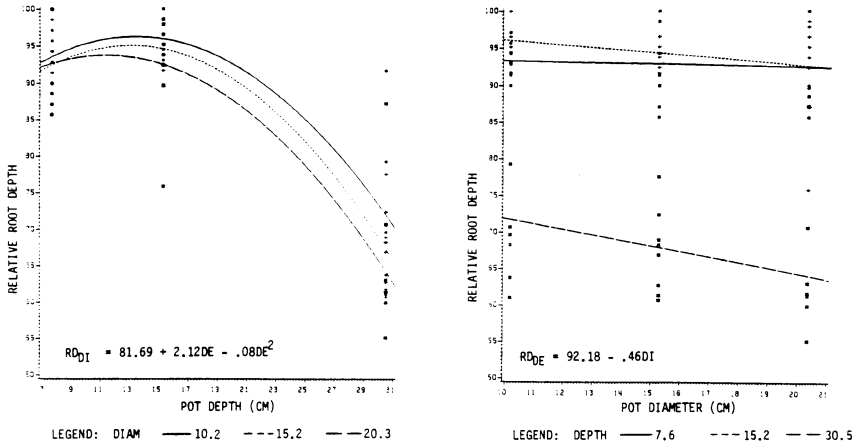

Fig. 7. Relative root depth (percentage of pot depth) for azalea grown in pots of 3 diameters as influenced by pot depth and grown in pots of 3 depths as influenced by pot diameter. Equation are for the common regression.

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Somatic Embryogenesis and Plantlet Formation from Christmas Palm Callus

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Additional index words. tissue culture, embryoid, in vitro

Abstract. **Excised zygotic embryos of Christmas palm [*Veitchia merrilli* (Bacc.) H.E. Moore] developed large haustoria and germinated normally in vitro on Murashige and Skoog (MS) medium plus 0.25% activated charcoal, 5–50 μM 2,4-D and 5 μM BA. Embryogenic callus was induced from mature zygotic embryos when they were cultured on charcoal-free MS medium supplemented with 170 mg/liter KH_2PO_4, 200–400 mg/liter glutamine, and 5–25 μM 2,4-D. Somatic embryos developed and matured in a hormone-free, glutamine-containing medium. Plantlets developed from somatic embryos on MS basal medium or MS plus 5 μM NAA, 5 μM 2iP, and 2.5 μM GA_3. Embryogenic calli have been maintained on MS medium for more than 6 months. Chemical names used: (2,4-dichlorophenoxy)acetic acid (2,4-D); *N*-(phenylmethyl)-1*H*purin-6-amine (BA); 1-naphthaleneacetic acid (NAA); *N*-(3-methyl-2-butenyl)-1*H*-purin-6-amine (2iP).**

Christmas (Manila) palm is an important ornamental palm in south Florida and in other tropical regions. This palm is heterozygous, arborescent and unbranched, and it is seed propagated. About 30 palm species including Christmas palm, coconut, and date palms are affected by the devastating disease "lethal yellowing" (LY) which has almost completely destroyed these palms in south Florida and in Caribbean countries (5). This disease is believed to be caused by a mycoplasma-like organism that has been found in LY-affected palms (5). Continuous feeding of the antibiotic oxytetracycline through the palm trunk is the only available method to reduce LY-symptoms, but even this treatment is expensive and frequently ineffective. Therefore, we initiated tissue cultures of Christmas palm to explore the possibility of selecting somaclonal variants tolerant or resistant to LY disease. In addition, regeneration of plants by tissue culture is the only feasible method of cloning these palms.

Mature fruit (2–3 cm long) of the Christmas palm were harvested during January to March of 1983 from open-pollinated palm collections of Fairchild Tropical Garden in Miami. The fruit are hard to cut with a scalpel or a knife. After surface-sterilizing with 1.25% sodium hypochloride for about 30 min, the fruit were rinsed once with sterile water and split into 2 longitudinal halves with a presterilized nut cracker. The zygotic embryos then were excised with a scalpel. The zygotic embryos were cultured in glass test tubes on 10 ml MS medium (6) supplemented with 170 mg/liter potassium dihydrogen phosphate, 5–500 μM 2,4-D, 2,4,5-T, (2-naphthalenyloxy)acetic acid (βNOA), or (4-chlorophenoxy) acetic acid (4-CPA). Some media contained 200–400 mg/liter glutamine, or 5–15 μM 2iP, 5μM BA, or 0.25% activated charcoal. All media were adjusted to pH 5.7 before autoclaving and were gelled with 0.7% Difco Bacto agar. The cultures were maintained in a growth chamber providing 24 μmol $s^{-1}m^{-2}$ light from Gro-Lux fluorescent tubes with a 16 hr photoperiod at 27°C, or under complete darkness.

Twenty embryos were cultured in each concentration of the auxins used. Seventy to 100% of the zygotic embryos on media containing 5–50 μM auxin, 5 μM BA, or 2iP and 0.25% activated charcoal germinated. Initially, there was enormous growth of the haustorium followed by the appearance of a shoot and root. The haustoria enlarged more than 100 times in 5–9 weeks after culture. The haustorium was white in dark-grown cultures, but they turned green within a week of exposure to light. The enlargement of haustoria was affected by the type and con-

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