Effect of Backfill Composition on Post-Transplant Root Growth of *Kalmia latifolia* L.[1]

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Abstract

Post-transplant root growth is critical for landscape plant establishment. The Horhizotron™ provides a way to easily measure root growth in a wide range of rhizosphere conditions. Mountain laurel (*Kalmia latifolia* L.) plants were removed from their containers and planted in Horhizotrons in a greenhouse in Auburn, AL, and outdoors in Blacksburg, VA. Each Horhizotron contained four glass quadrants extending away from the root ball, and each quadrant within a Horhizotron was filled with a different substrate (treatment): 1) 100% pine bark (*Pinus taeda* L., PB), 2) 100% soil, 3) a mixture of 50:50 (by vol) PB:soil, or 4) 100% soil along the bottom of the quadrant to a depth of 10 cm (4 in) and 100% PB layered 10 cm (4 in) deep on top of the soil. Root growth along the glass panes of each quadrant was measured bi-weekly in Auburn and weekly in Blacksburg. In both locations, roots were longer in all treatments containing pine bark than in 100% soil. When pine bark was layered on top of soil, roots grew into the pine bark but did not grow into the soil. Results suggest that amending soil backfill with pine bark can increase post-transplant root growth of container-grown mountain laurel.

Index words: landscape, Horhizotron™, ornamental, container-grown, mountain laurel, plant establishment, woody, native.

Species used in this study: 'Olympic Wedding' mountain laurel (*Kalmia latifolia* 'Olympic Wedding').

Significance to the Nursery Industry

Current efforts to improve transplant success of difficult-to-transplant species such as mountain laurel (*Kalmia latifolia*) include research that examines factors that affect post-transplant root growth. Results of our research indicate that post-transplant root growth of container-grown mountain laurel may be increased by amending the backfill with pine bark to overcome the differences in density between container substrate and landscape soil. Treatments that mimicked planting the root ball above the surface of the soil and mulching around the exposed root ball also resulted in more root growth than planting in 100% soil.

Introduction

Landscape installation specifications routinely suggest backfill amendments to improve transplant success, however research results vary in terms of the effects of this practice on post-transplant root and shoot growth as well as survival. English oak (*Quercus robur* L.) had higher shoot growth and photosynthesis when the backfill was amended with composted yard waste compared to unamended backfill (5). More root growth of red maple (*Acer rubrum* L.), Washington hawthorn (*Crataegus phaenopyrum* L.), and 'Redspire' callery pear (*Pyrus calleryana* Decne. 'Redspire') occurred when the backfill was amended with peat than when no amendment was added (3, 11). In contrast, the effect of backfill amendments on post-transplant root growth of *Ilex crenata* 'Green Luster' varied depending upon the container substrate in which the plant had been produced (8). Some tree species, such as sweet gum (*Liquidambar styraciflua* L.) and red maple and shrub species such as cranberry cotoneaster (*Cotoneaster apiculatus* Rehd. & Wils.) and compact Pfitzer juniper (*Juniperus* x*media* Van Melle. 'Pfitzeriana Compacta') showed no benefit of organic backfill amendments (7, 16, 18).

Poor transplant success of container-grown plants can result in situations where roots fail to grow from the original container substrate into the surrounding soil since they are unable to exploit the soil for water and nutrients and must rely solely on those resources in the original root ball (1). Mountain laurel frequently does not survive transplanting from containers into the landscape even in areas to which it is indigenous, and research has shown that it is due to limited overall root growth and a slow rate of growth into the surrounding soil (20). Mountain laurel produces a fibrous root system, which requires moist, well-drained, and acid soil conditions (4). Transplanting into a clayey soil can produce a hole that 'acts as a catch basin for water, thus causing the roots to rot' (10). In the wild, the majority of mountain laurel roots proliferate horizontally in leaf litter, surface organic matter, and the uppermost soil layer (personal observation). While one study showed no benefit of amending soil with pine bark prior to planting mountain laurel (14), in other cases field grown mountain laurel have been shown to have more shoot growth and higher survival (2) and more root growth (22) when the soil was amended with peat or pine bark compared to when grown in unamended soil. The potential benefit of a soil amendment at transplanting and mountain laurel's natural root distribution in the soil suggest that it may benefit from specialized planting practices.

