Aglaonema Cultivars Differ in Resistance to Chilling Temperatures[1]

Jianjun Chen[2], Richard W. Henley[3], Richard J. Henny[4], Russell D. Caldwell[5], and Cynthia A. Robinson[5]
University of Florida, IFAS, Mid-Florida Research and Education Center
2725 Binion Road, Apopka, FL 32703

Abstract

Aglaonema is considered one of the most chilling sensitive tropical ornamental foliage plants. However, information on resistance of the ever-increasing number of new cultivars to chilling temperatures is not available. In this study, the chilling response of 12 *Aglaonema* cultivars was evaluated after exposure to 1.7, 7.2, or 12.8C (35, 45, or 55F) for 24 hours. Results showed that a high degree of genetic variation existed among the cultivars. The cultivar 'Silver Queen' demonstrated the greatest sensitivity to chilling with 30% of leaves injured at 12.8C (55F). In contrast, three new cultivars, 'Emerald Star', 'Stars', and 'Jewel of India', were the most resistant, each showing no visible injury at 1.7C (35F). Data also indicated that chilling injury to young leaves was much less pronounced than in either mature or old leaves. Additionally, chilling sensitivity of the cultivars was reduced by pre-exposure to cooler temperatures that were slightly above the chilling range.

Index words: chilling injury, chilling resistance, Chinese evergreen, cold acclimation, foliage plants.

Significance to the Nursery Industry

Chilling can severely injure tropical foliage plants, including *Aglaonema*, during production, shipping, retail display, or interiorscaping. However, significant chilling resistance exists among *Aglaonema* cultivars, a genus considered extremely sensitive to chilling temperatures. 'Emerald Star', 'Stars', and 'Jewel of India' withstand exposure to 1.7C (35F) without injury. Whereas 'Silver Queen' was injured at 12.8C (55F). All cultivars also show increased resistance to chilling after prior exposures to temperatures slightly above individual chilling ranges. Use of resistant cultivars may greatly reduce the chance of chilling injury during production and transportation and also conserve energy used for greenhouse heating. In addition, resistant cultivars may be used in breeding to improve the chilling resistance of other new *Aglaonema* cultivars.

[1]Received for publication March 22, 2001; in revised form July 12, 2001. Florida Agricultural Experiment Station Journal Series No. R–08155. The authors would like to thank Dr. Richard C. Beeson, Jr. for helpful discussions and critical reading of this manuscript. Appreciation is also extended to Sunshine Foliage World, Zolfo Springs, FL, and Butler's Nursery, Miami, FL, for providing initial plant materials.

[2]Assistant Professor, to whom all correspondence should be directed.

[3]Professor Emeritus.

[4]Professor.

[5]Biological Scientists.

Introduction

The genus *Aglaonema*, commonly called Chinese evergreen, belongs to the family Araceae and is comprised of 21 species which are native to southeast Asia where they grow in the humid, heavily shaded tropical forest (11). *Aglaonema*, cultivated in the East for centuries, was believed to bring fortune to life and probably was introduced into the western world in 1885 (2). Currently, *Aglaonema* is among the most popular tropical ornamental foliage plant genera because of its attractive foliar variegation, low light and humidity tolerance, and few disease and pest problems (8, 12).

Aglaonema, however, has been considered one of the most chilling sensitive foliage plants when exposed to temperatures between 0C (32F) and 15.5C (60F) (7, 9, 10). Chilling injury, characterized by dark and greasy-appearing patches on injured leaves, can result in unsalable plants (3, 9). Chilling injury to *Aglaonema* may also occur during shipment, retail display, and interior decoration (1, 8, 12).

Hummel and Henny (10) studied chilling responses of 11 *Aglaonema* cultivars using a detached leaf method and found that variation in chilling sensitivity existed among cultivars. Chen et al. (4) found that a pre-chilling of *Aglaonema* cultivars to 15.5C (60F) for 24 hours decreased chilling sensitivity of the cultivars to subsequent exposures to 12.8C (55F) and 7.2C (45F). This temperature-conditioned chilling responses were also observed in a study conducted by Henley et al. (9).

With recently increased breeding activities and new cultivar releases, *Aglaonema* hybrids with different variegation patterns, showy petiole and stem colors, and varying growth habits have become available (5). However, the response of these new cultivars to chilling temperatures is largely unknown. The objectives of this study were to evaluate *Aglaonema* cultivars in response to chilling using a whole plant assay (3, 9) and to identify chilling resistant cultivars.

