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Root Growth of Red Maple following Planting from Containers

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Abstract. **Post-planting root development of red maple (*Acer rubrum* L.) on a well-drained site was compared with that on a site with a high water table. Container-grown red maple planted in 1985 were excavated in 1988 and cross-sectional root area (CSRA) calculated for roots >1 cm diameter, 5 cm beyond the edge of the original container rootball. Adventitious roots were generated in the field after planting, not in the container. Total adventitious CSRA was three times greater than CSRA of roots generated from the original container-produced root system. The number of adventitious roots (7.6) generated from the trunk and primary root after planting was greater than the number of roots originating from the existing root system (4.2). Adventitious root origin on both sites was within 5 cm of the soil surface, above the often circling, kinked, or twisted roots found within the container root ball. Four of the five largest roots were of adventitious origin. Root number, size, and growth rate were not modified by differences in cultural and environmental conditions between sites.**

Root system development on naturally regenerated trees differs from that on planted trees. Trees seeded in place tend to form tap roots where soil conditions permit, whereas planted trees form few tap roots. Those tap roots formed on planted trees are smaller in diameter and more easily broken in wind storms than the single, thick tap root on naturally regenerated trees (Somerville, 1979).

Roots proliferate in corridors of loose soil caused by mechanical disturbance during logging, land clearing, and planting, and this can lead to increased windthrow. Alignment may result more from disproportionally enhanced growth rates in the less-compacted soil than from root deflection. Diameter development of split-root systems of sitka spruce [*Picea sitchensis* (Bong.) Carr.] was regulated by the nutrient levels bathing a particular root (Coutts and Philipson, 1977). This result suggests that the asymmetry frequently associated with tree root systems (Stout, 1956) results from cultural and environmental influences, not genetically controlled mechanisms. Despite these influences, root growth of sitka spruce was found to be inherently regular and the species may possess mechanisms that ensure that the structural root system is more evenly spaced around the trunk than would result if growth were at random (Henderson et al., 1983).

Many trees produced for the landscape trade are grown in containers for a period of time during the production cycle. Although there is evidence to the contrary (Preisig et al., 1979), roots deflected by container walls can cause root deformations that may lead to long-term tree growth problems (Nichols and Aim, 1983). The significance of container-induced right-angled turns (kinks) in lateral roots is uncertain. Lindgren and Orlander (1978) found that circling roots contributed to tree instability in seedlings of scotch pine (*Pinus sylvestris* L.). Kinks were associated with restricted flow in the xylem or phloem (Hay and Woods, 1968). Roots deflected by obstacles in the soil frequently return to the pre-deflection orientation (Wilson, 1967) and may ensure a firm hold in the soil (Eis, 1974). Few studies, however, describe the fate of circling roots caused by container tree production. The objective of this study was to compare post-planting root development of red maple planted from containers.

Study sites were located in central Florida. The well-drained (WD) site was a deep fine sand (sandy, siliceous, hyperthermic, Hapladault) with a water table below 10 m. The poorly drained (PD) site was a Myakka fine sand (sandy, siliceous, hyperthermic, Aeric Haplaquod) with a water table maintained at 1 m. Two-year-old seed-propagated red maple about 2 m tall in circular 1 l-liter containers were planted at the same depth as they were in the container in Summer 1985 on 2-m centers on each site. Some small-diameter woody roots had begun circling the bottom of the containers at planting. Trees on the WD site were overhead-irrigated, those on the PD site were sub-irrigated by periodically raising the water table-≈0.5 m. In 1988, eight trees were randomly selected from each site and excavated. Roots washed free of soil were trimmed to a point 5 cm beyond the edge of the original container rootball. Roots >1 cm in diameter at this point were counted and sanded smooth in cross section with 120-grit sandpaper. Annual growth rings were traced onto paper and the cross-sectional root area (CSRA) calculated (Fayle, 1983) with a Delta T area meter (Decagon Devices, Pullman, Wash.) representing CSRA at the end of 1985, 1986, and 1987. Root depth at the point of emergence from the trunk was measured from the anatomical center of the root to the soil surface. Roots were divided into two classes: those originating directly from the trunk or upper primary root after planting (adventitious) and those growing from other roots existing at the time of planting. Roots that grew straight out from the trunk with no obvious container-induced deformations were placed in the adventitious class. Those growing from the existing root system were easily identified because of the kinked and circling nature of the container-grown roots from which they originated.

