Missouri Gravel Bed and a Pot-in-Pot System Superior to White Polyethylene and Foam for Overwintering *Syringa pubescens* subsp. *patula* Liners©

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The production of containerized nursery stock started in southern California because of its mild climate and long growing season (Whitcomb, 1987). As production of containerized stock moved into areas of the country with harsher climates, methods of overwintering were developed to protect plants from winter damage. Proper winter protection in the production of container-grown woody plants is crucial because a plant is no hardier than its root system (Patterson, 1936; Mathers, 2003). Unlike stems, roots exhibit little dormancy and can grow anytime soil temperatures permit (Romberger, 1963). Young roots tend to grow on the outside edge of the root ball in contact with the container wall. Because young roots are less hardy than mature roots, they are often the first to suffer winter injury (Mathers, 2003). When overwintering practices do not adequately protect young roots, new root regeneration in the spring is retarded resulting in plants that flush later and grow slower. To ensure that plants remain viable and marketable, overwintering protection must be adequate to protect plant roots from both extremely low and drastic fluctuations in temperature (Iles and others, 1993; Mathers, 2003).

The traditional method of overwintering container nursery stock is under white polyethylene coverings (Whitcomb, 2002; Mathers, 2003). Young and others (1987) found that covering plants with white polyethylene sheets could reduce temperature extremes. Later, Iles and others (1993) found that adding a thermo-blanket made of moderately translucent white polyethylene foam created an environment conducive to moderate plant root or shoot growth in late winter.

Pot-in-pot (PIP) production systems have also been tested as an overwintering method (Mathers, 2001). PIP systems originated in the south as a means of protecting roots from extreme summer temperature (Chong and Mathers, 1989). Because the liner-pot holding the plant is nested in a socket-pot placed permanently in the ground, the PIP system maintains soil temperatures on par with field production (Mathers, 2003). Initial costs associated with installing PIP systems are high; however, the savings accrued in reduced labor and materials from not having to cover plants with polyethylene sheets in the winter may offset these initial costs.

The Missouri Gravel Bed (MGB) is a recent innovation for liner production that utilizes a deep bed of gravel and hydroponics to produce plants that can be transplanted as bare-root stock in full leaf (Starbuck, 2000). Plants are removed from the gravel bed as needed throughout the growing season for planting in the field or shifted up to containers with outstanding survival (Gowdy, et al., 2003). Savings could be realized if the costly practice of stacking container-grown plant material under white polyethylene foam and polyethylene sheeting could be eliminated by overwintered plant liners in the MGB and then shifting up to marketable-sized containers in the spring. The objective of this study was to examine survival and growth of *Syringa pubescens* subsp. *patula* under three liner production methods (#1 and #2 containers and MGB) and three overwintering methods (MGB, PIP, and the traditional polyethylene foam and polyethylene sheets).

MATERIALS AND METHODS

We conducted the experiments at the University of Missouri Horticulture and Agroforestry Research Center near New Franklin, Missouri. In early May 2002, we planted 15-cm-tall rooted cuttings of *S. pubescens* subsp. *patula* 'Miss Kim' in #1 (3.8-L) and #2 (7.6-L) containers using a pine bark and peat moss potting medium. Pots were placed outdoors on raised wire benches in full sun with daily overhead irrigation. Concurrently, *S. pubescens* subsp. *patula* 'Miss Kim' liners were planted into a 2.4 m × 4.9 m × 0.45 m MGB consisting of a growing medium of 90 pea gravel : 10 sand (v/v). We irrigated individual plants for 3 min every 3 h during the day using inline drip emitters on a 0.3 m × 0.3 m spacing. We attached the lines to a submersible pump placed in a closed reservoir that captured the runoff and recirculated the irrigation water. Initially plants were given a side-dressing application of Osmocote® 13-13-13, 8–9 month slow-release (50 g/plant) followed by monthly applications of Peters® 20-20-20 water-soluble (3 g/plant) liquid fertilizer. Similar applications were done for the container stock. Because of persistent chlorosis in the MGB, we applied iron sulphate (1 g/plant) bimonthly to the rooting zone to help maintain a neutral pH (Kirk, Starbuck, and Van Sambeek, 2003). We pruned all the *S. pubescens* subsp. *patula* 'Miss Kim' liners in late May and again in early July to remove one-quarter of the top growth.

