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Growth and establishment of container-grown London planetrees in response to mulch, root-ball treatment and fertilization

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ABSTRACT

We conducted two experiments to evaluate the impact of cultural treatments on growth and establishment of container-grown London planetrees (*Platanus* × *acerifolia*' Bloodgood'). In both experiments, 48 trees grown in 100 l (#25) black plastic containers were assigned at random to one of three root-ball treatments prior to planting; no treatment (Control), outer 3 cm of roots removed around entire root-ball (Shave), or outer circling roots disentangled from the root-ball (Tease). In Experiment 1, half of the trees were fertilized with 400 g of controlled release fertilizer (15-9-12; N-P_2O_5-K_2O) at planting and the remainder of the trees were not fertilized. In Experiment 2, half of the trees were mulched with an 8 cm deep × 2 m diameter ring of coarse ground pine bark at planting and the remainder of the trees were not mulched. In Experiment 1, fertilization at planting increased SPAD chlorophyll content on two of four measurement dates but did not affect cumulative height or caliper growth after two years. After two growing seasons, root-ball treatments (shaving or teasing) increased root growth outside the original root-ball compared to control trees. Both root-ball treatments also reduced circling roots. In Experiment 2, mulching at planting increased soil moisture and cumulative tree height and diameter growth. Shaving increased new root growth and both root-ball treatments improved root architecture and reduced circling roots. Overall, the study demonstrates that root-ball manipulations can stimulate new root growth and reduce circling roots. Mulch is a valuable aid to conserve soil moisture and increase tree growth. Fertilization at planting provided little benefit in this experiment, which may have been related to a high level of soil fertility at the site or nutrient loading of the trees from nursery culture prior to transplanting.

1. Introduction

Nursery production of street trees and landscape shade trees in the United States is increasingly shifting toward container production (Hodges et al., 2009). Container production offers several advantages for nursery growers compared to balled-and-burlap (B&B) production including shorter production cycles, more flexible marketing and shipping, and more efficient use of nursery space. For landscapers and homeowners, container trees are light-weight and easier to handle than B&B stock. A frequent concern cited with trees grown in smooth-sided plastic containers is the tendency for trees to form circling roots (Amoroso et al., 2010; Gilman et al., 1996, 2010a; Gilman et al., 2010b, c; Ruter, 1994). Roots that begin to circle in the container can lead to permanent root deformation that can result in poor root architecture and structural issues that reduce root egress into the surrounding soil, potentially delaying tree establishment or contributing to long-term tree health issues (Gilman et al., 2015a; Nichols and Alm, 1983). Researchers have investigated various root-ball manipulations in order to reduce circling roots and promote new root growth. Some recommended techniques include slicing (scoring) roots by making a series of vertical slits in the root-ball to disrupt circling roots; pulling part circling roots, often referred to as 'teasing'; and slicing open the bottom of the root-ball and splaying the ends, often referred to as 'butterflying'. These techniques have yielded mixed results in terms of improving root development and transplanting success. Weicherding et al. (2007) measured new root growth of pot-bound *Tilia cordata* and *Salix alba* trees that were subjected to three root-ball manipulations (teasing, slicing, and butterflying) and observed no difference in new root growth 14 months after transplanting. Slicing root-balls of container-grown *Quercus virginiana* trees prior to transplanting did not affect caliper growth or root development when trees were harvested three years after planting (Gilman and Masters, 2010). Scoring root-balls prior to planting frequently improves root quality by reducing the proportion of circling roots (Gilman and Wiese, 2012; Gilman et al.,

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2016). Arnold (1996), however, found that removing the bottom mat of roots and scoring the sides of roots of Shumard oak seedlings before transplanting increased plant moisture stress and decreased new root growth compared to unpruned controls seedlings. More recently, Dr. Ed Gilman and his colleagues have reported improved root quality of container-grown trees by shaving the root-ball. Shaving, also referred to as box-cutting, is the removal of the bottom and outer circling roots of the root-ball of containers-grown trees prior to planting or up-potting (Gilman et al., 2010a; Gilman et al., 2015b). Shaving reduced circling roots and increased new growth in red maple when up-potting from #3 to #15 containers (Gilman et al., 2016). Shaving also reduced circling roots and increased root egress into backfill of container-grown *Quercus virginiana* when planted into a field nursery (Gilman and Wiese, 2012).

In addition to root-ball treatments, the relative value of fertilization and mulching at planting continues to be the subject of research and discussion. While the importance of plant nutrients is well established, researchers have often found little, if any, response of newly planted landscape trees to fertilization. Harris et al., (2008) conducted a series of studies of fertilization of trees at transplanting, including swamp white oak, shingle oak, Callery pear, Freeman maple, sweetgum and red maple and found no response in caliper growth to fertilization up to 4 years after planting. Similarly, fertilization at planting did not improve growth of newly-planted red maple or little leaf linden trees after 3 years (Day and Harris, 2007). In contrast, numerous mulching studies have consistently demonstrated improved plant performance due a myriad of effects including increased soil moisture, reduced weed competition and moderated soil temperatures (Chalker-Scott, 2007; Watson et al., 2014). Cregg and Schutzki (2009) found that 8 cm deep mulch (ground pine bark, hardwood bark or recycled pallets) significantly increased soil moisture and growth of a variety of landscape shrubs for two years after transplanting. Mulch increased soil moisture at 20 cm depth for three years in a tree establishment study in South Carolina (Fite et al., 2011). However, application of 8 cm of pine bark mulch at planting decreased height growth and survival of *Fraxiuns pennsylcanica* and *Koelreuteria bipinnata* two years after planting compared to trees that were not mulched (Arnold et al., 2005). Moreover, Gilman et al. (2012) reported that mulching increased surface evaporation from container substrate in a short-term lysimeter trial, calling into to question the benefit of mulching of container-grown trees and shrubs.

