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Stem and Leaf Hardiness of 12 *Abelia* Taxa[1]

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Abstract

Twelve taxa of *Abelia* were evaluated using laboratory procedures to determine maximum stem and leaf hardiness and to evaluate timing of acclimation and deacclimation over a two-year period. Among the 12 *Abelia* taxa evaluated, 'John Creech' was among the hardiest taxa for both stems and leaves on the majority of test dates. Stems and leaves of 'John Creech' survived to at least –26C (–15F) and –21C (–6F), respectively, in January 2001. 'Edward Goucher' and 'Confetti' had the least hardy stems and leaves, respectively. Stems of 'Edward Goucher' survived to at least –16C (3F) in January 2000, and 'Confetti' leaves survived to only –14C (7F) in December 2000. *Abelia* ×*grandiflora* consistently ranked among the first to attain cold hardiness in the fall and among the last to lose cold hardiness in the spring in both test seasons. Stems were equal in hardiness or hardier than leaves on the majority of test dates in both test seasons. Laboratory results were consistent with field observations, but often differed from published hardiness ratings. Differences in lowest survival temperatures and attainment and retention of cold hardiness closely followed temperature fluctuations just prior to sampling dates.

Index words: cold tolerance, acclimation, deacclimation, *Abelia*.

Taxa used in this study: *A. chinensis* R. Br., *A.* 'Edward Goucher'; *A.* ×*grandiflora* (André) Rehd.; *A.* ×*grandiflora* 'Compacta'; *A.* ×*grandiflora* 'Confetti'; *A.* ×*grandiflora* 'Francis Mason'; *A.* ×*grandiflora* 'Golden Glow'; *A.* ×*grandiflora* 'John Creech'; *A.* ×*grandiflora* 'Little Richard'; *A.* ×*grandiflora* 'Prostrata'; *A.* ×*grandiflora* 'Sherwoodii'; and *A. zanderi* (Graebn.) Rehd.

Significance to the Nursery Industry

Abelia are limited in their range of adaptability due more to cold than any other environmental factor. The northern distribution of *Abelia* is limited by both stem and leaf hardiness. *Abelia* ×*grandiflora*, Glossy Abelia, is appealing in the landscape due to its dark, lustrous, evergreen foliage. However, it becomes semi-evergreen in more northern climates, and the plants are not reported to be hardy below –20C (–4F). Evaluations of 12 *Abelia* taxa for stem and leaf hardiness in the southeastern United States revealed that 'John Creech' was consistently among the most cold hardy taxa for both stems and leaves during the majority of tests. 'Edward Goucher' and 'Confetti' had the least hardy stems and leaves, respectively. Midwinter hardiness and timing of acclimation and deacclimation are important criteria for the selection of plant materials for landscapes and parental germplasm for cultivar development. Cold hardiness data indicate 'John Creech' would make a logical choice for incorporation into a breeding program or landscape design if a cold-hardy taxon is needed.

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Introduction

The genus *Abelia* contains 30 species that vary in many traits including cold hardiness, flower color, and growth habit (3, 9, 11). *Abelia* ×g*randiflora* (André) Rehd. is widely used in the landscape because of its prolific floral displays of pinkish-white flowers and glossy semi-evergreen to evergreen foliage (3, 6, 11). However, it becomes semi-evergreen in more northern climates, and the plants are not reported to be hardy below –20C (–4F) (2, 4, 6, 8, 11, 18). The universal problem of freeze damage is of major economic importance even in subtropical regions (5, 19). Breeders are concerned with the cold acclimation of woody plants because cold, more than any other environmental factor, limits the use of plants (7). Interspecific hybridization among various taxa of *Abelia* R. Br. offers the potential for new cultivars with improved cold hardiness.

Hardiness ratings are available for a number of species of *Abelia*, but these ratings are based on field observations in a few locations and may not be applicable to different geographic regions (2, 4, 6, 8, 11, 16, 18). Studies conducted by Lindstrom and Dirr (13) have indicated a strong correlation between cold hardiness observed in the field and laboratory tests when plants were evaluated on multiple dates. Cold hardiness evaluations are needed for selection of superior parental germplasm and assurance of improved hardiness among progeny. The objective of this study was to evaluate 12 taxa of *Abelia* for stem and leaf cold hardiness.

