Seasonal Cold Hardiness Differences of Three Woody Plant Taxa during the Production Stage and as Established Landscape Plants[1]

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Abstract

Seasonal cold hardiness levels of Crape myrtle (*Lagerstroemia* L. 'Natchez'), Leyland cypress [x *Cupressocyparis leylandii* (A.B. Jacks. and Dallim.) Dallim. and A.B. Jacks.] 'Haggerston Gray' and Lacebark elm (*Ulmus parvifolia* Jacq. Allee™) were determined for nursery production and established landscape plants grown at the same location. Differences in cold hardiness between the growth treatments were taxon specific. During October, November and December, nursery-grown crape myrtle plants were up to 11°C (20°F) less cold hardy than those established in the landscape. Differences in Leyland cypress cold hardiness were detected, but were not as great as in crape myrtle. During October, November and December newly transplanted Leyland cypresses were from 3 to 6°C (5 to 11°F) less cold hardy compared to established landscape plants. Differences occurred between nursery production and established landscape plants of lacebark elm in January and February.

Index words: cold tolerance, crape myrtle, Leyland cypress, lacebark elm, nursery production, landscape establishment.

Species used in this study: Crape myrtle (*Lagerstroemia* L. 'Natchez'); Lacebark elm (*Ulmus parvifolia* Jacq. Allee™); Leyland cypress [x *Cupressocyparis leylandii* (A.B. Jacks. and Dallim.) Dallim. and A.B. Jacks.] 'Haggerston Gray'.

Significance to the Nursery Industry

Many plant taxa attain different levels of cold hardiness depending on the conditions under which they are grown. The cold hardiness of plants in the nursery production phase and plants of the same taxa established in the landscape at the same location were compared. Plant producers and growers should be aware that cold hardiness can vary for certain taxa, grown at the same location, depending on the taxa and their specific growing conditions. This can help growers to determine the timing and degree of frost protection necessary for successful production. Further, selected cultural strategies including nutrition and water restriction can be utilized to acclimate taxa like crape myrtle that grow late in fall.

Introduction

Differences in cold hardiness have been reported depending on plant taxa, plant environment, plant age, stage of development, and nutrient and water status (8, 9, 11). However, no consistent correlation exists between cold hardiness and the above-mentioned parameters. Age, for example, may have positive, negative or no correlation to cold hardiness, depending on the taxa studied (1, 2, 3, 4, 7).

Since no consistant relationship exists between plant cold hardiness and the physiological and environmental factors mentioned above, specific information is needed about the cold hardiness of taxa grown under different conditions. Two critical growing conditions for many plants produced are 1) in the nursery production phase and 2) when established in the landscape. Plants in the nursery production phase are at an earlier stage of development and are generally exposed to higher fertilization and water usage regimes as compared to plants established in the landscape. Therefore, the objective of our study was to compare the seasonal cold hardiness levels of three commercially important woody landscape plants, growing in the nursery production phase to those of the same taxa grown at the same location and established in the landscape.

Materials and Methods

Efforts were made to use plants that are similar to those grown in production nurseries and those established in the landscape. Stems of Leyland cypress were collected from two, and 10-year-old landscape plantings grown at the same location, (Griffin, Georgia). The plants were grown and cared for as described by Lindstrom et al. (10).

Stems from two- and eight-year-old 'Natchez' Crape myrtle were collected from containerized stock and established plantings grown at the same location (Athens, Georgia). The two-year-old plants were grown in 3-gal (11.4 l) containers, filled with equal parts of bark/peat/sand mixture, with the pH adjusted to 5–6. Scotts 20N-1.8P-5.8K-8S (20N-4-7-8) fertilizer was applied three times at recommended rates during the growing season. The eight-year-old plants were established in Cecil clay loam soil and no fertilizer was applied to the plants during the year of the experiment.

Stems from a two-year-old or a 40 to 45-year-old plant of Allee™ lacebark elm were collected from containerized stock and the established original plant grown at the same location (Athens, Georgia). The 40 to 45-year-old plant was established in compacted Cecil clay soil and no fertilizer was added during the course of the experiment. The two-year-old lacebark elms were container-grown as described above for crape myrtle.

