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Pruning Leads to Increased Incidence of Freezing Damage in Abelia Hybrids[1]

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Abstract

North of USDA hardiness zone 7B, abelia suffers from freeze damage. Cultural factors may impact abelia's level of cold hardiness. To determine whether mid-season pruning affects the level of freeze damage, six abelia genotypes were tested in Griffin, GA. Plants were established in replicated field plots in 2001 and on July 3–4, 2003, half the individuals of each genotype were severely pruned. Laboratory freeze tests were conducted monthly on pruned and unpruned plants of each genotype from October 2003 to April 2004. Over the winter, all genotypes with exception of 'Canyon Creek' were significantly more cold tolerant in unpruned compared to pruned treatments. Analysis of each month independently revealed a significant difference among genotype-pruning treatment combinations from December 2003 to February 2004. Results for October and November 2003 and March and April 2004 were not significant due to an absence of cold hardiness. These results indicate that mid-season pruning of abelia may significantly reduce cold hardiness and lead to serious stem dieback in pruned plants.

Index words: abelia, cold tolerance, winter damage, pruning, cold hardiness, stem dieback.

Species used in this study: *Abelia chinensis* R. Br. open pollinated seedlings; *A.* x *grandiflora* (Rovelli ex Andre) Rehder 'Sherwoodii'.

Significance to the Nursery Industry

Curtailing freeze damage is of great economic importance to the nursery industry in the Southern United States. Because abelia suffers freeze damage north of USDA zone 7B, any cultural practices that may further reduce cold hardiness should be identified so that businesses can avoid unnecessary losses. This study focused on the effect of mid-season pruning (July 3–4, 2003) on cold hardiness of six abelia genotypes, including the widely utilized cultivars 'Rose Creek', 'Canyon Creek', and 'Sherwoodii'. Over the winter season (October 2003–April 2004), all genotypes with exception of 'Canyon Creek' were significantly more cold hardy in unpruned versus pruned treatments. The month of December 2003 had the most notable differences in cold hardiness between pruned and unpruned treatments. Based on midsummer pruning data, we recommend that pruning not be carried out in summer because subsequent growth is not hardened off prior to winter.

Introduction

For a century or more, abelia species and hybrids have been utilized in landscapes of the Southern and Eastern United States. Used mainly in foundation or mass plantings (2, 5), abelia's key limiting factor at northern latitudes is freeze damage (2, 3, 5, 10). Many of the 30 species and their hybrids suffer significant leaf drop and stem dieback during winter months north of USDA hardiness zone 7B (2, 5) and no genotype has survived laboratory-induced temperatures below –26C (–14.8F) (11). To reduce size and improve form and flowering, abelia are often severely pruned in both production and landscape settings (5). The recommended time to prune abelia in the Southeastern U.S. is before spring growth initiates (12), yet actual pruning time is variable and dependant upon labor availability and plant appearance.

Most cold hardiness ratings of abelia are based on field observations, without consideration of effects of pruning (3, 11, 13). However, studies in several woody ornamental and fruit species have demonstrated that mid-summer or later pruning leads to increased freeze damage compared to unpruned controls. The cold hardiness of x *Cupressocyparis leylandii* 'Haggerston Gray' and *Lagerstroemia* 'Natchez' were significantly reduced when pruned in late summer through early winter compared to plants pruned in early spring (7). Similar results were observed with *Malus domestica* Mill. 'Jonathan' and 'Stayman' (4), *Malus spp*. L. (1), and *Vitis labrusca* L. 'Concord' (6).

Cold hardiness ratings from field (2, 3, 5, 10) and/or laboratory tests (11) are available for a number of species and cultivars of abelia. The effect of pruning on cold hardiness of abelia has not been reported. In this study, effect of mid-season pruning on cold hardiness of six abelia genotypes, including the widely utilized cultivars 'Rose Creek', 'Canyon Creek', and 'Sherwoodii', was investigated.