In October 2002, we shifted up half the liners grown in the #1 and #2 containers and the MGB. We planted liners to #5 liner pots (WhiteRidge, Inc., Reidsville, North Carolina) filled with a pine bark and peat moss potting medium. We placed liner pots in identical socket pots that had been sunk into an upland silty-clay-loam soil. Spacers made from polyvinyl chloride pipe 5 cm tall by 10 cm diameter were placed in the bottom of each socket-pot to prevent liner-pots from lodging in the sockets. The remaining S. *pubescens* subsp. *patula* 'Miss Kim' liners were overwintered uncovered in the MGB.

In mid-November 2002, we placed the other remaining half of the container-grown *S. pubescens* subsp. *patula* 'Miss Kim' liners under a 4 m × 4 m × 1 m semi-hoop-shaped structure made from three 1.3 m × 4.8 m #4-gauge galvanized-rod cattle panels placed atop a parameter of straw bales. The structure was then covered with a 0.6-cm thick closed-cell polyethylene foam Nursery Blanket (Hummert International™, Earth City, Missouri) and a single layer of 4-mil white polyethylene microfilm.

We monitored soil temperatures within the root zone at a depth of 15-cm in the MGB, at a depth of 12-cm in the center of the #5 liner in the PIP system, and the surface of the #2 containers under the white polyethylene foam and microfilm. We also monitored ambient air temperature above the MGB and inside the polyethylene-covered overwintering structure. Five thermocouples at each location were

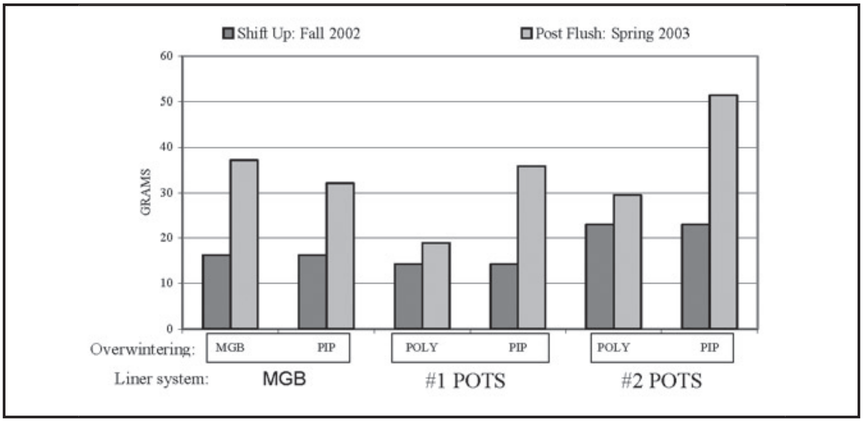

Figure 1. Total plant dry weights for *Syringa pubescens* subsp. *patula* 'Miss Kim'cuttings with three production and three overwintering methods. The 1% and 5% least significant differences are 6.4 and 4.7 g, respectively. Missouri gravel bed (MGB), pot-in-pot system (PIP).

connected to a Campbell 21X micrologger (Campbell Scientific, Inc., Logan, Utah) to record hourly temperatures. Minimum and maximum daily temperatures were determined for each sensor and averaged before plotting daily fluctuations.

In mid-May 2003 after the liners put on one flush of growth, we washed the soil or gravel from the roots of all plants. Roots and leafless shoots were dried separately at 50 ºC to determine shoot, root, and total plant dry weight. Root-to-shoot ratios (R : S) were calculated from dry weights. All data were subject to analysis of variance to determine if treatment differences existed at the 5% level and Fisher's unprotected least significant differences were calculated to separate statistically different means at the 1% and 5% levels.