Materials and Methods

Twelve taxa of *Abelia* (Tables 1–4) were evaluated for stem and leaf cold hardiness. Two deciduous species, *A. chinensis* R. Br. and *A. zanderi* (Graebn.) Rehd., and the evergreen species, *A.* ×g*randiflora* (André) Rehd., were evaluated. *Abelia* 'Edward Goucher', a cross between *A.* ×g*randiflora* and *A. schumannii*, and eight *A.* ×g*randiflora* cultivars, 'Compacta', 'Confetti', 'Francis Mason', 'Golden Glow', 'John Creech', 'Little Richard', 'Prostrata', and 'Sherwoodii', were also evaluated. All taxa were obtained from commercial sources and public arboretums. A specimen of *A.* ×g*randiflora*, unknown origin, was collected from the University of Georgia campus, Athens, GA, and included in the study.

Each representative of the 12 taxa was clonally propagated and grown in a #1 (3.8 liter) container. Eight plants of each taxon, except *A.* ×g*randiflora* 'Confetti' and *A. zanderi*, were planted into a field in Griffin, GA, in a completely randomized design in mid-September 1998. 'Confetti' and *A. zanderi* were added to the plot in preassigned locations within the completely randomized design in mid-October 1999. The research plot was located under a canopy of pecan trees [*Carya illinoinensis* (Wangenh.) C. Koch], drip irrigated as needed, and fertilized twice per year.

As described by Lindstrom and Dirr (13), 40 uniform stem tips, each approximately 10 cm (4 in) in length, were randomly collected from among the eight plants of each taxon on October 16, November 13, and December 11, 1999; January 8, February 12, March 11, October 17, November 14, and December 13, 2000; and January 16, February 13, March 13, and April 17, 2001, and prepared for testing within two hours of collecting. To prepare the stems and leaves for freezing, the terminal 7 cm (2.8 in) were removed, and leaves, if present, were removed from the stems. Following preparation, stem and leaf samples within each taxon were uniformly mixed. Four stems and leaves of each taxon were wrapped in cheesecloth and placed in a 25 × 200 mm test tube (1 × 8 in). A total of 9 test tubes per taxon (4 reps per test tube) were prepared. Tubes were then submerged in an ethylene glycol-water solution (1:1) in a Forma Scientific Model 2425 temperature bath (Forma Scientific, Marietta, OH) precooled to –2C ± 0.5 (28F ± 1). Controls (n = 4) were prepared and kept at 4C (39F) for the duration of the freezing test.

Stem and leaf temperatures were measured by thermocouples placed next to the samples and recorded by a Campbell Scientific datalogger (Model CR7-X, Campbell Scientific, Inc., Logan, UT). Crushed ice crystals were applied to the wet cheesecloth of stem and leaf samples to insure that the samples did not undercool. Temperature of the samples was held constant at –2C ± 0.5 (28F ± 1) for approximately 14 hrs. Samples were then cooled at a rate of not greater than 4C (7F) per hour. Four stems and leaves of each taxon were removed from the bath at progressively lower 3C (5F) intervals.

Frozen samples were allowed to thaw overnight at 4C ± 2 (39F ± 4). Samples were then removed from the tubes and placed in disposable, round, 100 × 15 mm (3.9 × 0.6 in) petri dishes containing filter paper saturated with distilled water to maintain 100 percent relative humidity. The petri dishes were placed on their sides in the dark at 22C ± 2 (72F ± 4). After 7–10 days, samples were visually evaluated for injury. Stems and leaves showing brown discoloration and breakdown of cells in the cambium and phloem were rated as dead. Browning was observed with the naked eye and with the aid of a stereomicroscope when needed. Controls and samples not injured in the freezing tests were identified by green coloration or no discoloration or no breakdown of cells in the cambium and phloem. The number of stems and leaves killed at each temperature was recorded and from this data the lowest survival temperatures (LSTs) were determined for each taxon. The LST is the lowest test temperature at which survival was observed (15). In many cases, no variability was observed among replicates when determining the LST. Where variability was present, the LST was calculated as the mean of the lowest temperature at which individual stem samples exhibited no injury. Standard deviations were calculated when variability was observed. The sensitivity of the laboratory evaluation detected only cold hardiness differences greater than 3C (5F). The lower limit of the freeze bath was –27C (–17F) on all test dates.

Monthly LSTs were compared within and between test seasons among both species and cultivars to assess timing of acclimation and deacclimation and to determine maximum stem and leaf hardiness. Among species, the timing of acclimation and deacclimation of stems only were evaluated due to the deciduous nature of *A. chinensis* and *A. zanderi*. Timing of acclimation and deacclimation for both stems and leaves were assessed for cultivars.