Materials and Methods

Six abelia genotypes were evaluated in this study. Five of six genotypes originated as open pollinated seedlings of *Abelia chinensis* R. Br. and two of these are named cultivars: 'Rose Creek' and 'Canyon Creek'. The remaining genotype, 'Sherwoodii', is an *A.* x *grandiflora* (Rovelli ex Andre) Rehder selection. All plant material was collected as cuttings from stock plants in Athens, GA, and grown in #1 (3.8 liter) containers. Twenty plants of each genotype were planted into a field plot in Griffin, GA, in a completely randomized design in October 2001. Plants were maintained through drip irrigation and fertilized annually with Osmocote Pro Controlled Release Fertilizer Plus Minors (19 N–2.2 P–7.47 K) (Scotts-Sierra Horticultural Products Company, Marysville, OH). No pesticides were applied. On July 3–4, 2003, stunted plants and plants with significant dieback were discarded. Half the remaining individuals of each genotype were randomly selected and severely pruned (75% of growth re-

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moved). Unselected plants were left unpruned. The number of plants of each genotype-treatment combination ranged from five to eight.

Eighty uniform stem sections were randomly collected from all plants within a genotype-treatment combination (160 total sections per genotype) on October 13, November 17, and December 15, 2003, and January 12, February 16, March 15, and April 12, 2004. Stems were selected for collection based on size, with a target diameter of 2.5–3.5 mm (0.098–0.138 in) and upon collection immediately prepared for testing. Stems were prepared by removing all foliage and cutting each stem into 2.5–3.0 cm (0.984–1.181 in) sections. To ensure uniformity in diameter, no more than four sections were collected per stem and no sections were collected from the terminal 15 cm (5.906 in) of each stem. As described by Lindstrom and Dirr (8), for each genotype-treatment combination all stem sections were mixed and then bundled together in groups of four by wrapping in moist cheesecloth. The resulting 20 bundles per genotype-treatment combination were individually inserted into 25 × 200 mm (0.984 × 7.874 in) test tubes. Eighteen tubes per genotype were submerged in an ethylene glycol-water solution (1:1) in a Forma Scientific Model 2425 temperature bath (Forma Scientific, Marietta, OH) precooled to –2C (28.4F). The remaining two tubes per genotype were kept at 21C (69.8F).

Stem temperatures were measured by thermocouples inserted into six random tubes and recorded by a Campbell Scientific datalogger (Model CR7-X, Campbell Scientific, Inc., Logan, UT). When temperatures reached and maintained –2C (28.4F) for one hour, crushed ice crystals were added to nucleate each sample. Temperatures of the sample were held constant at –2C ± 0.5 (28.4F ± 0.9) for 14 hrs. Samples were subsequently cooled at a rate of 3–4C (5.4–7.2F) per hour. Two tubes of each genotype-treatment combination (two reps of four stems each) were removed at –3C (26.6F) and thereafter at –3C (5.4F) increments to –27C (–16.6F).

Immediately following removal from the temperature bath, tubes were thawed at 4C ± 1.5 (39.2F ± 2.7) for 24 hrs. Stems were removed from each tube (including controls), unwrapped from the cheesecloth, and placed onto moistened filter paper inside a disposable 100 × 15 mm (3.937 × 0.591 in) petri dish. Petri dishes were sealed with Parafilm M (Fisher Scientific, Hampton, NH) and placed in darkness at 21C ± 2 (69.8F ± 3.6) for five days. At five days, samples were visually measured for injury. Stems exhibiting greater than 50% brown-black discoloration of cambium and phloem as a result of tissue death were rated as dead. Injury was determined using the naked eye and a stereomicroscope. The number of stem sections killed in each replication (tube), out of four possible sections, was recorded (0 = none dead; 4 = all dead). Data were log-transformed and analyzed with SAS 8.2 (SAS Institute, Cary, NC) using the PROC Genmod procedure to examine the effect of testing date, pruning treatment, and temperature and the interactions of testing date by treatment and temperature by treatment over the entire season. Data were then analyzed by month of testing using PROC GLM. Mean damage values were compared for all genotype-treatment combinations by month using LSD analysis.

The minimum survival temperature was calculated by taking a weighted average based on the number of surviving stems at the lowest temperatures at which stems survived. The number of stems (1–8) that were rated as alive at the lowest temperature [e.g., 3 stems at –20C (–4F)] were assigned that temperature value. All stems rated as dead at the lowest temperature were assigned the preceding temperature value in which stems were rated as alive [e.g., 5 stems at –17C (1.4F)]. The subsequent eight values assigned to each of the eight stems were averaged to acquire the mean minimum survival temperature.