Materials and Methods

Lateral shoots of 12 *Aglaonema* cultivars (Table 1) with 8–10 leaves were separated from stock plants in June 1999 and rooted singly in 10.4 cm (8 in) pots containing Vergo Container Mix A (Verlite Co. Tampa, FL): Canadian peat, vermiculite, and perlite (3:1:1 by vol). Plants were grown in a shaded glasshouse at a maximum light level of 284 µmol/m^2/s (1,500 foot candles) and a relative humidity of 70 to 90%. Temperatures in the shaded glasshouse ranged from 20 to 32C (68 to 90F) unless otherwise specified. Two weeks after potting, 5 g (0.18 oz) of a controlled-release fertilizer, 18N–2.6P–10K (Osmocote 18–6–12, The Scotts Co., Marysville, OH), were applied to the surface of each pot.

Three months after potting, the first experiment was initiated on September 28. Twelve uniform plants of each cultivar were selected and labeled. Leaf totals per plant ranging from 12 to 14 depending on cultivars were recorded and categorized as young (the most recently fully expanded leaves up to and including the newest unfurled leaf), mature (leaves immediately below the young leaves down to the old leaves), and old (about three to four basal leaves). The difference between mature and old leaves was that old leaves were smaller than the mature ones. Leaf numbers from each age group were recorded and labeled as well.

Temperatures in walk-in coolers [3.1 × 3.1 meters (10 × 10 ft)] were set at 1.7, 7.2, or 12.8C (35, 45 or 55F) until they stabilized. Three single-plant replicates of each cultivar were randomly selected and placed into each temperature regime (3 coolers per temperature regime and 12 cultivars per cooler). Remaining three plants of each cultivar were left in the shaded glasshouse as controls. After 24 hours of chilling, plants were moved back to the shaded glasshouse for chilling injury evaluation.

Injury was indicated by visual foliar blemishes. Since *Aglaonema*'s aesthetic appearance is directly related to foliage color and quality, any damage on leaves, regardless of severity, can greatly reduce its ornamental value in the market place. Therefore, the percentage of injured leaves was the primary parameter used to determine the sensitivity of cultivars to chilling temperatures. Numbers of injured leaves from each age group were counted two days after chilling and every other day thereafter up to 10 days. The percentage of injured leaves relative to total number of leaves per plant was calculated. Leaf chilling responses of different age groups were determined based on the number of injured leaves from each age group relative to total injured leaves.

The experiment was arranged in a completely randomized split-plot design with cultivar as the main plot and temperature as the subplot using three single plant replicates. Effects of cultivar and temperature were determined by analysis of variance according to the general linear model procedure of the Statistical Analysis System (SAS Institute Inc., Cary, NC). To define how each cultivar responded to the three chilling temperatures, the percentages of injured leaves per cultivar two or ten days after chilling were separately analyzed within each temperature regime. Cultivar differences were separated by the least significant difference (LSD) procedure at $P = 0.05$ level. Differences of leaves injured from three age groups 10 days after chilling at 1.7C (35F) were also separated by LSD procedure at $P = 0.05$.

The second experiment, initiated on October 25, 1999, was designed to determine if cultivars, after exposed to natural chilling in late October, responded differently from those recorded in September. Six supplementary plants each of cultivars 'Manila Pride', 'Maria', 'Royal Queen', 'Silver Queen', and 'Silver Frost' were labeled and leaf totals per plant were recorded. Three plants of each cultivar were placed into three coolers at 1.7C (35F) for 24 hours (one cultivar per cooler) and then moved back to the shaded glasshouse. The treatment arrangement was in a completely randomized design with three single plant replicates. Remaining three plants per cultivar were left in the shaded glasshouse as controls.

The shaded glasshouse was not heated in October. The plants grown in the glasshouse were under the similar production conditions as those grown in September. The only environmental factor in October that notably differed from that in September was night temperature. Before the chilling treatment, the cultivars had been exposed naturally to a night temperature of 14.8C (58.6F) for one hour, followed by two consecutive nights of 13.8C (56.8F) lasting for about 5 hours each night.

Table 1. Brief description of 12 *Aglaonema* cultivars used for chilling response.