In this project we conducted two experiments to determine the response of trees following transplanting. The objectives of the study were to determine:

1) The effect of root-ball manipulation at planting on root development and tree growth
2) The effect of fertilization at planting on leaf chlorophyll content index and tree growth
3) The effect of mulch application on planting on soil moisture, leaf gas exchange and tree growth

2. Materials and methods

2.1. Plant materials and nursery culture

London planetrees (*Platanus × acerifolia* 'Bloodgood') trees were obtained from a commercial liner producer (J. Frank Schmidt and Son, Co., Boring, OR) as 3.8 cm caliper branched bare-root liners. Trees were planted in a substrate of pine bark and peat moss (80:20; v: v) in spring 2010. The trees were grown for two years in 100 l black plastic containers (model GL10000, Nursery supplies, Inc., Chambersburg, PA) in a Pot-in-Pot nursery at the Michigan State University Horticulture Teaching and Research Center near East Lansing, Michigan USA. During nursery production trees were top-dressed with 400 g of controlled release fertilizer (Osmocote Plus 15-9-12 (N-P_2O5-K_2O), 5–6 month release, ICL) each spring. During the growing season (mid-May to mid-October) trees were watered at a rate equivalent to 1 cm depth of water daily via an automated irrigation system using pressure compensated spray stakes (Netafim USA, Fresno, CA). Trees were not pruned during the nursery production phase except to remove dead or damaged branches.

Table 1
Soil description and soil nutrient concentration of the two field sites used for transplant studies.

	Experiment 1 Fertilization × Root manipulation	Experiment 2 Mulch × Root manipulation
Soil series	Riddles-Hillsdale sandy loam	Colwood loam
Typical profile	E - 0 to 22 inches: sandy loam Bt - 22 to 60 inches: sandy loam C - 60 to 66 inches: sandy loam	Ap - 0 to 10 inches: loam Bg - 10 to 26 inches: silty clay loam Cg - 26 to 60 inches: fine sand to silt loam
Drainage class	Well drained	Poorly drained
Soil pH	7.6	6.6
Phosphorus	65 mg kg^{-1}	10 mg kg^{-1}
Potassium	127 mg kg^{-1}	120 mg kg^{-1}
Magnesium	148 mg kg^{-1}	186 mg kg^{-1}
Calcium	2269 mg kg^{-1}	1488 mg kg^{-1}

2.2. Experiment 1: root manipulation × fertilization

In May 2012, 48 trees were selected at random from the planetrees at the Pot-in-Pot nursery and transplanted at the Michigan State University Beaumont Nursery. The soils on the site are a Riddles-Hillsdale sandy loam, which is characterized as a well-drained sandy loam to a depth of over 200 cm. Soil samples (0–20 cm depth) were collected from the site and analyzed by the MSU Soil and Plant Nutrient laboratory for analysis (Table 1). Soil phosphorus was determined using BrayP1. Potassium and calcium were determined by flame emission and magnesium was determined colorimetrically.

2.2.1. Experimental design and treatments

Trees were assigned at random to a 2 × 3 factorial of fertilization and root ball manipulation. The three root-ball treatments were: Control - container removed and tree planted as is, Teased – all circling roots visible on the outer surface of the root-ball were disentangled, and Shaved – the outer 3 cm of the root-ball circumference and bottom of the root-ball were removed using a pruning saw. Trees were planted in holes dug with a 90 cm diameter tractor-mounted auger. All trees were planted with the root-collar visible at the soil surface. Holes were backfilled with unamended soil from the planting hole. Trees were not mulched. Following planting, one-half of the trees were fertilized with 400 g of controlled release fertilizer. Fertilizer was spread evenly over the root-ball and backfill. After planting and fertilization, trees were managed by the Beaumont Nursery staff following their standard cultural practices. Trees were irrigated weekly via a drip irrigation system for the first month following transplanting. Subsequently they were watered as needed; typically, once every two weeks in the absence of rainfall. Aisle ways between trees were periodically mowed. Competing vegetation near trees was controlled as needed by a combination of hand weeding and directed sprays of glyphosate.

2.2.2. Assessments

2.2.2.1. Growth. Tree height and stem caliper were measured at planting and each subsequent spring. Tree height was determined using a telescoping height pole. Stem caliper was measured at 30 cm above ground-line using digital calipers. A mark was made on each stem using an indelible marker to ensure that caliper measurements were repeated at the same point along the stem. We measured caliper in