Results and Discussion

PROC Genmod results. Five parameters and interactions were examined using PROC Genmod: testing date, pruning treatment, temperature, testing date by treatment, and temperature by treatment (Table 1). When assessing goodness of fit, deviance calculations were above 0.80 for all cultivars (deviance of 1.0 is ideal), signifying that tests were accurate and reliable. Temperature by treatment interaction was significant for all genotypes except 'Canyon Creek' ($P < 0.05$). This indicated that unpruned and pruned treatments performed differently at different temperatures evaluated. Examination of the testing date revealed that the cold hardiness of each genotype varied among the seven months that genotypes were tested (all genotypes; $P < 0.0001$). This was expected as the cold hardiness of Abelia varies dramatically from October thru April, with maximum cold hardiness in central Georgia occurring in the December to February time period (11). Temperature followed the same pattern as date, with a significant difference observed among survival of twigs at the ten temperature intervals evaluated in the freeze test. Interaction of date by pruning treatment was not significant for any genotype. Thus throughout the testing period there

Table 1. Significance of three factors and two interactions over the winter season (October 2003–April 2004), as recorded for each genotype utilized in this study.

		Pr > ChiSq				
Genotype[z]	Deviance[y]	Date[x]	Treatment	Temperature	Date × Treatment	Temperature × Treatment
98-8	0.877	<0.001	<0.001	<0.001	0.809	0.003
98-11	0.803	<0.001	0.001	<0.001	0.519	0.003
98-13	0.834	<0.001	0.073	<0.001	0.755	0.015
'Rose Creek'	0.853	<0.001	0.002	<0.001	0.346	0.027
'Canyon Creek'	0.847	<0.001	0.323	<0.001	0.744	0.495
'Sherwoodii'	0.809	0.001	0.030	<0.001	0.995	0.038

[z]Each of six genotypes utilized in this study.

[y]Determined by Proc Genmod procedure, a deviance of 1.0 is perfect. Deviances above 0.80 indicate the statistical model used was sound.

[x]Factors and interactions considered in the model statement.

Table 2. Mean freeze damage ratings for all genotype-treatment combinations, grouped in ascending order.

December[z]			January			February		
Cultivar	**Treatment**	**Damage**	**Cultivar**	**Treatment**	**Damage**	**Cultivar**	**Treatment**	**Damage**
'Rose Creek'	Unpruned	1.60[y]a[x]	'Rose Creek'	Unpruned	1.05a	'Rose Creek'	Unpruned	1.05a
98-8	Unpruned	1.75ab	'Canyon Creek'	Unpruned	1.20a	98-11	Unpruned	1.20a
98-13	Unpruned	1.85ab	98-11	Unpruned	1.30a	98-8	Unpruned	1.25a
98-11	Unpruned	1.95ab	98-13	Unpruned	1.35a	'Canyon Creek'	Unpruned	1.35a
'Canyon Creek'	Unpruned	2.20abc	98-8	Unpruned	1.35a	'Canyon Creek'	Pruned	1.45a
'Rose Creek'	Pruned	2.30bcd	98-13	Pruned	1.45a	98-13	Unpruned	1.45a
98-13	Pruned	2.65cde	98-8	Pruned	1.60a	98-8	Pruned	1.50a
'Canyon Creek'	Pruned	2.65cde	98-11	Pruned	1.65ab	98-11	Pruned	1.50a
98-8	Pruned	2.90de	'Canyon Creek'	Pruned	1.75ab	'Rose Creek'	Pruned	1.75ab
'Sherwoodii'	Unpruned	3.00e	'Rose Creek'	Pruned	1.80ab	98-13	Pruned	1.80ab
'Sherwoodii'	Pruned	3.15e	'Sherwoodii'	Pruned	2.45bc	'Sherwoodii'	Pruned	2.35b
98-11	Pruned	3.20e	'Sherwoodii'	Unpruned	2.65bc	'Sherwoodii'	Unpruned	2.40b
Pr>F		<0.0001[w]			0.0039			0.0267

[z]Testing date: December 15, 2003; January 12, 2004; February 16, 2004.

[y]Mean damage rating over two replications of four stems each, with 0 representing no dead stems and 4 representing all stems dead.

[x]Mean separation based on least significant difference (LSD) at $P < 0.05$. Means followed by the same letters are statistically similar.