Cultivar	Morphological characteristics
Black Lance	Long and narrow tricolored leaves with two shades of silver green, plants are tall and upright.
Emerald Star	Dark green leaves with bright yellow to cream colored spots.
Green Lady	Tricolored leaves with areas of silver in the center are accented by two shades of green border.
Green Majesty	Large leaves marked with silver-green margin and dark green center.
Jewel of India	Grayish green leaves with white and silver to gray blotches.
Manila Pride	Large and dark green leaves with pink petioles and stems.
Maria	Deep green foliage highlighted by bands and flecks of silvery green.
Moonshine	Thick, silver-gray leaves that resemble the glow of the moon.
Royal Queen	Large tricolored leaves marked with two shades of silver green, large spreading growth habit.
Silver Queen	Grayish green leaves with white and silver to gray blotches.
Silver Frost	Predominantly silver-green leaves prominently marked in the center and along the leaf margin with dark green.
Stars	Dark green leaves marked with dark silver-green blotches and white yellow-green speckles.

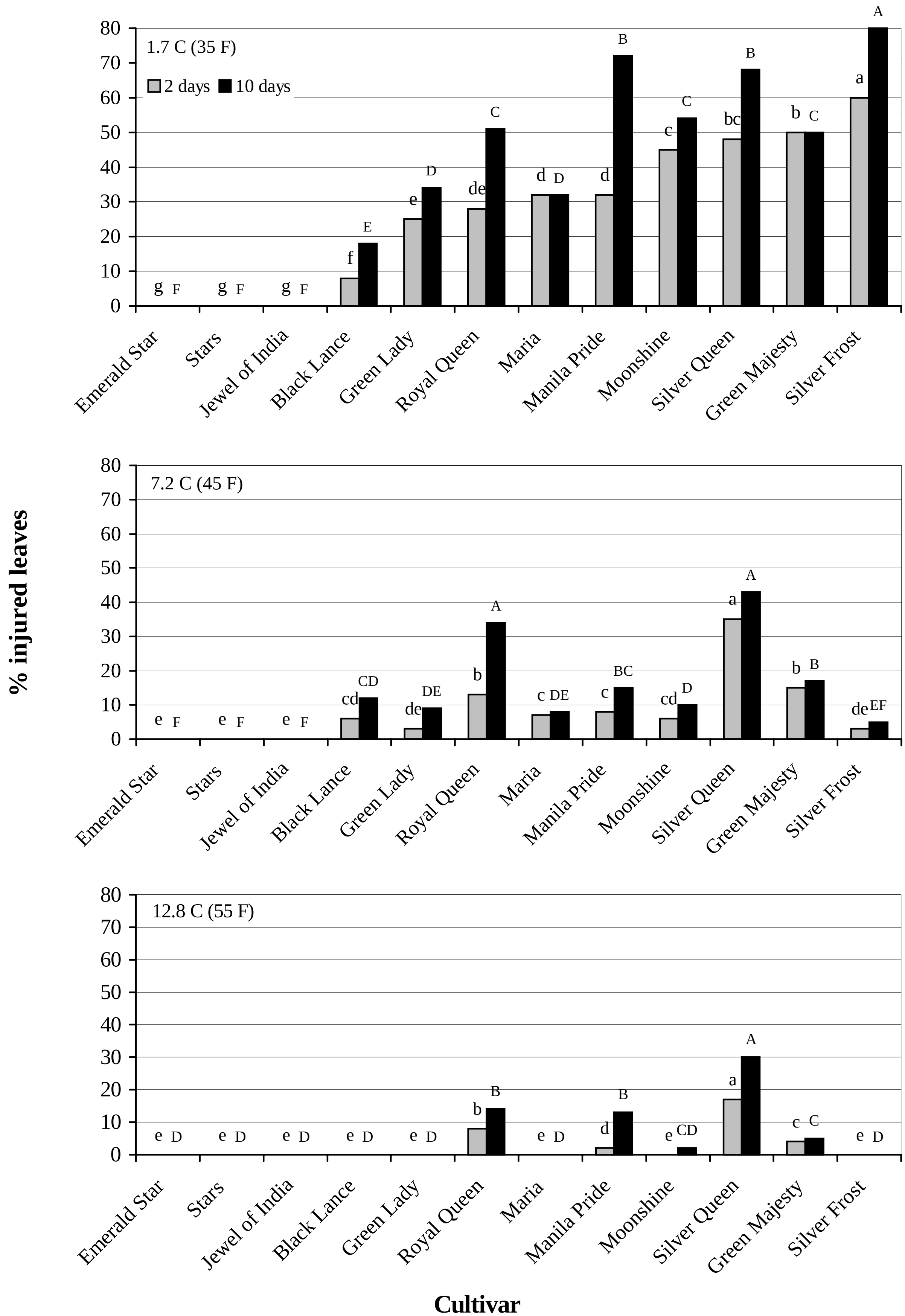

Fig. 1. Mean percentage of injured leaves of 12 *Aglaonema* cultivars 2 or 10 days after 24 hours of chilling at 1.7 (35F), 7.2 (45F), and 12.8C (55F). Means with different small letters are significantly different 2 days after chilling and with different capital letters are significant different 10 days after chilling based on the LSD test (*P* = 0.05).

