Development of a Double Crop Production System in Retractable Roof Houses

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Significance to the Industry: Container grown trees are an important product for the nursery and landscape industry (Fare, 2006). More than 50% of the $26 billion wholesale production of woody nursery crops in the United States is produced in containers (Mathers et al., 2007). In recent years, increased interest in retractable roof greenhouses (RRG's) and pot-in-pot (PIP) systems to accelerate tree liner/caliper production has occurred (Mathers, 2006; Mathers et al., 2007) and can reduce most of the problems of the shipped whips from the West Coast like long periods of storage, transplanting shock, and mortality. Plant responses in RRG include stronger root systems, reduced internode lengths, thicker cuticles, fewer root and foliar diseases, fewer insect pests, and less stress and shock following transplanting (Vollebregt, 2004). Studies conducted at The Ohio State University have shown that the RRG increases root mass (Stoven et al., 2006) and improve plant adaptation to stress (Mathers et al., 2007) versus conventional container or bare-root grown plants. Also, the demand for container grown trees in 26.4 liter (#7) and 56.8 liter (#15) containers has increased in recent years (Fare, 2006). It has been found that smaller liners of Red Sunset red maple (*Acer rubrum* 'Franksred') potted into larger container produced significantly better height and caliper growth (Fare, 2006; Mathers et al., 2007). With the RRG, larger and better liners can be produced and upshifted to PIP to accelerate nursery tree production. The objectives of this study are: 1) evaluate the growth of landscape trees from a cell size (plugs) to 3-, 7- or 15-gallon (#3, #7, and #15, repectively) container size when grown double-cropped (6-month) versus a twelve- month-cycle in a RRG; 2) evaluate the time of up-shift and out-planting of fall versus summer on root growth; 3) compare different fertilizer schemes; and 4) explore root dormancy using bottom heat temperatures as means of manipulating plant growth to significantly reduce production times. The following summary includes only the first fall planting results of this study.

Materials and methods. The production trial was conducted at The Ohio State University (OSU), Columbus, Ohio, starting on October 1, 2007. Two landscape tree species were selected to be grown in the RRG, Red Maple (*Acer rubrum* 'October Glory®') and Littleleaf Linden (*Tilia cordata* 'Greenspire®'). All the trees were grown from tissue culture and they had a start height of 8-10" (20-25 cm). All the plants were put into #3 containers with a soilless mix [60% pine bark, 20% rice hulls, 10% sand, 5% comtil (composted sewage sludge), and 5% stone aggregate] in the RRG. The roof and sidewalls of the OSU RRG were controlled by a MicroGrow control system (MicroGrow Systems, Temecula, Calif.). The MicroGrow controller operated according to outside air temperature. The roof and sidewalls were programmed to close at 70° F during the day and 50° F during the night. From October to December plants were irrigated using aerial irrigation 3 times per day applying approximately 1.7mm of total water per pot. During winter plants were watered based on the need and protected from freezing temperatures using a propane heater. From December to March plants were separated into two groups: one with bottom heat (BH) using low watt propagation mats (Olson products Inc., Medina, Ohio) set at 40 °F and the other at ambient temperature (AT). Root growth was determined by water displacement before and after BH treatments. From March to June the irrigation was applied using a cyclic-micro-irrigation two times/day, applying 500 ml of water total. From June to September irrigation was applied one time per day, applying 250 ml of water. Two fertilization treatments were imposed starting in April: control release (CR) fertilizer (40g

of Osmocote 19-5-8) applied at potting and a combination of 20g of the CR applied at potting supplemented with liquid fertilizer (LF) (Scott's 21-7-7 at 400 ppm) delivered by a Dosatron® injector every two weeks. The same total nitrogen was delivered in the CR and the CR + LF treatments. Plants were arranged in a split plot design (main plot- temperature, subplot – fertilizer) with 4 replications. Three plants per treatment were harvested for growth measures, which consisted of height, caliper (taken at 2.4 cm), leaf area, and shoot and root dry weights. EC, pH and NO_3 were also measured using a VTEM pour-through procedure (Ruter, 1998). The measures were analyzed in ANOVA using PROC GLM with SAS software (SAS Institute, Inc., Cary, NC). Treatments were compared using least significant differences with $\alpha = 0.05$.