[w]Significance of test based upon ANOVA.

was a similar level of discrepancy between cold hardiness of pruned versus unpruned treatments. Examination of pruning treatment revealed that in all cases except 'Canyon Creek', significant differences between pruned and unpruned treatments existed.

PROC GLM and means separation results. PROC GLM and means separation were conducted on a monthly basis (October 2003–April 2004) to examine whether significant differences occurred among genotype-treatment combinations (Table 2). Overall, results were significant for the months of December 2003 and January and Feburary 2004 ($P < 0.05$) and non-significant for the months of October and November 2003 and March and April 2004. Differences in significance are due to variations in cold acclimation of individuals in this study. Cold acclimation in abelia is a rapid physiological process, as is shown by the 11C (18.8F) increase in cold hardiness of the 98-11 pruned individuals from December 15, 2003, to January 12, 2004 (Table 3). Similar results were obtained by Scheiber et al. who noted a 15.7C (28.3F) difference in hardiness on testing dates 30 days apart (11). Effects of pruning are most evident prior to new growth hardening off. As was the case with *Lagerstromia* 'Nachez' and x *Cupressocyparis leylandii* (7), the optimal month to distinguish effects of pruning versus not pruning was the first month that temperatures below freezing were recorded. The December 15, 2003, test date was the first that plants had experienced temperatures below freezing. Eight days between November 17 and December 15, 2003, had below freezing temperatures (Fig. 1).

Differences existed among genotype-treatment combinations in the December test ($P < 0.0001$) (Table 2). Also, separation of mean damage ratings was observed for genotype-treatment combinations. Effects of pruning on damage ratings is evident, with more damage ($P < 0.05$) occurring in pruned compared to unpruned individuals. Four of the six genotypes, including 'Rose Creek', 98-8, 98-11, and 98-13, had less damage ($P < 0.05$) in unpruned versus pruned treatments. 'Canyon Creek' and 'Sherwoodii' showed no significant differences ($P > 0.05$) for treatment. The difference in minimum survival temperatures between pruned and unpruned stems within a single genotype (Table 3) for the

Table 3. Mean minimum survival temperatures, in degrees Celsius, for each genotype-treatment combination, recorded monthly, from October 2003 to April 2004.

Genotype	Treatment	Month						
		October	**November**	**December**	**January**	**February**	**March**	**April**
'Canyon Creek'	Pruned	–4.5[z]	–6.8	–7.5	–14.3	–16.5	–9.8	–10.5
'Canyon Creek'	Unpruned	–5.3	–8.3	–9.8	–18.0	–16.5	–12.8	–8.3
'Rose Creek'	Pruned	–4.5	–7.5	–10.5	–13.5	–14.3	–10.5	–7.5
'Rose Creek'	Unpruned	–5.3	–8.3	–15.8	–18.8	–18.8	–12.0	–10.5
'Sherwoodii'	Pruned	–1.5	–1.5	–3.8	–9.0	–9.8	–6.8	–5.3
'Sherwoodii'	Unpruned	–3.8	–3.8	–5.0	–7.2	–8.3	–8.3	–6.0
98-8	Pruned	–3.8	–4.5	–7.5	–15.0	–15.8	–12.0	–10.5
98-8	Unpruned	–5.3	–6.8	–12.8	–16.5	–17.3	–14.3	–11.3
98-11	Pruned	–1.5	–4.5	–3.0	–14.3	–15.0	–7.5	–5.3
98-11	Unpruned	–5.3	–8.3	–12.8	–17.3	–18.0	–12.0	–8.3
98-13	Pruned	–3.8	–6.0	–7.5	–12.8	–15.0	–13.5	–8.3
98-13	Unpruned	–4.5	–6.8	–13.5	–16.5	–15.8	–11.3	–11.3

[z]The minimum survival temperature was calculated by taking a weighted average based on the number of surviving stems at the lowest temperatures at which stems survived.