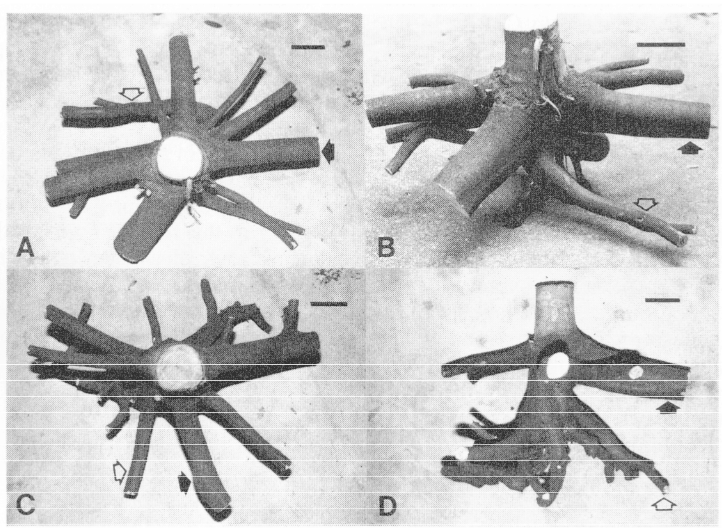

Fig. 1. **(A)** and **(C)** Top view of root systems of red maple growing in the high water table and well-drained sites, respectively. Solid arrows indicate position of the largest adventitious roots generated after planting. Unfilled arrows show position of roots growing from circling roots produced in the container. **(B)** and **(D)** Side view of same root systems showing (unfilled arrows) the smaller-diameter roots growing from the original container-produced root system. Note the relatively large diameter of the adventitious roots (solid arrows). Horizontal bars = 5 cm.

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Table 1. Root number, cross-sectional area, and root depth of red maple on high water table and well-drained sites, 3 years after planting.

Root type[z]	No. of roots[y]			Cross-sectional root area[x] (cm^2)			Root depth (cm)		No. of roots of each type of the five largest roots		
	1985	1986	1987	1985	1986	1987	At trunk	5 cm beyond container	1985	1986	1987
High water table											
Adventitious	7.2[w]	8.7	8.7	1.0	10.0	23.5	3.0	6.6	3.2	3.9	4.0
Existing	5.2	5.7	5.7	0.5	3.8	7.8	9.9	12.1	1.8	1.1	1.0
Well-drained											
Adventitious	6.8	7.0	7.0	3.0	10.9	23.5	5.0	7.9	4.5	4.3	4.3
Existing	2.9	2.9	2.9	0.5	2.5	5.1	12.4	15.4	0.5	0.7	0.7
Significance											
Site	NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS
Root type	*	**	**	**	**	**	**	**	**	**	**
Site × root type	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[z]Adventitious = roots originating from the trunk or upper primary root after planting. Existing = roots originating from the existing root system.
[y]Number of roots >1 cm diameter, 5 cm beyond original container rootball.
[x]Cross-sectional root area at a point 5 cm outside original rootball.
[w]All values represent the mean of eight observations.
NS,*,**Nonsignificant or significant at $P = 0.05$ or 0.01, respectively.

Trunk diameter (5.2 cm) at 15 cm above the soil line and tree height (4.4 m) were recorded at the end of the 1987 growing season.

There was no site effect for any measured characteristic except that adventitious CSRA in the WD) site was greater than in the PD site in 1985 (Table 1). The number of roots generated after planting remained constant during the first 3 years following planting. Roots that were largest 1 year after planting were also the largest at 3 years (data not presented). Preferential thickening on certain roots took place within 6 years of germination on sitka spruce (Coutts, 1983) and other conifers (Eis, 1974), resulting in three to eleven major roots, which is similar to mean root number in the current study. In sitka spruce, the distinction between large major roots and the smaller minor roots established during the early years was maintained throughout the 34-year study. Coutts (1983) reported that on average no more than five major roots served most conifer trees and contributed 80% or more to CSRA. In the current study, from 70% to 86% (depending on site and year) of CSRA was in the five largest roots. This supports the hypothesis of a similarity in basal root form among tree species (Eis, 1974).

There were more adventitious roots (7.6) generated after planting than roots originating from the existing root system (4.2), which agrees with findings of Coutts (1983). Adventitious root origin on both sites was within 5 cm of the soil surface, and above the often circling, kinked, or bent roots found within the container rootball (Fig. 1 A-D). More than 72% of CSRA on both sites was in adventitious roots in 1986 and 1987, representing about four of the five largest roots (Table 1). Roots deflected by the container walls generally grew down and in a circular manner. Roots originating from these deformed roots were deeper and represented a small fraction of CSRA (<28%).

Root deformation within the container may not have a long-term effect on growth of red maple in the landscape, since the majority of the root system was initiated above, and thus presumably removed from the influence of the potential girdling effects of root deformations caused by container production. Perhaps some species adapted to wet sites, such as red maple, can avoid the potential problems of container-induced root deformations by developing adventitious roots close to the soil surface, even in well-drained soil. However, root and trunk diameter growth may be restricted if a major portion of the root system had originated from existing, deformed roots. Long-term growth on species producing a less-adventitious, deeper root system originating from roots produced in the container may be more affected by these root deformations. Vascular constrictions on deformed roots could inhibit proper root function and lead to reduced long-term growth or tree stability problems (Lindgren and Orlander, 1978).

The duration of time in the container may play an important role in governing container-induced root form. If trees in this study were left in the container for another year before planting, adventitious roots might have been produced in the container and would have been deflected by the container walls. Longer-term studies are required to address this issue.

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