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Retracting Statements: Tree Liner Production in Retractable-Roof Greenhouses (RRGs)

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Introduction

This article describes a study that began at The Ohio State University, Columbus, Ohio, in August 2002 and in September 2002 at Willoway Nurseries, Inc., Avon, Ohio. The research was led by graduate student Alison Stoven at Ohio State, under the guidance of Drs. Hannah Mathers and Dan Struve. The Willoway study was led by Dale Hammersmith, Liner and Pot-in-Pot Production Manager at Willoway, and Tom Demaline, President, Willoway Nurseries, Inc.

In nursery production, a "liner" refers to a small plant that is transplanted and grown on to become a larger plant. Tree liners are often referred to as whips. They are small trees, branched or unbranched, typically 4-ft. to 8-ft. tall and 1/2-in. to 3/4-in. in caliper. Liner shoots are one or two growing seasons old. Their root systems may be three- to six-years old, depending on the species and whether they have been grafted or budded. If they are produced from seed or tissue culture, the root system is generally the same age as the top.

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However, this is not always true; oaks, as an example, are produced from seed and may have three-year-old roots and one-year-old tops.

Traditionally, Midwestern and Eastern U.S. growers buy bareroot, field-grown whips, and transplant and grow these on to become caliper trees. These whips are harvested bare root, stored, and shipped by trucks to the Midwestern and Eastern states. Bareroot liner growers are progressive, and their years of experience and expertise in liner production should not be underestimated.

However, there is a place for a Retractable-Roof Greenhouse (RRG)-grown containerized liner based on price, availability, and niche markets, such as coarse-rooted and difficult-to-transplant taxa. RRG liners may also fit well in pot-in-pot production. Therefore, two years ago, in 2002, Willoway Nurseries, Inc., Avon, Ohio, started to experiment with growing tree liners for their own use.

The first year Willoway started production in a large polyhouse growing between 30 and 40 plant taxa. They wanted to assess liner production and determine what they were capable of producing before making a capital investment to purchase a specialized structure. Their first year of producing liners yielded good results.

Beginning in September 2002, Willoway was able to produce a RRG liner in a three-gallon container that was large enough to be shifted to a seven-gallon by September 2003. Willoway was mainly interested in using the RRG liners in their pot-in-pot operation; however, in 2002 and 2003, they have also placed some of their liners into field production for side-by-side comparison with bareroot tree liners. At Ohio State, we have also taken some of the liners produced from our 2003 study and are doing a similar replicated field trial. Results from the OSU field study should be available in winter 2006.

Obtaining Greater Control

In 2003, Willoway Nurseries constructed a RRG to begin container whip production. This decision coincided with Drs. Mathers and Struve, at The Ohio State University, approaching Willoway Nurseries to be a cooperator on the *Development of a Tree Liner Production System in Retractable-Roof Greenhouses.* This project was submitted to the United States Department of Agriculture and the Ohio Department of Agriculture, through the Ohio Nursery and Landscape Association (ONLA), for developing a tree liner production system using retractable-roof greenhouses.

The retractable-roof house design allows for the roof to retract 90%. The houses also use 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 in 2001 for the flat-roof houses averaged $1.00 per sq. ft; bare-bones peaked-roof houses, $3.00 per sq. foot.

Liner production in a RRG at Ohio State

Four taxa of trees were evaluated — *Acer* x *freemanii* 'Jeffersred' (Autumn Blaze™ red maple), *Malus* 'Prairifire' (Prairifire crabapple), *Cercis canadensis* (Eastern redbud), and *Quercus rubra* (red oak). The crabapples and maples were rooted tissue-culture cuttings that were grown in band-pots. The redbuds were bed-grown bareroot seedlings; the red oaks were grown from seed started in February at Ohio State. All plants except the oak were approximately one-year-old plants. They were approximately 12- to 18-in. tall with a 2- to 4-in. root system.

Rooted cuttings and seedlings were planted in Spinout-copper treated 250-XL containers (Nursery Supplies Inc., Chambersburg, Pa.) in February in a heated greenhouse at Ohio State University, Columbus. The medium was 510 MetroMix (O. M. Scotts & Sons, Marysville, Ohio), a soilless medium with a nutrient charge. In mid-March, the plants were taken to the Cravo retractable-roof structure and placed on heated mats (A. M. Leonard, Inc., Piqua, Ohio) set at 70°F. The objective of the heated mats was not to heat the house but to stimulate root growth and establishment without stimulating top growth. It was felt that by May, when light levels were sufficient to support vigorous top growth, the roots would be established and able to "push" vigorous shoots.

In mid-May, plants were upshifted into 3-gallon Spin-out® treated containers and spaced out. Harvests were conducted in May (for initial measurements), July, and October. At each harvest, height and caliper of a select number of trees were measured, and the entire plant was destructively harvested to obtain dry root and shoot weight. Trees were trained to

6-ft. bamboo stakes and a wired trellis system, pruned on a regular basis, and not allowed to develop lateral shoots until August.

The roof and sidewalls of the OSU Cravo were controlled by a MicroGrow control system (MicroGrow Systems, Temecula, Calif.). The MicroGrow controller operated according to outside air temperature. The roof remained open when the temperature was between 55°F and 85°F. If the outside temperature dropped below 55°F or went above 85°F, the roof closed. The sidewalls were programmed to close when the outside temperature dropped below 70°F.

These controller settings were chosen to provide optimum growing conditions through reduction of environmental stress such as high and low temperatures. In general, the sidewalls were open all summer to allow ventilation and wind movement to build tree caliper. Four data loggers were placed throughout the two environments to record air temperature, soil temperature, and light intensity on an hourly basis throughout the growing season.