Results and Discussion

Stem hardiness of species. Mid-winter cold hardiness was similar for all three species (Table 1). The mean lowest survival temperature was –26C (–15F) for *A. chinensis* in December 1999, and –25C (–13F) for *A. zanderi* and for *A.* ×g*randiflora* in February 2000. Published reports of hardiness ratings for *A. chinensis*, *A.* ×g*randiflora*, and *A. zanderi* range from zone 6 to 8, zone 5 to 7, and zone 5 to 6, respectively, depending on the authority (2, 4, 6, 8, 11, 18). Dirr (6)

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Table 1. Mean lowest survival temperatures (LST C ± SE) for stems of 3 *Abelia* species from October 1999 to April 2001 (n = 4).

	Date													
	Oct 1999	Oct 2000	Nov 1999	Nov 2000	Dec 1999	Dec 2000	Jan 2000	Jan 2001	Feb 2000	Feb 2001	March 2000	March 2001	April[z] 2000	April 2001
Deciduous species														
A. chinensis	C[y]	–9.8[†]	–12.8[†]	–9.8[†]	–25.5[††]	–23.3[†]	–23.3[†]	–21.8[†]	–24.0	–15.8[†]	C[y]	C[y]	—	C[y]
A. zanderi[x]	—	–3.8[†]	–15.8[†]	–9.8[†]	–24.8[†]	–20.3[†]	–20.3[†]	–23.3[†]	–25.5[††]	–15.8[†]	C[y]	–9.8[†]	—	–1.5[††]
Evergreen species														
A. ×g*randiflora*	–1.5[††]	–6.8[†]	–9.8[†]	–13.5[††]	–22.5[††]	–21.8[†]	–18.8[†]	–19.5[††]	–24.8[†]	–15.8[†]	–3.8[†]	–6.8[†]	—	–3.0

[z]Test not conducted in April of the first test season.

[y]Only control (C) survived.

[x]Added to the study after the first test date, October 16, 1999.

[†]Standard deviation of 1.5.

[††]Standard deviation of 1.7.

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reports that *A. chinensis* will survive to zone 5 as a herbaceous perennial.

Across all test dates, no species was consistently more cold hardy than the others. However, differences in deacclimation were observed. During the first test season, *A.* ×g*randiflora* retained cold hardiness in March, surviving to –4C (25F), while only the controls survived for the other species. In the second test season, both *A. zanderi* and *A.* ×g*randiflora* retained some hardiness through the April test date, but *A. chinensis* lost all cold hardiness in March.

A comparison of test seasons reveals that in the second season, *A. chinensis* and *A.* ×g*randiflora* developed cold hardiness in October, reaching –10C (14F) and –7C (19F), respectively. In the first test season, *A. chinensis* had no cold hardiness in October and *A.* ×g*randiflora* was hardy to only –2C (20F). In February 2000, all species survived to at least –24C (–11F), but in February 2001, they survived to only –16C (3F).

Leaf hardiness of species. In January 2001, leaves of *A.* ×g*randiflora* survived to –23C (–9F). This was the lowest survival temperature observed among these species (Table 2). During the first test season, leaves of *A. chinensis* and *A. zanderi* abscised following the January test date. Mean low temperatures were lower in October of the second test season resulting in the abscission of *A. chinensis* leaves after the November test date. Despite colder temperatures in year two, *A. zanderi* did not defoliate, and only the controls survived the March and April sampling dates.

Stem hardiness of cultivars. 'John Creech' was consistently among the most cold hardy plants on 10 out of 13 of the test dates (Table 3). Stems of 'John Creech' survived to approximately –23C (–9F) in February 2000 during the first test season and approximately –26C (–15F) in January 2001 of the second test season. Other cultivars that were relatively cold hardy on most test dates were 'Compacta' and 'Little Richard'. On the other hand, 'Edward Goucher' was consistently among the least cold hardy cultivars on nearly all the test dates. The mean lowest survival temperature recorded for 'Edward Goucher' in both seasons was –16C (3F), which occurred in January 2000 and in December 2000. Depending on the reference, 'Edward Goucher' has been reported hardy to zone 5 or 6 (6, 8, 11). It was expected that 'Edward Goucher' would be among the least hardy taxa based upon its parentage. It is an interspecific hybrid between *A.* ×g*randiflora* and *A. schumannii*. Published hardiness rankings, based on field observations, vary for both *A.* ×g*randiflora* and *A. schumannii*. *A.* ×g*randiflora* is reported hardy from zone 5 to zone 7, and hardiness rankings for *A. schumannii* range from zone 6 to zone 8 (2, 4, 6, 8, 11, 18).

During the first test season, acclimation of most cultivars was not detected until November, with only 'Francis Mason' and 'Golden Glow' surviving the freezing test in October

Table 2. Mean lowest survival temperatures (LST C ± SE) for leaves of 3 *Abelia* species from October 1999 to April 2001 (n = 4).