RESULTS AND DISCUSSION

Syringa patula liners produced from rooted cuttings were larger after one growing season when grown in #2 containers than when grown in #1 containers or the MGB (Fig. 1). The largest liners after the spring flush where produced when liners from the #2 containers where shifted up to #5 containers and overwintered in a PIP system. Other liners that more than doubled total plant dry weight after the spring flush included liners grown in the MGB and overwintered in the MGB and liners grown in #1 containers and shifted up to #5 containers before overwintering in the PIP system. Liners that showed the smallest increase in total plant dry weights following the spring flush were those overwintered under white polyethylene foam and microfilm sheets.

Syringa pubescens subsp. *patula* 'Miss Kim' liners exhibited high R : S ratios after one growing season primarily in response to top pruning in May shortly after planting and again in early July after the second flush, especially liners grown in the MGB (Fig. 2). Statistically no differences existed in R : S ratios for liners harvested after the spring flush (Fig. 3); however, there was a trend for liners overwintered in the MGB or the PIP system to show the least change in R : S ratios. The largest changes occurred in R : S ratios for liners overwintered under white polyethylene foam and microfilm sheets. The large change in R : S ratio along with the small-

Figure 2. *Syringa pubescens* subsp. *patula* 'Miss Kim'1-year-old liner overwintered in the Missouri gravel bed.

est increase in total plant dry weight indicated there may have been a substantial loss of the fine root system. Alternatively, a small change in R : S ratio and substantial increase in dry weight could indicate that plant liners held in the MGB or PIP system over the winter had root systems that continued to develop during periods of mild weather from late fall through early spring.

Daily temperature under the white polyethylene foam and microfilm sheets fluctuated between -5 and 5 ºC when air temperatures ranged from -12 to 25 ºC (Fig. 4). Temperatures on the soil surface of container-grown stock also showed relatively large fluctuations until the soil froze. Temperatures within the center of the socket pots in the PIP system and the rooting zone of the MGB showed greater daily fluctuations than occurred in the pots under the white polyethylene sheets (Fig. 5). On relatively warm days in February, daily temperatures within the rooting zone of the MGB where higher than temperatures within the liner pots of the PIP system and may have been warm enough to allow for some root growth. An incomplete temperature record did not allow us to determine when soils may have warmed sufficiently to allow for root growth under the white polyethylene foam and microfilm sheets.

CONCLUSIONS

Our research indicates that overwintering plants in either the MGB or in a PIP system is superior to overwintering plants under white polyethylene foam and microfilm sheets. Production and overwintering of liners within the MGB may offer considerable cost savings to a nursery operator through more efficient water usage, use of an inexpensive reusable growth medium, and considerable labor savings. Labor savings result because plants in the MGB require less care than containerized stock, because there is a larger window of opportunity to step-up liners to better utilize a smaller workforce, and because intact plants can be easily pulled from the gravel for shipment as high-quality bare-root stock.

Although startup costs for a PIP system can be high, it also offers several advantages over the traditional white polyethylene foam and microfilm sheets for overwintering plants. By shifting up to large liner pots in the fall, root growth can occur under favorable soil conditions producing larger, more marketable plants in the spring. Individual plants in liner pots can be easily removed, transported, and marketed throughout the spring. In addition, the costly ordeal of covering contain-