The Horhizotron™ is an instrument that can be used to easily measure root growth over time under a wide range of rhizosphere conditions (19). The key design feature of the Horhizotron allows a plant (removed from its container) to be placed in the center of wedge-shaped quadrants that extend away from the plant's root ball. The quadrants are made from glass panes and filled with substrate allowing observa-

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tion and measurement of root growth over time into the substrate within each quadrant. Measuring changes over time in horizontal root length (length measured parallel to the ground) characterizes the ability of roots to grow out from the original root ball and into the surrounding soil. Horhizotrons can be used in greenhouses and outdoors. The entire assembly is enclosed in a box made from thermal insulation board that is easily removed to facilitate root growth measurements. Because of the importance of root growth responses in elucidating factors that affect transplant survival and the ease with which different rhizosphere treatments can be applied using the Horhizotron, the objective of this study was to use Horhizotrons to determine the effect of different backfill compositions on post-transplant root growth of mountain laurel.

Materials and Methods

Horhizotrons constructed for use in this research had four wedge-shaped quadrants constructed from two 0.3 cm (0.125 in) thick glass panes [20.3 × 26.7 cm (8 × 10.5 in)] extending outward away from plant root balls. A 0.6 m × 0.6 m × 0.3 cm (2 ft × 2 ft × 0.125 in) sheet of aluminum formed the base for each Horhizotron, and this aluminum base was attached to a wooden frame constructed from 5.1 × 5.1 cm (2 × 2 in) treated lumber. Quadrants and plant root balls were enclosed by exterior walls and a lid constructed from 1.9 cm (0.75 in) thick foam insulation board (aluminum foil on outside and plastic on inside) to exclude light from and provide insulation for the root system. Each quadrant within a Horhizotron was filled with a different substrate (treatment): 1) 100% pine bark (*Pinus taeda*, PB), 2) 100% soil, 3) a mixture of 50:50 (by vol) PB:soil, or 4) 100% soil along the bottom of the quadrant to a depth of 10 cm (4 in) and 100% PB layered 10 cm (4 in) deep on top of the soil (hereafter referred to as mulched). The purpose of the last treatment was to mimic a planting situation in which a plant is planted with the top of the root ball above the surface of the ground (finished grade) and then mulch is piled up around the root ball. Plants used were three-year-old 'Olympic Wedding' mountain laurel produced in 19 liter (5 gal) containers in a substrate of 95% pine bark and 5% peat (Historyland Nursery, Warsaw, VA). Container dimensions were: upper inner diameter 30 cm (11.8 in), lower inner diameter 24 cm (9.4 in), and height 29 cm (11.4 in). Within the container, prior to placing in Horhizotrons, roots reached the edge of the substrate-container interface, but were not circling. Mountain laurel roots are extremely fibrous, and for plants used in this study, roots were present throughout the container profile, but plants were not pot-bound (visual observation). At planting, no attempt was made to disturb or disrupt roots.

On March 28, 2003, one plant was placed in the center of each of five Horhizotrons outdoors at the Virginia Tech Urban Horticulture Center, Blacksburg. Horhizotrons for outdoor use were constructed by eliminating the wood frame and aluminum base and placing the connected glass quadrants directly on the ground. The unit was stabilized on the ground by driving four 0.39 in (1 cm) concrete reinforcing bars into the ground at the inner intersection of the glass panes (the point of contact with the root ball). Exterior wall units with lids for outdoor use were made as described above and placed directly on the ground around the root ball and glass quadrants. Treatments were as described above using a Groseclose silt loam soil (native soil type at Blacksburg location). This soil has a bulk density of 1.45 g/cm^3 and a pH of 7.0 (17).

On June 15, 2003, one plant was placed in the center of each of five Horhizotrons located in the Paterson Horticulture Greenhouse Complex at Auburn University in Auburn, AL [day/night temperatures set at 79/70F (26/21C)]. Horhizotrons used in Auburn contained the aluminum base and wood frame described above, and the soil type used was a Marvyn sandy loam (native soil type at Auburn location). This soil has a bulk density 1.5 g/cm^3 and a pH of 7.1 (17).