	Date													
	Oct 1999	Oct 2000	Nov 1999	Nov 2000	Dec 1999	Dec 2000	Jan 2000	Jan 2001	Feb 2000	Feb 2001	March 2000	March 2001	April[z] 2000	April 2001
Deciduous species														
A. chinensis	C[y]	–1.5[††]	–4.5[††]	–2.3[†]	–7.5[††]	—[x]	–13.5[††]	—[x]	—[x]	—[x]	—[x]	—[x]	—	—[x]
A. zanderi[w]	—	C[y]	C[y]	C[y]	–6.8[†]	–15.8[†]	–12.8[†]	–12.8[†]	—[x]	–4.5[††]	—[x]	C[y]	—	C[y]
Evergreen species														
A. ×g*randiflora*	C[y]	–0.8[†]	–8.3[†]	–4.5[††]	–12.8[†]	–6.8[†]	–9.8[†]	–23.3[†]	–9.8[†]	–15.8[†]	–3	–7.5[††]	—	–4.5[††]

[z]Test not conducted in April of the first test season.

[y]Only control (C) survived.

[x]Leaves had abscised by the given test date.

[w]Added to the study after the first test date, October 16, 1999.

[†]Standard deviation of 1.5.

[††]Standard deviation of 1.7.

Table 3. Mean lowest survival temperatures (LST C ± SE) for stems of 9 *Abelia* cultivars from October 1999 to April 2001.

	Date													
Cultivar	Oct 1999	Oct 2000	Nov 1999	Nov 2000	Dec 1999	Dec 2000	Jan 2000	Jan 2001	Feb 2000	Feb 2001	March 2000	March 2001	April[z] 2000	April 2001
'Compacta'	C[y]	–6.8[†]	–11.3[†]	–9.8[†]	–19.5[††]	–21.8[†]	–18.0	–23.3[†]	–22.5[††]	–19.5[††]	–3.0	–9.0	—	–3.8[†]
'Confetti'[x]	—	–4.5[††]	–3.8[†]	–9.0	–19.5[††]	–22.5[††]	–21.0	–22.5[††]	–19.5[††]	–14.3[†]	–4.5[††]	–8.3[†]	—	C[y]
'Edward Goucher'	C[y]	–3.8[†]	–2.3[†]	–6.0	–8.3[†]	–15.8[†]	–16.5[††]	–12.8[†]	–15.8[†]	–12.8[†]	–3.8[†]	–6.8[†]	—	–1.5[†]
'Francis Mason'	–1.5[††]	–4.5[††]	–3.8[†]	–8.3[†]	–15.0	–21.8[†]	–12.8[†]	–21.8[†]	–22.5[††]	–12.8[†]	–2.3[†]	–6.0	—	C[y]
'Golden Glow'	–0.8[†]	–5.3[†]	–4.5[††]	–9.8[†]	–13.5[††]	–18.8[†]	–17.3[†]	–22.5[††]	–15.8[†]	–4.5[††]	–2.3[†]	–7.5[††]	—	–0.8[†]
'John Creech'	C[y]	–4.5[††]	–4.5[††]	–13.5[††]	–19.5[††]	–21.8[†]	–21.8[†]	–25.5[††]	–23.3[†]	–22.5[††]	–6.8[†]	–9.0	—	C[y]
'Little Richard'	C[y]	–6.8[†]	–9.8[†]	–12.8[†]	–16.5[††]	–21.8[†]	–23.3[†]	–21.8[†]	–22.5[††]	–15.8[†]	–2.3[†]	–6.0	—	–1.5[††]
'Prostrata'	C[y]	–6.8[†]	–12.8[†]	–10.5[††]	–17.3[†]	–22.5[††]	–17.3[†]	–24.8[†]	–17.3[†]	–11.3[†]	–3.0	–9.0	—	C[y]
'Sherwoodii'	C[y]	–6.8[†]	–6.8[†]	–9.8[†]	–15.8[†]	–21.8[†]	–16.5[††]	–24.0	–19.5[††]	–14.3[†]	–2.3[†]	–7.5[††]	—	C[y]

[z]Test not conducted in April of the first test season.

[y]Only control (C) survived.

[x]Added to the study after the first test date, October 16, 1999.

[†]Standard deviation of 1.5.

[††]Standard deviation of 1.7.