Numbers of total injured leaves were recorded 10 days after the chilling treatment. The mean percentage of injured leaves per cultivar from the October experiment was compared to that of corresponding cultivars from the September experiment using the two-sample *t* tests of the SAS program.

Results and Discussion

Cultivar differences in resistance to chilling. Chilling injury was not observed on those control plants remaining in the shaded glasshouse, but dark and greasy-appearing patches became visible between midvein and leaf margin on the upper surface of mature and/or old leaves two days after chilling. The number of leaves injured continuously increased for up to 10 days (Fig. 1a, b, and c) depending on cultivars, but no further injury appeared 10 days thereafter. The percentage of injured leaves increased as the temperature decreased. Injured areas or individual patches of leaves were irregular, varying from 10% to 80% of the entire leaf area (data not shown).

Cultivars were significantly different in resistance to chilling temperatures. 'Silver Queen', one of the most popular cultivars in the foliage plant industry, was extremely vulnerable to chilling, with 17, 35, and 48% of leaves injured at 12.8, 7.2, and 1.7C (55, 45, and 35F) respectively two days after chilling and 30, 43, and 68% of leaves injured at these respective temperatures 10 days after chilling. 'Maria', a cultivar well known for its chilling resistance, was not the most resistant one tested. Ten days after chilling at 1.7C, 32% of Maria's leaves were injured but there was no discernable injury on 'Emerald Star', 'Stars', or 'Jewel of India'. 'Emerald Star', 'Stars', and 'Jewel of India' are the most chilling resistant cultivars identified thus far. In addition, 'Black Lance' and 'Green Lady' appeared to be slightly better than or at least equal to 'Maria' in chilling resistance.

These results demonstrate genetic differences to chilling among cultivars and suggest that chilling resistance has been incorporated into *Aglaonema* hybrids. Cultivation of the resistant cultivars will reduce chilling injury incidence and energy used for heating during production.

Difference in critical chilling temperatures. Results from this study also demonstrated that cultivars differ in their sensitivity to critical chilling temperature, i.e. a temperature that chilling injury occurs. For example, 10 days after chilling, 'Silver Frost' had no injury at 12.8C (55F) and only 5% leaf injury at 7.2C (45F), but 80% of the leaves were injured when exposed to 1.7C (35F) (Fig. 1a, b, and c). A similar pattern occurred in 'Maria' and 'Green Lady'. In contrast, 'Silver Queen' and 'Royal Queen' had 30 and 14% injured leaves, respectively, 10 days after chilling at 12.8C (55F). Implications are that critical chilling temperatures of 'Silver Frost', 'Maria', and 'Green Lady' are around 7.2C (45F), whereas critical temperatures of 'Silver Queen' and 'Royal Queen' are above 12.8C (55F). Critical chilling temperature distinctions are potentially important in *Aglaonema* production because growers will be able to manage their greenhouse temperatures based on cultivar-dependent chilling temperature sensitivity ranges.

Temporal variation in chilling symptom development. Cultivars also varied temporally in chilling symptom expression. Most cultivars had higher percentage of injured leaves at 10 days than two days after chilling (Fig.1a, b, and c). For example, the percentage of injured leaves of 'Manila Pride' increased from 32% two days after chilling at 1.7C (35F), to 72% 10 days after the chilling. An increase in injured leaf number suggests that the chilling injury symptoms develop in a time-dependent manner. The more severely injured cells