Results and Discussion. *Bottom Temperature.* Different studies have shown that the root dormancy of woody plant is species dependent. In two root growth experiments at OSU, it was found that *Magnolia virginiana* does not show root dormancy but *Cornus kousa* roots showed true dormancy (Daniel, Mathers and Case, 2008, unpublished). This root growth could help the shoot to come out more vigorously. There was no significant difference between the BH treatments for red maple of littleleaf linden in this study (data not shown). The plants used for this experiment were small so if there was a growth it was not enough to measure by water volume displacement. It was interesting that both species were planted from the same size but they had different amount of roots. Red maple had 1 ml of water volume displacement in both measures (before and after) and Littleleaf Linden had about 2 ml of water volume displacement. It was also observed that the roots were growing only downward to the bottom of the pot during this time. It is important to mention that the heating mat sensor was put in the middle of the pot, but the plants were so small that they were only at the top of the pot. Because of the sensor placement, there was only a little temperature difference between the BH treatments. If this experiment is repeated the sensor should be placed closer to the roots. There were no significance differences for any of the measures (height, caliper, leaf area, root and shoot dry weights) between the BH treatments (data not shown). As we did not find any differences in root growth, it is expected that the measures also did not show any differences.

Fertilizers. The fertilizers were evaluated to determine if there is enhanced growth with different fertilizer schemes. There were no significant differences for height, leaf area, dry shoot and root weights between the two fertilizers scheme when averaged over species and temperatures. However, caliper was significant between the two fertilizer treatments. Caliper measures were higher for the trees with the combination of controlled release and liquid fertilizer than the controlled release alone (Fig. 1). The electrical conductivity (EC), pH and NO_3 measures were not significantly different between fertilizers (Table 1). Ruter and Garber (1998) recommend that an EC between 0.2 and 1 mS/cm with a controlled release fertilizer for nursery crops is acceptable. They mention that a liquid feed should have an EC between 0.75 and 1.5 mS/cm. The values in this study were in the acceptable range for the EC for both fertilizers. In a previous study we found that the LF was excessive; however, in that study, LF was applied daily instead of intermittently as in this study and 1500 mL of water was applied daily. In this experiment we used 500ml or less of water per day and the liquid fertilization was applied every two weeks. The amount of total nitrogen and fertilizer was the same. Also, the previous study was conducted over three months, and the duration of this experiment was one year. The pH measures were also in the recommended range (5.2-6.2), which is acceptable for most of the nursery plants grown in soilless media. According to the Florida Container BMP Guide (2006), the adequate

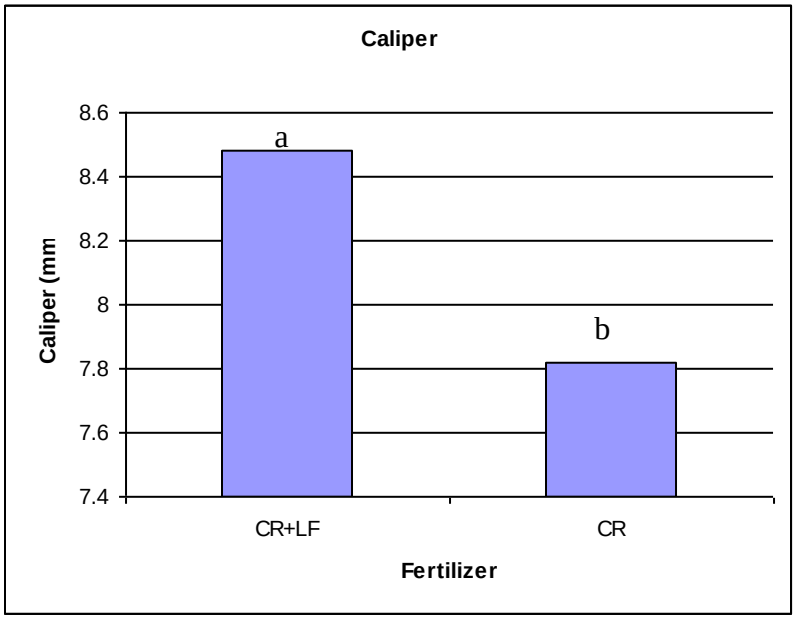
amount of NO_3 using the pour through method should be between 15 to 25 ppm for a slow release and between 50 to 100 ppm for liquid fertilizers. In this case the CR showed a higher NO_3 than the adequate amounts for container plants but the CR+LF was in the appropriate rage (Table 1).