Plants in Blacksburg were fertilized by topdressing each quadrant with 2.5g 12N–6P_2O_5–6K_2O (Harrell's Inc., Sylacauga, AL), while plants in Auburn did not receive any supplemental fertility in order to evaluate post-transplant root growth in the absence of any supplemental nutrition. The root balls of plants and individual quadrants in both loca-

Table 1. Effect of backfill composition (treatment) on final horizontal root length (HRL[z]) of mountain laurel growing in Horhizotrons in Auburn, AL (90 DAP[y]), and Blacksburg, VA (171 DAP), regression equations for change in HRL over time with corresponding R^2 term and significance of regression equation (P-value), and significance of treatment main effects and interactions for HRL. Plants were grown in a greenhouse in Auburn (June 15–September 13) and outdoors in Blacksburg (March 28–October 16).

	Auburn				Blacksburg			
Treatment	HRL (cm)	Equation[x]	R^2	P-value	HRL (cm)	Equation[x]	R^2	P-value
100% soil	12.6c[w]	y = 0.097x + 4.42	0.17	<0.0001	0.4d	y = –0.0002x + 0.51	<0.01	0.8032
100% pine bark	21.9b	y = 0.17x + 6.12	0.82	<0.0001	9.2b	y = 0.073x – 2.92	0.72	<0.0001
50:50 pine bark:soil	23.5a	y = 0.16x + 8.74	0.77	<0.0001	1.6c	y = –0.002x + 2.25	<0.01	0.3073
Mulched[v]	21.8b	y = 0.16x + 7.36	0.82	<0.0001	13.9a	y = 0.10x – 1.75	0.65	<0.0001
Significance	P-value				P-value			
Treatment	<0.0001				<0.0001			
DAP	<0.0001				<0.0001			
Treatment × DAP	<0.0001				<0.0001			

[z]HRL = root length measured parallel to the ground.

[y]DAP = days after planting in Horhizotron.

[x]y = HRL, × = DAP.

[w]Lowercase letters denote mean separation (n = 50) among treatments within location by PDIFF at $P < 0.05$ (12).

[v]Mulched treatment was soil in bottom 10 cm (4 in) and pine bark in top 10 cm (4 in).