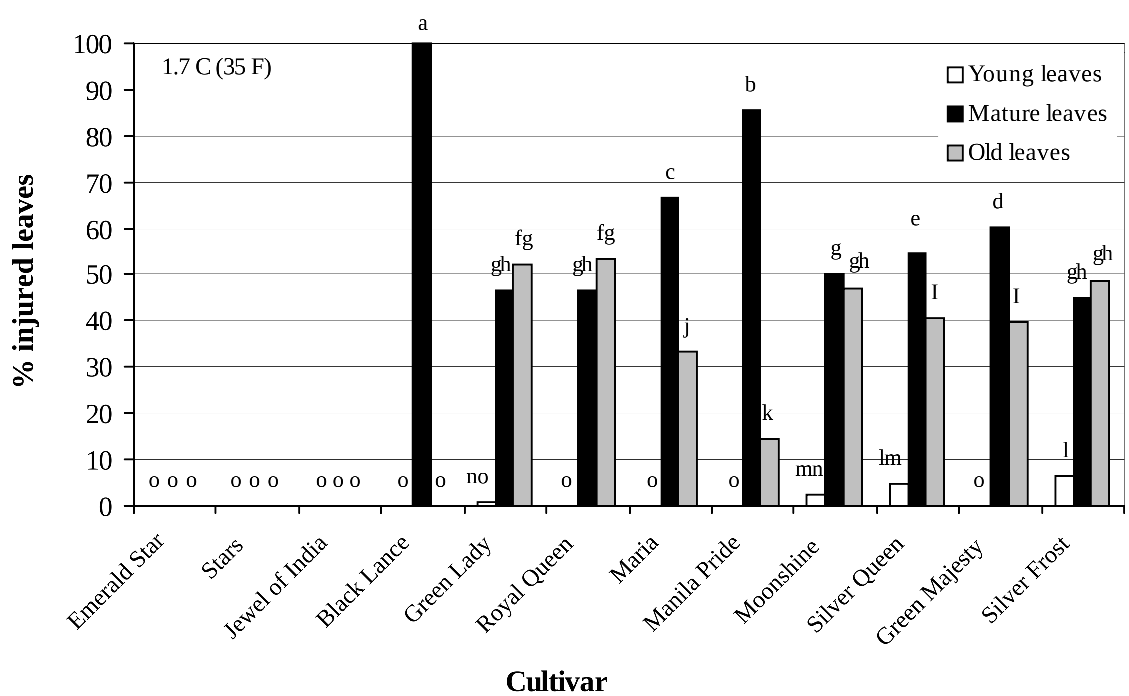

Fig. 2. Comparative percentages of leaf injury categorized by leaf maturity (young leaves: the most recently fully expanded leaves up to and including the newest unfurled leaf, mature: leaves immediately below the young leaves down to the old leaves, and old: about three to four basal leaves) 10 days after chilling at 1.7C (35F). Means with the different letters are significantly different based on the LSD test (*P* = 0.05).

Table 2. The mean percentage of injured leaves of *Aglaonema* cultivars 10 days after chilling at 1.7C (35F) in September and October 1999.

Cultivar	Chilling month		Significance[z]
	September	October	
Manila Pride	72	58	**
Maria	32	10	**
Royal Queen	51	30	**
Silver Queen	68	56	*
Silver Frost	80	54	**

[z]*t* test: * or ** indicate that means within rows are significantly different at the 5% or 1% level, respectively.

exhibited symptoms sooner than less severely injured cells. Total injury manifestations maximized 10 days after chill treatments. Notably, however, two cultivars 'Green Majesty' and 'Maria' had 50 and 32% injured leaves, respectively, at 1.7C (35F) two days after chilling and no increases in injury 10 days after chilling. This suggests that cultivars may differ in the temporal expression of chilling symptoms.

Leaf maturity affects chilling sensitivity. Leaves of different maturity also expressed dissimilar responses to chilling temperatures. Mature and old leaves appeared to be much more vulnerable to chilling than young leaves. Among the injured leaf totals, mature leaf injury ranged from 45 to 100% and old leaf 14 to 53%, but young leaf injury was only 0 to 6% depending on cultivars (Fig. 2). 'Green Lady', 'Moonshine', 'Silver Queen', and 'Silver Frost' each had less than 6% of young leaves injured. 'Black Lance' was the only cultivar where injury occurred exclusively on mature leaves. 'Maria', 'Manila Pride', 'Silver Queen', and 'Green Majesty' had more mature leaves injured than old ones. Mature and old leaf injury percentages were similar in 'Green Lady', 'Royal Queen', 'Moonshine', and 'Silver Frost' expressing injury. These data conform with work by Qu et al. (18) in which chill injury was confined to mature and old leaves of *Spathiphyllum* but differed from other studies, which documented no effect of leaf age on *Passiflora* (17) and greater susceptibility in immature banana tissue (16).

