Accelerated whip production using retractable roof greenhouses

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Significance to the Industry: Traditionally, Ohio growers have purchased bare root whips from the West Coast. These whips are then transplanted to the field, pot-in-pot systems, or above-ground containers, and then allowed to grow into caliper trees for sale in the Midwest and East. The whips confront several situations when coming from the West Coast, such as long periods of storage, transplanting shock, and mortality. The retractable roof greenhouse (RRG) can reduce most of the problems of shipped whips, production in the Midwestern states, and the whips could be double cropped in the RRG. The retractable-roof house design allows for the roof to retract 90%. The house at The Ohio State University also utilizes roll-up ends and side-walls. Opening and closing the roof and the side-walls controls temperature, humidity, wind, and light conditions and extends the growing season. The Cravo (Cravo Equipment, Ltd., Brantford, Ontario, Canada) retractable-roof greenhouse used at Ohio State University (constructed in 2001) can be purchased with flat- or peaked-roof styles. Prices for the bare bones structure for the flat-roof houses average $1.50 per sq. ft; bare-bones peaked-roof houses, $3.75 to $6.00 per sq. foot, depending on slope of the roof. Double cropping in a RRG would give a grower more incentive to construct a RRG and produce whips in Ohio. The objectives of this study are to accelerate tree production using a double cropped RRG whips and to determine the effects of different fertilizer and irrigation regimes.

Materials and Methods: The production trial was conducted at The Ohio State University, Columbus, Ohio, starting on May 1, 2007. Three landscapes tree species were selected to be grown in the RRG , Red Maple (*Acer rubrum* 'October Glory®'), Redbud (*Cercis canadensis*) and Littleleaf Linden (*Tilia cordata* 'Greenspire®'). All species were grown from tissue culture and they had a start height of 8-10" (20-25 cm). All the plants were put into 3 gal 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 inside air temperature. The roof remained closed throughout the growing season. The sidewalls were programmed to close when the outside temperature dropped below 70° F (Mathers et al. 2004) during the day and 50° F during the night. The treatments began on May 7, 2007. Treatments consisted of 3 water frequencies and 3 fertilization schemes. The watering frequencies were: one time watering for six minutes (W1) at 8:00am, two times for three minutes each (W2) at 8:15am and 2:00pm and three times for two minutes (W3) at 7:45am, 11:45am and 4:30pm. The fertilization schemes were: slow release (S) fertilizer (40g of Osmocote 19-5-8) applied at the beginning of the experiment; liquid (L) fertilizer (Scott's 21-7-7 at 256 ppm) with a Dosatron® that applied 524.8mg/1500 ml (256 ppm) per day; and a combination of S + L (SL) with 20 g of the S for the first half of the experiment and L for the last half. The L rate was selected based on total nitrogen of the S fertilizer. Three sub-samples of each variety were in each treatment with 4 replications of a split plot design (main plot – water frequency, subplot – fertilizer). One sub-sample of each replication was 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 pour through procedure (Ruter and

Garber, 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:

Water Frequencies. The water frequencies were evaluated to determine if different irrigation times enhanced growth although the same amount of water, ≈ 1500 ml/day was used. There were no significance differences for all measures. The height, caliper, leaf area, dry shoot and root weights, EC, pH and NO_3 readings were similar between the three water frequencies when averaged over species and fertilizer (Tables 1 and 2). In this case the water frequencies did not affect growth of the trees. According to the leachate fraction (82-86%, data not shown) the amount of water applied was obviously too much for a 3 gallon pot in the RRG. This suggests that less water could be applied in the RRG with greater water efficiency. Based on leachate fractions from this study, total water applied with a 10% leachate fraction should be from 360 to 420 ml/day for a three gallon pot.

Fertilizers. The fertilizers were evaluated to determine if there is enhanced growth with different fertilizer schemes. There were no significant differences for height, caliper, leaf area, dry shoot and root weights between the three fertilizers schemes when averaged over species and water frequencies (Tables 1 and 2). This indicates that the type of fertilizer applied was not important. The electrical conductivity was 0.7 mS/cm for S, which was significantly lower than 2.39 mS/cm for L and 2.37 mS/cm for SL (Table 3). 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 EC found for the L and SL suggest that the amount of fertilizer was excessive. An EC more than 3.0 mS/cm could result in decreased plant quality and injury of young plants (Ruter and Garber, 1998). The pH measures were not significantly different between the fertilizers (Table 3). The S had a pH of 5.3 versus the L and SL that had a pH of 4.8 and 4.9 respectively. The pH should be in a range of 5.2-6.2 for most of the nursery plants. A different pH (lower or higher) would limit the availability of the nutrients in the soil. Similar to the EC, the NO_3 measures were significantly lower for S than for L and SL. 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. All the measures for the NO_3 were higher than the adequate amounts for container plants. The Ec and NO_3 levels with lack of growth difference between fertilizer treatments seem to indicate fertility supplied at the lowest level, i.e. SL was not limiting but not so excessive to cause injury.