1999. In October of the second test season, however, all cultivars survived to at least –4C (25F), and 'Compacta', 'Little Richard', 'Prostrata', and 'Sherwoodii' survived to approximately –7C (19F). LSTs of stems were either similar or lower on all sampling dates during the second test season relative to the corresponding test date in the first test season, with the exception of the January and February sampling dates.

Leaf hardiness of cultivars. As was observed with stems, leaves of 'John Creech' were consistently cold hardy, having among the lowest LSTs of all cultivars on 9 out of 13 of the test dates (Table 4). The LST recorded for 'John Creech' was –21C (–6F) in January 2001. On the other hand, 'Confetti' leaves were among the least hardy on 8 out of 12 test dates; the lowest LST observed was –14C (–7F) in December 2000. Among the remaining cultivars, mean LSTs ranged between –16C (3F) and –19C (–2F), and all were recorded in January 2001.

Leaves vs. stems. Stems of all evergreen taxa generally had lower LSTs than leaves (Tables 1–4). The majority of occasions when leaves had lower LSTs occurred as plants were acquiring cold hardiness in October 1999 and as plants began to lose hardiness in March 2000 and April 2001. During the midwinter test dates of December through February, only two instances occurred where leaves had lower LSTs than stems: *A.* ×*grandiflora* and 'Edward Goucher' in January 2001. Field observations revealed that evergreen taxa often appeared semi-evergreen during the midwinter months, but plant survival was not affected by leaf hardiness.

Temperature effects. Temperature is a major factor controlling a plant's ability to acclimate, deacclimate, and ultimately develop maximum cold hardiness (5, 12). Several authors have reported that variations in cold hardiness throughout the fall, winter, and early spring months are correlated to temperature fluctuations. An empirical cold hardiness model developed by Anisko et al. (1) to explain the effect of temperature on cold hardiness demonstrates that a plant's ability to harden and deharden in response to fluctuating temperatures is modulated by the accumulation of heat and chill hours. Pellett et al. (17) reported rapid dehardening of flower buds of Flame Azalea (*R. calendulaceum* (Michx.) Torr.), Roseshell Azalea (*R. prinophyllum* (Small) Millias) and Swamp Azalea (*R. viscosum* (L.) Torr.) in response to increases in air temperature just prior to the testing dates.

Table 4. Mean lowest survival temperatures (LST C ± SE) for leaves of 9 *Abelia* cultivars from October 1999 to April 2001.

	Date													
Cultivar	Oct 1999	Oct 2000	Nov 1999	Nov 2000	Dec 1999	Dec 2000	Jan 2000	Jan 2001	Feb 2000	Feb 2001	March 2000	March 2001	April[z] 2000	April 2001
'Compacta'	–0.8[†]	C[y]	C[y]	–4.5[††]	–10.5[††]	–15.8[†]	–11.3[†]	–15.8[†]	–15.8[†]	–14.3[†]	–0.8[†]	–4.5[††]	—	–1.5[††]
'Confetti'[x]	—	C[y]	–2.3[†]	C[y]	–3.8[†]	–14.3[†]	–5.3[†]	–10.5[††]	C[y]	–6.8[†]	C[y]	C[y]	—	C[y]
'Edward Goucher'	C[y]	–0.8[†]	C[y]	–3.8[†]	–3.8[†]	–15.8[†]	–9.8[†]	–18.0	–13.5[††]	–2.3[†]	–3.8[†]	C[y]	—	C[y]
'Francis Mason'	C[y]	–1.5[††]	C[y]	–3.8[†]	–12.8[†]	–9.8[†]	–9.8[†]	–18.8[†]	–14.3[†]	–13.5[††]	–1.5[††]	–4.5[††]	—	–3.8[†]
'Golden Glow'	–0.8[†]	–1.5[††]	C[y]	–5.3[†]	–9.8[†]	C[y]	–13.5[††]	–16.5[††]	–12.8[†]	–5.3[†]	–2.3[†]	–0.8[†]	—	–0.8[†]
'John Creech'	–0.8[†]	–3.8[†]	–4.5[††]	–7.5[††]	–9.8[†]	–15.8[†]	–13.5[††]	–21.0	–13.5[††]	–14.3[†]	–11.3[†]	C[y]	—	–0.8[†]
'Little Richard'	C[y]	C[y]	–0.8[†]	–0.8[†]	–0.8[†]	–7.5[††]	–11.3[†]	–18.8[†]	–15.8[†]	–10.5[††]	–2.3[†]	–7.5[†]	—	–3.8[†]
'Prostrata'	–0.8[†]	C[y]	C[y]	–6.8[†]	–9.0	–11.3[†]	–9.8[†]	–15.8[†]	–12.0	–12.0	–2.3[†]	–6.0	—	–3.0
'Sherwoodii'	C[y]	–1.5[††]	–2.3[†]	–4.5[††]	–7.5[††]	–13.5[††]	–12.8[†]	–16.5[††]	–10.5[††]	–0.8[†]	C[y]	–5.3[†]	—	C[y]

[z]Test not conducted in April of the first test season.