Thirty-six uniform, 10 cm (4 in) long stem tips were removed from each plant on seven dates, October 31, November 28, December 12, 1990 and January 9, February 20,

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March 12 and April 19, 1991. Leaves were removed from the stems if present, except for Leyland cypress. Samples were wrapped in moist paper towels, put in plastic bags and then placed on ice for transport to the lab. Within four hours of collection the leaves and stems were prepared for freezing.

For the freezing test the terminal 7 cm (2.75 in) of each stem was removed, wrapped in moist cheesecloth and placed into a test tube (25 × 200 mm) (1 × 8 in). The tubes were then submerged in ethylene glycol-water solution (1:1) in a temperature bath precooled to –2 ± 0.5°C (28 ± 1°F).

Stem temperatures were measured by thermocouples placed next to the samples and recorded by a datalogger. Crushed ice crystals were applied to the wet cheesecloth to insure that samples did not undercool. The temperature of the samples was held constant at –2 ± 0.5°C (28 ± 1°F) for approximately 14 hours. Samples were then cooled at a rate of ≤ 4°C (7°F) per hour. Four stems of each taxon were removed from the bath at progressively lower 3°C (5°F) temperature intervals. Controls were prepared and kept at 4°C (39°F) for the duration of the freezing test.

After thawing at 4°C (39°F) overnight, the samples were removed from the tubes and placed in disposable, round, 100 × 15 mm (3.9 × 0.1 in) petri dishes containing filter paper saturated with water to maintain a 100 percent relative humidity. The petri dishes were placed on their sides at room temperature (22 ± 2°C) (72 ± 4°F) for 10–14 days. At this time the samples were visually evaluated for injury (5, 6, 13, 14, 15). Stem segments showing brown discoloration and breakdown of cells in the cambium and phloem were rated as dead. The controls and samples not injured by the freezing treatments remained green and showed no discoloration in the cambium or phloem. The number of stems killed at each temperature was recorded and from these data the lowest survival temperature (LST) was determined. The LST is the lowest temperature at which little or no injury is observed as described by Sakai et al. (12). In many cases, there was no variability between replicates when determining the LST for a specific cold hardiness determination. Where variability was present, the standard deviation was reported. The lack of variation between replicates can be explained based on use of individuals of a taxon which were uniform in nature, and the cold hardiness was also determined only within a 3°C (5°F) intervals.

Results and Discussion

Differences in cold hardiness between plants from the same location grown in the nursery production phase and those established in the landscape were time and taxon specific. Differences in cold hardiness between these two treatments ranged from 0 to 11°C (0 to 20°F) depending on the time and taxon of the year sampled (Table 1).

In crape myrtle, the largest differences in cold hardiness between container and established landscape plants occurred during the fall (Table 1). During October and November, established landscape plants were about 10°C (18°F) more cold hardy than those grown in containers. For the remaining sampling dates the established crape myrtle plants were from 1 to 3°C (2 to 5°F) more cold hardy than nursery grown plants.

Smaller differences in Leyland cypress cold hardiness were found between the cultural regimes. The cold hardiness differences between the nursery plants and those established in the landscape were the greatest in the fall and early winter (October, November and December) (Table 1). On these sampling dates, established plants were from 3 to 6°C (5 to 11°F) more cold hardy than the nursery production plants. During the late winter and early spring (January, February, March, and April) there were no significant differences between the two cultural regimes.

No significant differences in cold hardiness of lacebark elm were found between the treatments during October, November, December and March (Table 1). However, in midwinter (January and February) established plants were about 5°C (9°F) more cold hardy than nursery-grown plants.

The data reveal that younger nursery-grown plants attain less cold hardiness when compared to a plant of the same taxon established in the landscape. This is especially true for crape myrtle and Leyland cypress, particularly in the fall. Higher fertilization and soil moisture levels, in general, exist in nursery grown plants as compared to plants established in the landscape. These two factors can affect cold hardiness of woody plants (1, 2, 3, 4, 7, 11). This finding is also supported by nursery and field observations. After mild frosts on November 4–7, 1991 (–1 to 2°C, 30 to 29°F) in the Athens/Atlanta, Georgia area, frost damage was observed on *Lagerstroemia* taxa. Leaves and young stems were killed and bark split was evident in high fertility (400 lb actual N/Acre) plants. Damage did not occur on established landscape specimens of Crape myrtle (M. Dirr, personal communication).

Even though we cannot currently define the specific relationship between cultural treatments and cold hardiness, cold hardiness differences do exist between nursery production plants and established landscape plants grown at the same location for the three woody taxa studied. In addition, the differences that occur are specific to taxon and time of year.