Species. The *Cercis canadensis* and *Tilia cordata* are considered difficult to grow trees compared to *Acer rubrum*, which is considered easy to grow (Ohio nursery growers, personal communication). In this experiment the height of the *Cercis* was significantly higher than the *Tilia* and *Acer* (Table 1). The *Acer* was, on average, the shortest tree. However, the *Acer* was almost four feet tall; the desired height of a liner tree is four to eight feet (Mathers et. al., 2004). The caliper measures were similar for *Cercis* and *Tilia* and lower for *Acer* (Table 1). Leaf areas were similar for *Tilia* and *Acer* and significantly higher for *Cercis* (Table 1). Similar growth patterns were found for the dry shoot and root weights, where the Cercis had the higher weight followed by *Tilia* and *Acer* (Table 2).

Comparing the growth of the trees, statistical differences within the chemical analysis, the *Acer* had a lower pH than the pH found in *Tilia* (Table 3). According to the Ohio Department of Natural Recourses web page, the *Acer* prefers acidic soils, so the pH could not be a reason for the slow growth in this experiment. The nitrate was similar for all the species. On other hand, the *Cercis* had the statistically higher EC compared with the Tilia and Acer.

Some of the trees died during the experiment. The mortality for each was: three *Acer*, four *Tilia* and 29 *Cercis*, of the 324 total trees. The *Cercis* could have more difficulties in the initial stage of the production, because the trees that survived had significantly higher growth compared with the other species.

Future studies:

The future studies that will be conducted at The Ohio State University will involve water efficiency with an adequate leaching fraction, different fertilization applications that promote more root growth, and trials to produce double-cropped trees in the RRG.

Literature Cited:

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Table 1. Average of height, caliper and leaf area for each treatment and species.

Treatments and Species	Height (cm)		Caliper (mm)		Leaf Area (cm^2)	
Water Frequency 1	143.75	a*	8.77	a	3436.93	a
Water Frequency 2	143.17	a	8.96	a	3543.61	a
Water Frequency 3	153.69	a	9.61	a	3537.15	a
Slow Release Fertilizar (S)	146.80	a	9.16	a	3435.69	a
Liquid Fertilizar (L)	143.33	a	9.07	a	3502.61	a
Slow Release + Liquid Fertilizer (SL)	151.37	a	9.11	a	3581.61	a
Acer	118.86	c	7.49	b	3224.39	b
Cercis	175.86	a	9.75	a	4317.98	a
Tilia	145.97	b	10.13	a	2950.16	b

* Treatments with different letters are significantly different between the same evaluation measure.

Table 2. Average of dry shoot and root per each treatment and species.

Treatments and Species	Dry shoot (g)		Dry root (g)	
Water Frequency 1	38.18	a*	13.21	a
Water Frequency 2	45.50	a	14.99	a
Water Frequency 3	45.92	a	15.85	a
S	41.70	a	16.77	a
L	41.81	a	12.23	a
SL	46.10	a	15.00	a
Acer	29.57	c	5.57	c
Cercis	57.54	a	20.48	a
Tilia	42.40	b	17.93	b

* Treatments with different letters are significantly different between the same evaluation measure.

Table 3. Average of chemical analysis of each treatment and species

Treatments and Species	EC (mS/cm)		pH		NO_3 (ppm)	
Water Frequency 1	1.95	a*	5.2	a	139.4	a
Water Frequency 2	1.67	a	4.8	a	112.6	a
Water Frequency 3	1.86	a	5.1	a	139.6	a
S	0.71	b	5.3	a	61.8	b
L	2.39	a	4.8	a	153.7	a
SL	2.37	a	4.9	a	178.1	a
Acer	1.90	ab	4.7	b	155.2	a
Cercis	2.25	a	4.9	ab	123.2	a
Tilia	1.33	b	5.4	a	113.0	a

* Treatments with different letters are significantly different between the same evaluation measure.