[y]Only control (C) survived.

[x]Added to the study after the first test date, October 16, 1999.

[†]Standard deviation of 1.5.

[††]Standard deviation of 1.7.

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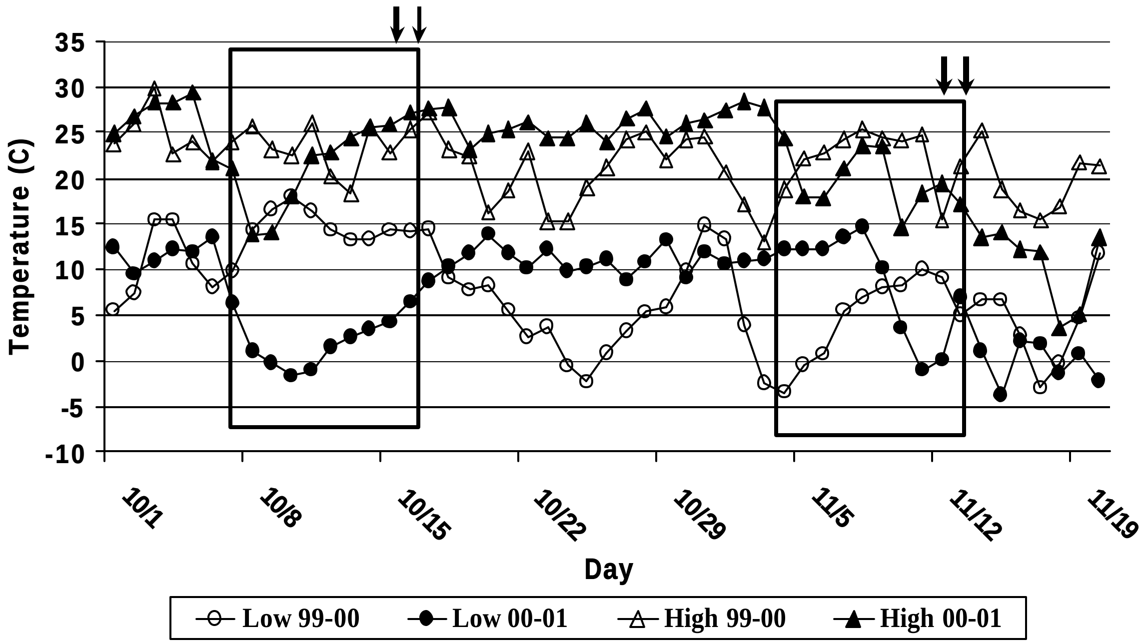

Fig. 1. Low and high temperatures for the period of October 1, 1999, through November 20, 1999, and October 1, 2000, through November 20, 2000. Arrows indicate the sampling dates. Boxes indicate the 10-day period prior to the sampling date.

Significant correlations were reported between the LSTs of grapevine buds and the mean maximum and average temperatures that the grapevines were exposed to prior to sampling throughout the winter season (10). However, significant correlations between mean minimum temperature and cold hardiness were only found during midwinter.

In the present study, differences in monthly LSTs, as well as timing of acclimation and deacclimation both among and within taxa can be attributed to differences in high and/or low temperatures 7 to 10 days prior to the test dates (Figs. 1–3). The mean high and low temperatures were lower during the second test season for all sampling periods except February. The minimum temperature was nearly 20C (33F) lower one week prior to the test date in October 2000 than October 1999 (Fig. 1). The average low temperatures were 11.4C (20.5F) lower in the 10 days preceding the October 2000 sampling date than in October 1999 (Fig. 1), but average high temperatures were only 0.8C (1.4F) lower. Stems of all taxa were more hardy in October 2000 than October 1999 and decreases in LSTs of 3 to 10C (5 to 17F) were recorded.