Table 1. Lowest survival temperature (LST °C ± SD) of nursery grown and established in the landscape plants of Leyland cypress, lacebark elm, and crape myrtle. Cold hardiness evaluations were made monthly from October, 1990 to April, 1991.

	Leyland cypress		Lacebark elm		Crape myrtle	
Date	Nursery	Established	Nursery	Established	Nursery	Established
October 31	–9	–12	–11 ± 2	–11 ± 2	–3	–14 ± 2
November 28	–6	–11 ± 2	–16 ± 2	–16 ± 2	–6	–16 ± 2
December 12	–9	–15	–29 ± 2	–27	–22 ± 2	–24
January 09	–18	–18	–26 ± 2	–30[z]	–24	–25 ± 2
February 20	–17 ± 2	–18	–14 ± 2	–19 ± 2	–15	–18
March 12	–12	–14 ± 2	–16 ± 2	–19 ± 2	–16 ± 2	–17 ± 2
April 19	–9	–9	—	—	–9	–12

[z]Lower limit of freeze test; all replications survived this exposure.

Plant producers and landscapers should be aware that 'Natchez' crape myrtle and 'Haggerston Gray' Leyland cypress nursery production plants do not harden as quickly as established landscape plants. The large difference in cold hardiness between the two growing treatments of Leyland cypress and crape myrtle suggests reducing the amount of fertilizer and/or water used in the production stage may increase fall cold hardiness or the need to offer earlier winter protection for these plants if high fertilization rates are used.

Literature Cited

1. Batchelor, L.D. 1922. Winter injury to young walnut trees during 1921-22. Colo. Agr. Expt. Sta. Circ. 234:1–5.

2. Brown, G.N. and J.A. Bixby. 1976. Relationship between black locust seedling age and induction of cold hardiness. For. Sci. 22:208–210.

3. Chandler, W.H. 1919. Winter injury in New York state during 1917–1918. Proc. Amer. Soc. Hort. Sci. 15:18–24.

4. Cochran, P.H. and C.M. Bernstein. 1973. Tolerance of lodgepole and ponderosa pine seedlings to low night temperatures. For. Sci. 19:272–280.

5. Fuchigami, L.H., C.J. Weiser, and D.R. Evert. 1971. Induction of cold acclimation in *Cornus stolonifera* Michx. Plant Physiol. 47:98–103.

6. Hummel, R.L., P.D. Ascher, and H.M. Pellett. 1982. Inheritance of the photoperiodically induced cold acclimation response in *Cornus sericea* L., red-osier dogwood. Theor. Appl. Genet. 62:385–394.

7. Larcher, Von W., H. Bauer, G. Bendetta, J. Harrasser, H.Hilschler and B. Mair. 1969. Anwendung und Zuverlössigkeit der Tetrazoliummethode zur Feststellung von Schäden in pflanzlichen Gewebe. Mikroskopie 25:207–218.

8. Levitt. J. 1956. The Hardiness of Plants. Academic Press, New York, NY. 278 p.

9. Levitt, J. 1980. Responses of Plants to Environmental Stresses. 2nd ed. Academic Press, New York, NY. 497 p.

10. Lindstrom, O.M., D.J. Moorhead, and G.W. Kent. 1989. Propagation and care of Leyland cypress Christmas trees. Georgia Coop. Ext. Service Misc. Publ. 350, 7 p.

11. Pellett, H.M. and J.V. Carter. 1981. Effect of nutritional factors on cold hardiness of plants. Hort. Rev. 3:144–171.

12. Sakai, A., L. Fuchigami, and C. J. Weiser. 1986. Cold hardiness in the genus *Rhododendron*. J. Amer. Soc. Hort. Sci. 111:273–280.

13. Smithberg, M.H. and C.J. Weiser. 1968. Patterns of variation among climatic races of red-osier dogwood. Ecology 49:495–505.

14. Stergios, B.G. and G.S. Howell, Jr. 1973. Evaluation of viability tests for cold stressed plants. J. Amer. Soc. Hort. Sci. 98:325–330.

15. van Huystee, R.B., C.J. Weiser and P. H. Li. 1967. Cold acclimation in *Cornus stolonifera* under natural and controlled photoperiod and temperature. Bot. Gaz. 128:200–205.