Species. The Red maples and littleleaf linden trees started at approximately the same size. After one year of growth, the littleleaf linden was significantly taller (Fig. 2) and had a larger caliper (Fig. 3) than the red maple. However, the growth habit between species varies, so it is not surprising that the growth is different between the species in this study. All the trees were trained to bamboo stakes, pruned on a regular basis, and not allowed to develop lateral shoots. However, there were no significant differences between the species for leaf area and root and shoot dry weight (data not shown).

Table 1. Average of chemical analysis

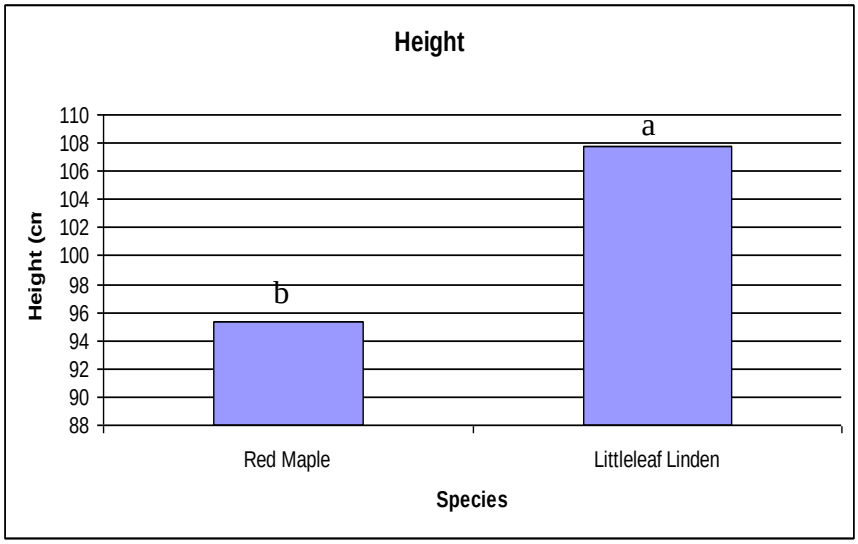
Fertilizers	EC (mS/cm)	pH	NO_3 (ppm)
CR	0.76	5.24	115.63
CR + LF	0.76	5.28	87.0

Figure 1. Caliper measures for fertilizer averaged over species (red maple and littleleaf linden) and temperature (bottom heat or no bottom heat) when grown in a retractable roof greenhouse.



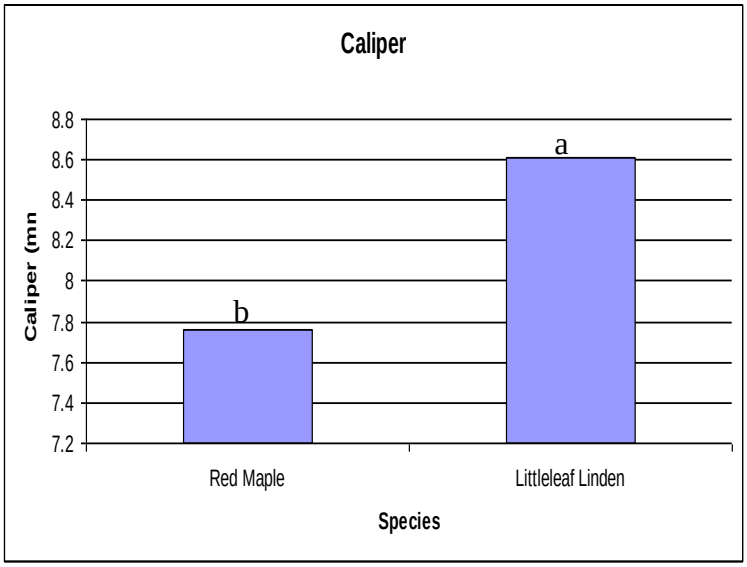
Treatments with different letters are significantly different between the same evaluation measures.

Figure 2. Height of red maple and littleleaf linden when averaged over fertilizer (control release and control release + liquid feed) and temperature (bottom heat or no bottom heat) when grown in a retractable roof greenhouse.



Treatments with different letters are significantly different between the same evaluation measures.

Figure 3. Caliper measures of red maple and littleleaf linden when averaged over fertilizer (control release and control release + liquid feed) and temperature (bottom heat or no bottom heat) when grown in a retractable roof greenhouse.



Treatments with different letters are significantly different between the same evaluation measures.

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