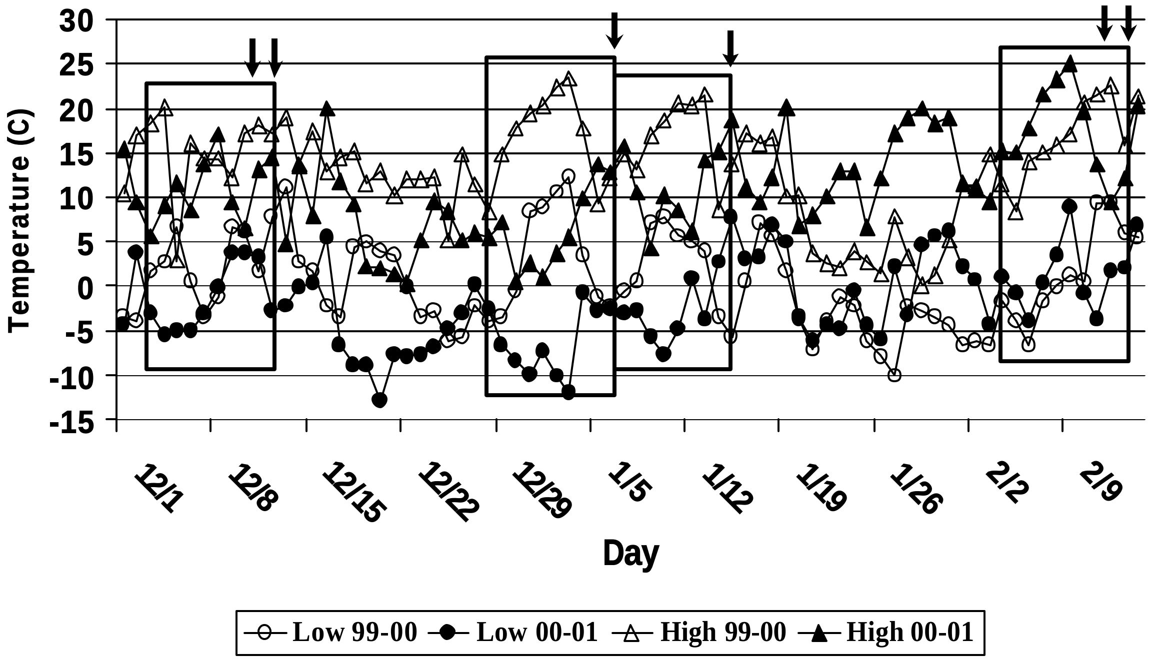

Fig. 2. Low and high temperatures for the period of December 1, 1999, through February 12, 2000, and December 1, 2000, through February 12, 2001. Arrows indicate the sampling dates. Boxes indicate the 10-day period prior to the sampling date.

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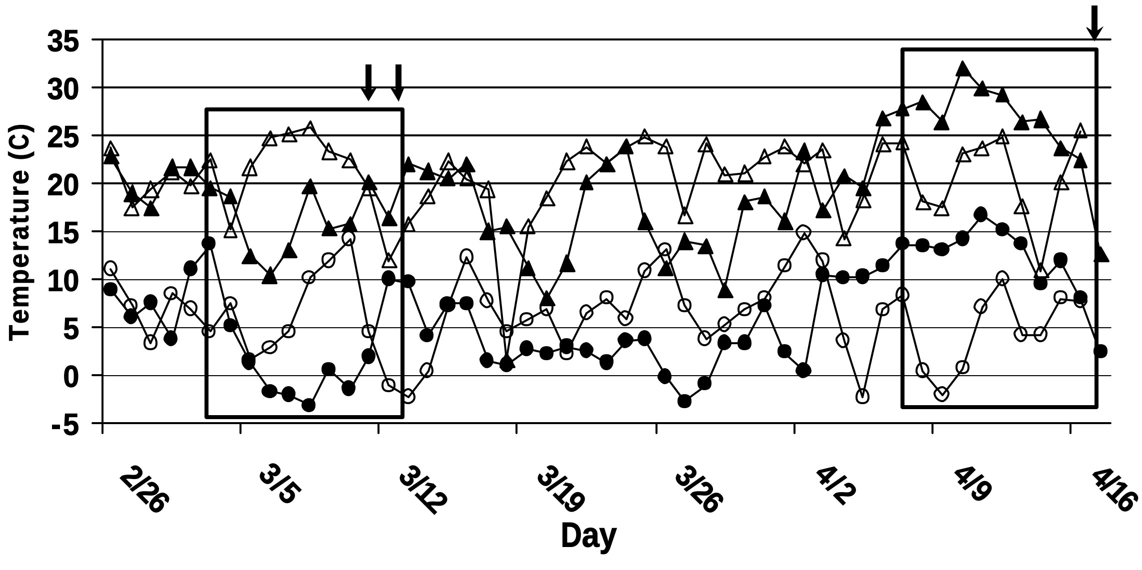

Fig. 3. Low and high temperatures for the period of February 26, 2000, through April 17, 2000, and February 26, 2001, through April 17, 2001. Arrows indicate the sampling dates. Boxes indicate the 10-day period prior to the sampling date.