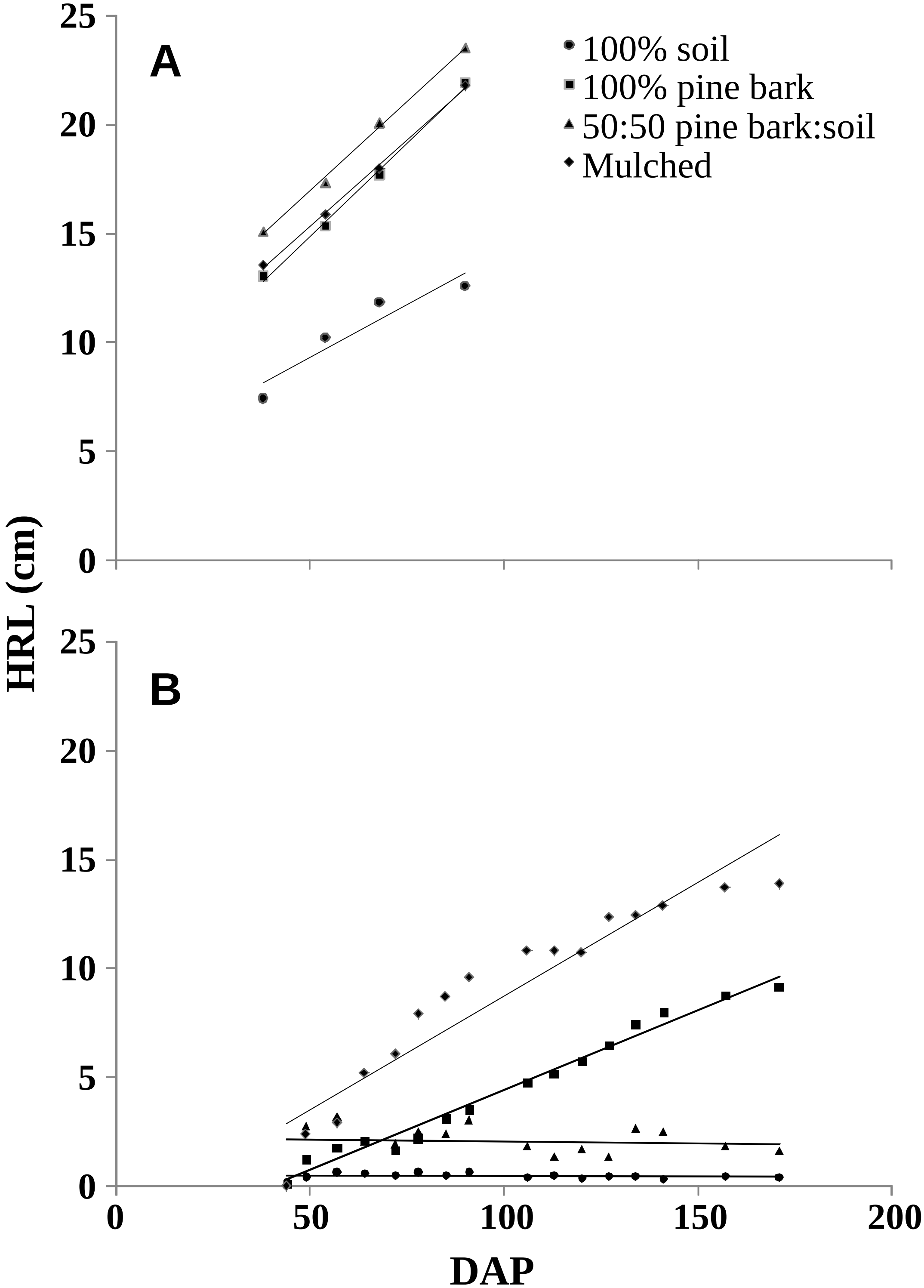

Fig. 1. Effect of backfill composition (treatment) on horizontal root length (measured parallel to the ground, HRL) of mountain laurel growing in Horhizotrons (A) in a greenhouse in Auburn, AL (June 15–September 13) and (B) outdoors in Blacksburg, VA (March 28–October 16). In Auburn, HRL increased linearly (P < 0.0001) in all treatments. In Blacksburg, HRL increased linearly (P < 0.0001) in 100% pine bark and the mulched treatment and did not increase in 100% soil and 50:50 pine bark:soil. Mulched treatment was soil in bottom 10 cm (4 in) and pine bark in top 10 cm (4 in). DAP = days after planting in Horhizotron (March 28 and June 15 in Blacksburg and Auburn, respectively). Points are means of 50 observations.

tions were hand watered as needed by applying the same amount of water to all quadrants (approximately 500 mL per quadrant). Plants were grown until September 13, 2003, in Auburn and until October 16, 2003, in Blacksburg.

Each Horhizotron contained one quadrant of each treatment, assigned randomly. Five Horhizotrons were used in each location, constituting a randomized complete block design with five blocks. The horizontal lengths (parallel to the base of the Horhizotron) of the five longest roots visible along each glass pane of a quadrant (2 panes per quadrant) were recorded once a week in Blacksburg and once every two weeks in Auburn. Horizontal root length (HRL) represents the extent to which roots would penetrate the landscape soil or backfill, in other words, the advancement of the root growth 'front'. Shoot dimensions were not recorded due to the fact that they were extremely consistent within each location both at the beginning and the end of the experiment as a result of all plants within a location being treated the same. As this was one of the first experiments done using the Horhizotron, the researchers were interested in evaluating the use of these instruments both in indoor greenhouse (Auburn) as well as outdoor (Blacksburg) environments. Data were analyzed separately for each location using GLM procedures, regression analysis, and means separation using PDIFF (15).