Height, Caliper, and Root Growth at Ohio State

The tallest trees produced in the Cravo were the redbud (7.5′) followed by the red maple (7.1′). The maples had the largest caliper of any trees (0.65″). Root dry weights increased significantly from July to October for all four species. Most trees filled the three-gallon pots by October. In October, the tree with the largest root dry weight was maple (3.5 oz) in October; however, maple root mass was not significantly larger than oak or crabapple in July. The root dry weight of maple increased more than six times over the three months (0.5 oz in July, 3.5 oz in October). Many Ohio growers have expressed an interest in producing their own tree liners after seeing the 2003 Ohio State University results.

Growing in RRGs at Willoway Nurseries

In 2003 Willoway evaluated 84 taxa in its RRG that were potted in September of 2002. They felt that by potting in the fall, they could establish the plants, over winter them in the house, and have them ready to start growing in early April. This was quite different from the Ohio State study, where plants were started in early spring. A study beginning in fall 2004 at Ohio State will explore the Willoway fall planting timeline.

Willoway set the heaters to 32°F daytime and 28°F night temperatures for the winter. Willoway wanted the plants to go dormant for the winter but they did not want the pots to freeze solid. They tried to achieve a light crust of frost on the top of each container. With the aid of the end vents, they could maintain these temperatures even when the sun warmed up the house above freezing on sunny days.

The plan was to turn up the heat April 1, 2003; however, March was warmer than expected, so they decided to increase the heat in the house starting March 15 to 65°F daytime and 50°F night, providing a positive DIF. DIF was developed by Dr. Royal Heins, retired from Michigan State University, and is commonly used in greenhouse production. DIF refers to the difference between day and night temperatures. A positive DIF means the daytime temperatures are higher than the night temperatures. The reverse is true of negative DIF. These temperatures were maintained for one week.

On March 22 temperatures were increased to 75°F daytime and 65°F night until mid-May 2003. May 15 temperatures were lowered to 65°F daytime and 50°F night. Willoway indicates they are continuing to work with these temperature settings and adjustments in 2004.

In tree-liner production, keeping the trunk straight is extremely important. The trees in the Willoway and Ohio State trials are growing exceptionally fast. To keep them straight, Willoway and Ohio State used pencil thin, six-foot bamboo stakes and tied the trees to these stakes. Dale Hammersmith does not recommend using masking tape for tying; however, he uses a loose fitting tape that does not stick to the trunk. As side branches started to grow, Willoway would head these back, but not remove them. They believe the side branches were important to caliper development.

Caliper and Root Development at Willoway

Increasing caliper development is one of the most important goals in the studies at Willoway and Ohio State. The ability of the sidewalls to open allows for free air movement within the houses; this improves air circulation to reduce disease infestation and allows for tree movement which results in improved caliper development.

However, spacing can also be an important criterion in caliper development. Side branch development, which further aids in caliper enlargement, will not occur if the trees are spaced too close together. At Willoway, trees were placed can tight from the beginning of the trial (fall 2002) to May 1, 2003. On May 1, plants were spaced out to 12- to 18-in. centers to allow for greater side branch development. By September 30, 2003 (end of the trial), average calipers for most species were one inch. Willoway and Ohio State researchers considered these calipers to be very impressive.

Root masses were also excellent! For Willoway, most species filled the three-gallon copper-treated pots by September 1, 2003. Some species were up-shifted into seven-gallon containers. One species chosen for seven-gallon up-shifting was *Acer* 'Red Sunset.' The Red Sunsets were shifted from three- to seven-gallon pots on September 1, 2003. By October 30, 2003, the Red Sunsets' roots filled the seven-gallon containers as did the roots of several other species. Dale and Tom decided that in 2004 some species will go straight from three-gallon to 15-gallon pots.

Height Growth at Willoway

One of Willoway's objectives was to produce a healthy tree, five-feet high, by early July. Three different plants from a large number of taxa were selected, labeled, and heights were measured every two weeks starting on April 1 and continuing to July 3, 2003. Most taxa reached five feet by July 4, 2003.

In fact, some species, such as *Prunus, Taxodium, Betula,* and *Malus,* were so tall by June 10, 2003, that they needed to be moved outside the RRGs in order to slow their growth. Some species such as pin oaks *(Quercus palustris)* and sourgum *(Nyssa sylvatica)* did not make it to five feet by July 4, 2003, or even by August. Listed in Table 1 are the heights of *Acer* 'Autumn Blaze' taken during the course of the growing season.

Conclusions

Retractable-roof greenhouses have been described as a brand-new style of growing structure (Grey 2001). Retractable-roof

Table 1. Heights (inches) of Three Selected Plants of *Acer* 'Autumn Blaze' Recorded over the 2003 Growing Season at Willoway Nurseries, Inc., Avon, Ohio, in an Erie Greenhouse.

Acer 'Autumn Blaze'	Tree No. 1	Tree No. 2	Tree No. 3
Starting Height (April 2003)	15″	11.5″	10.5″
May 13, 2003	21″	19.75″	20.5″
June 5, 2003	36″	36.5″	38.25″
June 17, 2003	46.75″	45.5″	51.25″
July 3, 2003	66.5″	65.25″	73.75″

production allows for greater manipulation of the growing environment in winter, summer, and spring.

However, with any new system or structure, there is much to learn. For example, the optimum set points for the roof and the side-walls may be species specific. Which species do best in this production system and to what extent do container sizes, types, and growing media influence growth potentials are all key questions. However, we do know containerized liner production increases the number of species that can be grown and reduces production times.

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