Effects of temperature conditioning on cultivar chilling responses. Although tropical plants cannot be hardened like temperate-zone plants, chilling sensitivity of *Aglaonema* cultivars appeared to be reduced when cultivars were previously exposed to temperatures slightly above their specific chilling ranges. Comparisons of five cultivars chilled in September (Experiment 1) and October (Experiment 2) revealed that the percentages of injured leaves from cultivars chilled in October were significantly lower than those chilled in September (Table 2). This percentage decline was likely attributed to temperature conditioning or cold acclimation because cultural and environmental conditions in the shaded glasshouse between September and October were similar except three occasions that night temperatures dropped below 15.5C (60F) as described previously, whereas plants in the September experiment were not subjected to seasonal temperature fluxes below 20C (68F) before chilling treatments.

This naturally slight chilling in decrease of the sensitivity of *Aglaonema* to subsequent chilling concurs with work by Henley et al. (9) where more injury occurred when *Aglaonema* chilled in September than those chilled in October 1997. This cold acclimation is also widely observed in *Aglaonema* production where chilling injury is usually most severe when plants have been growing at a relatively high temperature prior to a chilling period (6). However, this temperature conditioning did not protect all leaves from injury because temperature conditioning is only a phenomenon of phenotypic plasticity and its protection is temporary and limited (13, 14, 15). Complete protection needs to use chilling resistant cultivars such as 'Emerald Star', 'Stars', or 'Jewel of India', whose resistance is genetically determined.

Literature Cited

1. Blessington, T.M. and P.C. Collons. 1993. Foliage Plants: Prolonged Quality, Postproduction Care and Handling. Ball Publishing, Batavia, IL.

2. Brown, D. 2000. Aroids: Plants of the Arum Family. Second Edition. Timber Press. Portland. OR.

3. Chen, J., R.W. Henley, R.J. Henny, R.D. Caldwell, and C.A. Robinson. 1998. A simple leaf-assay method for evaluating *Aglaonema* sensitivity to chilling temperatures. Proc. Fla. State Hort. Soc. 111:43–46.

4. Chen, J., R.J. Henny, D.B. McConnell, and T.A. Nell. 2000. Cultivar differences in interior performances of acclimatized foliage plants. Acta Hortic. 543:135–140.

5. Cialone, J. 2000. New Chinese evergreen cultivars for the interiorscape. Ohio Florists' Assoc. Bull. No. 847:1, 9–10.

6. Conover, C.A., R.T. Poole, R.J. Henny, R.A. Hamlen, and A.R. Chase. 1981. *Aglaonema* production guide for commercial growers. Florida Cooperative Extension Service Fact Sheet OHC–1, IFAS, University of Florida.

7. Fooshee, W.C. and D.B. McConnell. 1987. Response of *Aglaonema* 'Silver Queen' to nighttime chilling temperatures. HortScience 22:254–255.

8. Griffith, L.P. 1998. Tropical Foliage Plants: A Grower's Guide. Ball Publishing, Batavia IL.

9. Henley, R.W., R.J. Henny, and J. Chen. 1998. Chilling injury on twenty *Aglaonema* cultivars. Proc. Southern Nursery Assoc. Conf. 43:117–121.

10. Hummel, R.L. and R.J. Henny. 1986. Variation in sensitivity to chilling injury within the genus *Aglaonema*. HortScience 21:291–293.

11. Huxley, A. 1994. The New Royal Horticultural Society Dictionary of Gardening. The Macmillon Press Ltd, London.

12. Joiner, J.N. 1981. Foliage Plant Production. Prentice-Hall, Englewood Cliffs, NJ.

13. Levitt, J. 1980. Responses of Plants to Environmental Stresses. Academic Press, New York.

14. Lyons, J.M. 1973. Chilling injury in plants. Ann. Rev. Plant Physiol. 24:445–466.

15. Nilsen, E.T. and D.M. Orcutt. 1996. The Physiology of Plants under Stress. John Wiley and Sons, Inc. New York.

16. Pantastico, E.B., W. Grierson, and J. Soule. 1968. Chilling injury in tropical fruits: I. bananas. Amer. Soc. Hort. Soc. 11:82–91.

17. Patterson, B.D., T. Murata, and D. Graham. 1976. Electrolytic leakage induced by chilling in *Passifloria* species tolerant to different climates. Aust. J. Plant Physiol. 3:435–442.

18. Qu, L., J. Chen, R.J. Henny, C.A. Robinson, R.D. Caldwell, and Y. Huang. 2000. Response of *Spathiphyllum* cultivars to chilling temperatures. Proc. Fla. State Hort. Soc. 113:165–169.