Results and Discussion

Auburn. Horizontal root length (HRL) increased linearly in all treatments (Table 1, Fig. 1A). At the end of the experiment [90 days after planting (DAP)], HRL was longest in the 50:50 PB:soil treatment, was similar in the 100% PB and mulched treatments, and was lowest in 100% soil (Table 1, Fig. 1A).

Blacksburg. HRL increased linearly over the course of the experiment in quadrants containing 100% pine bark (PB) and mulched treatments (Table 1, Fig. 1B). HRL was relatively constant throughout the experiment in the 100% soil and 50:50 PB:soil treatments and did not exhibit strong linear or other growth trends (Table 1, Fig. 1B). At the end of the experiment (171 DAP) HRL was longest in the mulched treatment, followed by 100% PB, then 50:50 PB:soil, and was lowest in 100% soil (Table 1).

Within each location (greenhouse in Auburn and outdoors in Blacksburg), the effect of treatment on root growth was consistent throughout the course of the experiment (Fig. 1). Due to small gaps between glass panes at the tip of each quadrant roots did not continue to grow once they reached the end, in effect being air-pruned. Other roots continued to grow until reaching the end of the quadrant. Roots grew at a faster rate in Auburn than in Blacksburg, likely due to higher air temperatures. More root growth into 50:50 pine bark:soil occurred in Auburn than in Blacksburg, likely due to differences in bark supply as well as soil type, which was a sandy loam in Auburn and a silt loam in Blacksburg. Because no fertilizer was added in Auburn, the soil could have added some fertility to the pine bark, improving root growth compared to the 100% pine bark. Although HRL in Blacksburg was lower in the 50:50 PB:soil treatment than the 100% PB or mulched treatments, the four-fold higher values for final HRL in the 50:50 PB:soil treatment compared to 100% soil in Blacksburg and the positive response for this treatment in Auburn (Table 1) suggest that penetration of landscape soil and thus HRL following transplanting can be increased if soil is amended with 50% PB. These results agree with previously published research that showed that growth and survival of field-grown mountain laurel were improved when the soil was amended with pine bark (2). Previous research has also demonstrated that dissimilarities in the physical properties of pine bark-based nursery container substrates and those of a landscape soil or backfill can hinder root growth (1, 13).

In the mulched treatment roots grew only in the pine bark and not in the soil (visual observation). This is likely due to the fact that mountain laurel produces fine, hair-like roots that in the wild tend to proliferate laterally within the organic understory layer. Other shrub species with roots thicker than mountain laurel such as Japanese holly have been found to be easy-to-transplant (20), since increasing root diameter (and thus increased root pressure) has been positively correlated with increased soil penetration (12). Minimal root growth in 100% soil was likely due to the dramatic difference in density of the soil and the original pine bark-based container substrate. Bulk density of pine bark is typically about 0.2 g/cm^3 (6, 9, 21) compared to approximately 1.5 g/cm^3 in the soil types used in this experiment (17). As the density of a container substrate decreases (such as with pine bark), so does root penetration into surrounding soil following transplanting (13). The substantially longer roots in the mulched treatment (Blacksburg, Table 1) likely resulted from the fact that roots proliferated in a smaller portion of the profile [upper 10 cm (4 in.)] than in other treatments allowing carbon allocation to fewer roots, so roots could grow longer. Additionally, since mountain laurel prefers an acidic soil environment (10) and the pH of pine bark is typically lower than that of the two soil types used in this experiment, this may explain in part the increased growth of mountain laurel roots in pine bark substrate compared to 100% soil.

In an effort to improve transplant survival of mountain laurel, it is necessary to take steps at planting to encourage post-transplant root growth. In treatments that simulated planting such that the top 1/3 of the plant's root ball is above the surface of the soil (above grade) and mulch is piled up around the root ball root, growth occurred only in the pine bark and not in the soil. This agrees with field studies that have been completed in which more mountain laurel root growth occurred when this above grade planting practice was used with pine bark or when the backfill was amended with pine bark (22). Thus mixing pine bark at a rate of 50% by volume into soil backfill can also increase post-transplant root growth of mountain laurel compared to backfilling with 100% soil.

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