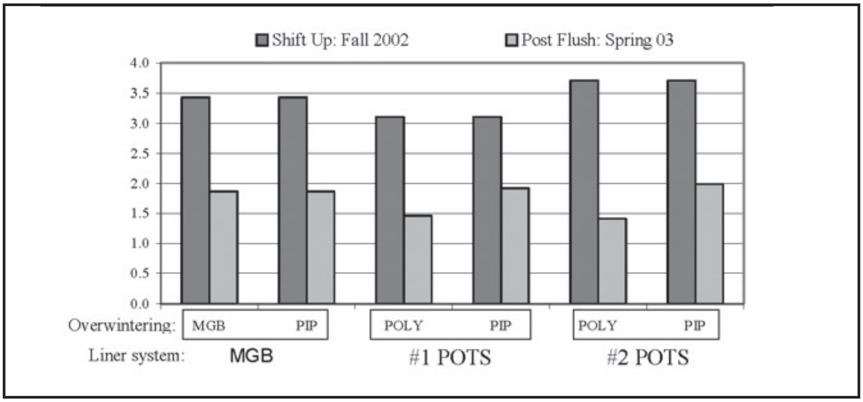

Figure 3. Root-to-shoot ratios for *Syringa pubescens* subsp. *patula* 'Miss Kim'cuttings grown under three production methods and after three approaches for overwintering liners. The 1% and 5% least significant differences are 1.23 and 0.91, respectively. Missouri gravel bed (MGB), pot-in-pot system (PIP).

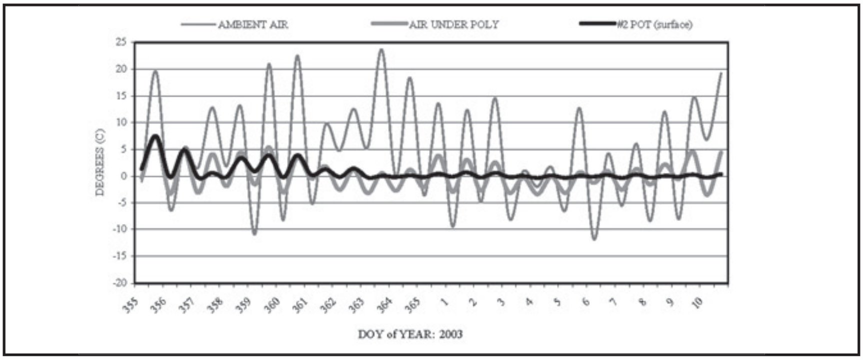

Figure 4. Daily temperature fluctuation over a 3-week period above and below polyethylene foam and microfilm sheets and on the soil surface of *Syringa pubescens* subsp. *patula* 'Miss Kim' liners in #2 upright containers. DOY = day of year.

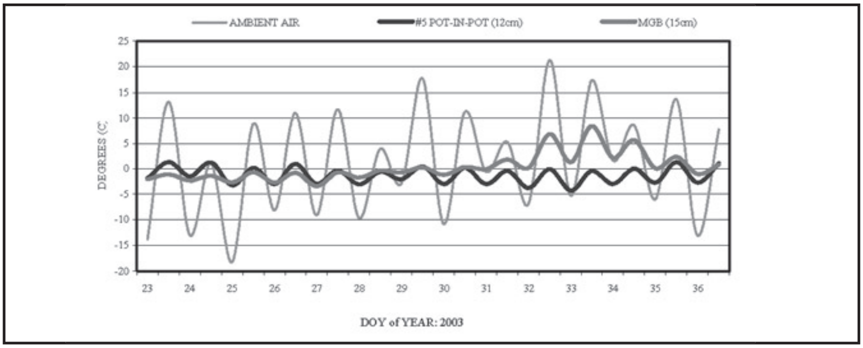

Figure 5. Daily temperature fluctuations over a 2-week period in the rooting zone of the Missouri Gravel Bed and the center of a #5 liner pot within the pot-in-pot system. DOY = day of year.

erized stock under white polyethylene foam and microfilm sheets is avoided.

By examining the data collected in the early winter when liners were first covered, we can assume the same fluctuations in soil temperature also occurred in late winter. This could likely indicate plants under white polyethylene may initiate some shoot as well as root development before they can be permanently uncovered in plant hardiness Zone 5. The resulting early growth while still under cover, apparently subjected the liners to considerable stress resulting in damage to fine roots and a reduced rate of growth. In contrast, it appears that plants in the PIP and the MGB maintained shoot dormancy until environmental conditions were appropriate for normal growth.

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