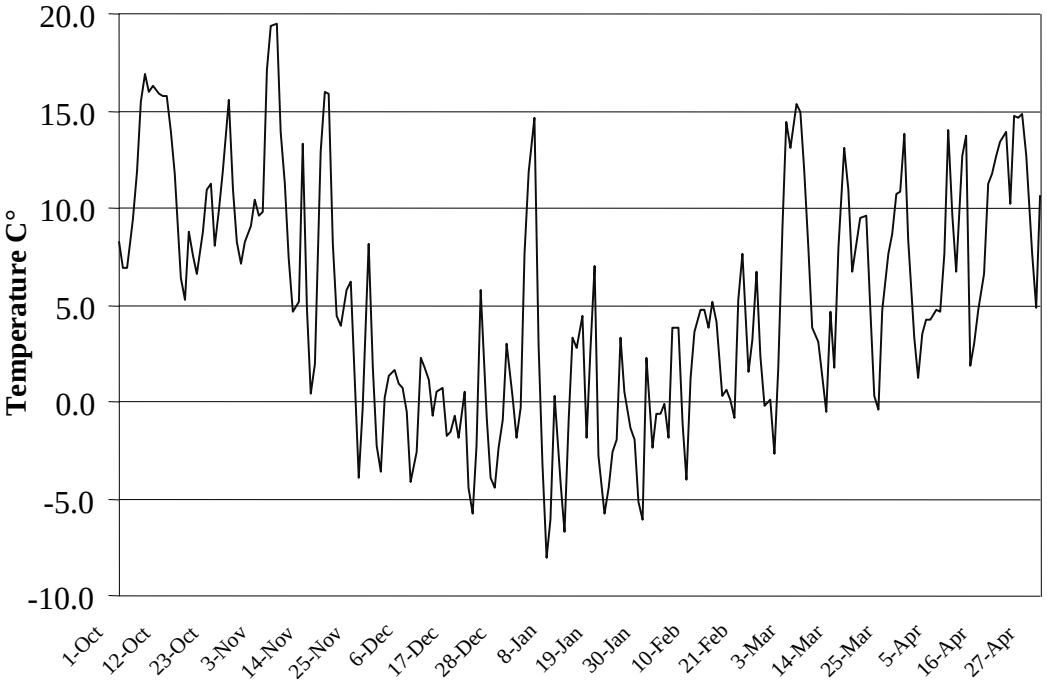

Fig. 1. Daily low temperatures (degrees Celsius) from October 1, 2003, to April 30, 2004, 450 meters SE of the test plots, in Griffin, GA.

month of December ranged from 1.3C for 'Sherwoodii' to a maximum of 9.8C for 98-11.

In January and February 2004, no statistical differences ($P > 0.05$) occurred between pruned and unpruned treatments within a genotype (Table 2). Apparently, the non-woody growth observed on pruned abelia plants prior to the December 2003 test date had acclimated substantially by the January and February 2004 test dates. Despite the lack of statistically significant differences, the mean damage ratings (Table 2) and minimum survival temperatures (Table 3) of unpruned genotypes in January and February 2004 were lower than their pruned counterparts.

Results of Proc GLM analysis for the months of October and November 2003 and March and April 2004 were not significant ($P > 0.05$) (data not shown). The lack of significance in October and November 2003 tests was due to a delay in cold acclimation, leading to severe damage of all stems in those months. This response is consistent with work by Scheiber et al. (11). The first freezing temperatures of the fall occurred on November 25, 2003 (Fig. 1), a week after the November 17, 2003, test date. This may explain why neither pruned nor unpruned plants had acclimated to cold temperatures. This concurs with the minimum survival temperatures for November (Table 3), with no genotype-treatment combination surviving below –8.3C. The last freeze occurred on February 28, 2004, sixteen days prior to the March 15 test date (Fig. 1). This lack of cold temperatures prior to the March 15 test allowed all individuals to initiate significant spring growth, resulting in rapid de-acclimation.

All genotypes that received mid-season pruning exhibited rapid growth from approximately two weeks after pruning until first freeze, often returning to their pre-pruned size. This rapid growth was in contrast to unpruned entries that demonstrated a typical growth pattern for abelia, including slow growth rates in mid-summer with a small burst of growth as temperatures cooled and soil moisture increased in late summer. Such rapid growth of pruned entries, lasting until first freeze, was accompanied by delayed cold acclimation of plant tissue since tissues were primarily non-woody at the time of first freeze. Results of this study mirror previous studies conducted on mid to late-season pruning in other species (1, 2, 4, 6, 7, 9). Based on this study, pruning of abelia is not recommended in mid-summer.

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