In February 2001, the stem LSTs recorded were 3 to 11C (5 to 18F) higher than the stem LSTs recorded in February 2000. Mean high and low temperatures in February 2000 were 2.2C (3.9F) and 2.4C (4.3F) lower, respectively, during the 10 days preceding the sampling date than in February 2001 (Fig. 2). Similar temperature and LST trends were observed during the March sampling dates. In March 2000, the mean high and low temperatures 10 days prior to the sampling date were 6.0C (10.8F) and 4.8C (8.6F) higher, respectively, than in March 2001 (Fig. 3). Stems of all taxa, except *A. chinensis*, had lower LSTs in March 2001. Only the controls of *A. chinensis* survived during either March sampling date.

Temperature fluctuations just prior to sampling dates appear to significantly affect lowest survival temperatures and timing of acclimation and deacclimation among *Abelia* taxa. Timing of acclimation and deacclimation can be more critical in southern landscapes than actual midwinter hardiness because of unexpected cold spells in the early fall and late spring (5, 14, 15, 16). Although midwinter hardiness varied little among all taxa, 'John Creech' had the greatest stem and leaf hardiness on the majority of test dates. Midwinter hardiness and timing of acclimation and deacclimation are important criteria for the selection of superior parental germplasm to assure improved hardiness among resulting cultivars. Based on the data, 'John Creech' would make a logical choice for incorporation into a breeding program.

Literature Cited

1. Anisko, T., O.M. Lindstrom, and G. Hoogenboom. 1994. Development of a cold hardiness model for deciduous woody plants. Physiol. Plant. 91:375–382.

2. Bailey Hortorium. 1976. Hortus Third. Macmillan. New York.

3. Bean, W.J. 1970. Trees and Shrubs Hardy in the British Isles, 8th ed. Vol. I. John Murray Ltd. London.

4. Beckett, G. and K.A. Beckett. 1983. Hardiness survey 1981/82. Plantsman. 4:219–228.

5. Chen, T.H.H. 1994. Plant adaptation to low temperature stress. Can. J. Plant Pathol. 16:231–236.

6. Dirr, M.A. 1998a. Manual of Woody Landscape Plants. 5th ed. Stipes Publishing Co. Champaign, IL.

7. Dirr, M.A., O.M. Lindstrom, R. Lewandowski, and M.J. Vehr. 1993. Cold hardiness estimates of woody taxa from cultivated and wild collections. J. Environ. Hort. 11:200–203.

8. Griffiths, M. 1994. Index of Garden Plants. Timber Press. Portland, OR.

9. Hillier, J. 1998. The Hillier Manual of Trees and Shrubs. David & Charles Publishers. Devon, England.

10. Hubackova, M. 1996. Dependence of grapevine bud cold hardiness on fluctuations in winter temperatures. Am. J. Enol. Vitic. 47:100–102.

11. Krussmann, G. 1985. Manual of Cultivated Broadleaved Trees and Shrubs. Vol. I. Timber Press. Portland, OR.

12. Levitt, J. 1980. Responses of Plants to Environmental Stresses. Vol. I. Academic Press. New York, NY.

13. Lindstrom, O.M. and M.A. Dirr. 1989. Acclimation and low-temperature tolerance of eight woody taxa. HortScience 24:818–820.

14. Palonen, P. and L. Linden. 1999. Dormancy, cold hardiness, dehardening, and rehardening in selected red raspberry cultivars. J. Amer. Soc. Hort. Sci. 124:341–346.

15. Palta, J.P., J.B. Bamberg, Y. Chen, S.E. Vega, L.S. Weiss, and B.H. Karlsson. 1998. Understanding genetic control of freezing resistance using potato species as a model system. In: P.H. Li & T.H.H. Chen (Eds.), Plant Cold Hardiness: Molecular Biology, Biochemistry, and Physiology, pp. 67–75. Plenum Press, New York.

16. Pellett, H. and S. Moe. 1986. Flower bud hardiness of *Rhododendron* taxa. J. Amer. Rhod. Soc. 40:203–205.

17. Pellett, N.E., N. Rowen, and J. Aleong. 1991. Cold hardiness of various provenances of flame, roseshell, and swamp azaleas. J. Amer. Soc. Hort. Sci. 116:23–26.

18. Rehder, A. 1937. Manual of Cultivated Trees and Shrubs Hardy in North America. Macmillan. New York, NY.

19. Weiser, C.J. 1970. Cold resistance and injury in woody plants. Science 169:1269–1277.

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