HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

Leaf and Stem Cold Hardiness of 17 Broadleaf Evergreen Taxa[1]

Michael A. Dirr[2] and Orville M. Lindstrom, Jr.[3]
Department of Horticulture
University of Georgia,
Athens, GA 30602

Abstract

The leaves and stems of 17 broadleaf evergreen taxa were screened for cold hardiness in laboratory tests. Leaves of *Ilex* were generally less cold hardy than stems. However, the leaves of *I.* × *koehneana* 'Wirt L. Winn', *Ilex latifolia* and *Ilex* 'Lydia Morris' were equal to or more cold hardy than the stems. Maximum cold hardiness of most taxa occurred in mid-January. *Ilex opaca, Ilex opaca* 'Greenleaf', and *Ilex* × *attenuata* 'Foster's #2,' were the most cold hardy. Among the *Ilex* × *attenuata* cultivars, 'Foster's #2' was more cold tolerant than 'Savannah' and 'East Palatka.' *Ilex latifolia* and *Ilex* 'Lydia Morris' were least cold hardy. *I.* 'Nellie Stevens' and *I.* × *koehneana* 'Wirt L. Winn' were intermediate.
Osmanthus heterophyllus 'Gulftide' was the hardiest tea-olive, followed by *Osmanthus americanus, Osmanthus* × *fortunei* and *Osmanthus heterophyllus* 'Rotundifolius'.
Prunus laurocerasus 'Zabeliana' was hardier than 'Schipkaensis' than 'Otto Luyken'. The actual differences, however, were slight.

Index words. *Ilex, Osmanthus, Prunus*, freezing, cold hardiness, acclimation

Species and cultivars used in this study.

American Holly (*Ilex opaca* Ait.); Devil-wood (*Osmanthus americanus* Gray); East Palatka Holly (Ilex × attenuata Ashe 'East Palatka'); Fortune's Teaolive (Osmanthus × fortunei Carr.); 'Foster's #2' Holly (*Ilex* × *attenuata* Ashe 'Foster's #2'); Greenleaf American Holly (*Ilex opaca* Ait. 'Greenleaf'); Gulf Tide Holly Teaolive (*Osmanthus heterophyllus* G. Don 'Gulf Tide'); Holly Teaolive (*Osmanthus heterophyllus* G. Don); Lusterleaf Holly (*Ilex latifolia* Thunb.); Lydia Morris Holly (*Ilex* L. 'Lydia Morris'); Nellie Stevens Holly (*Ilex* L. 'Nellie Stevens'); Otto Luyken Common Cherrylaurel (*Prunus laurocerasus* L. 'Otto Luyken'); Roundleaf Holly Teaolive (*Osmanthus heterophyllus* G. Don 'Rotundifolius'); Savannah Holly (*Ilex* × *attenuata* Ashe 'Savannah'); Schipka Common Cherrylaurel (*Prunus laurocerasus* L. 'Schipkaensis'); Wirt L. Winn Koehne Holly (*Ilex* × *koehneana* Loes. 'Wirt L. Winn'); and, Zabel Common Cherrylaurel (*Prunus laurocerasus* L. 'Zabeliana').

Significance to the Nursery Industry

The results of laboratory cold hardiness tests with broadleaf evergreens, compare favorably with observed performance in the landscape. *Ilex opaca* and 'Greenleaf' proved most cold hardy with *I.* × *attenuata* 'Foster's #2' quite similar. *Ilex opaca* is one of the parents of the *I.* × *attenuata* hybrids and its hardiness genes have been transmitted to the offspring. Screening for cold hardiness under laboratory conditions would significantly shorten the normal evaluation process which is largely trial and error.

The tests are not infallible and the *Osmanthus* taxa results were not in complete agreement with observed field performance, especially relative to leaf and stem hardiness. However, *O. heterophyllus*, 'Gulf Tide', and *O. americanus* which are the most cold hardy under field conditions were also the hardiest in the laboratory tests. The laboratory cold hardiness levels of the *Prunus laurocerasus* taxa were relatively similar to observed field performance.

Multiple date laboratory cold hardiness testing holds great promise to provide an index of a particular plant's low temperature tolerance. With judicious use, it can provide useful information about the low temperature adaptability of a particular taxon.

Introduction

Broadleaf evergreens, especially *Ilex, Osmanthus* and *Prunus* are economically important landscape plants. Cold hardiness determined through field observations of the taxa listed is known (2, 3, 4, 5); however, no absolute lower limits, as a function of time of year, have been established. Further, the leaves are generally considered less cold hardy than stems and with broadleaf evergreens the foliage is the essential ornamental characteristic. For example, the leaves of *Osmanthus* × *fortunei* and *Osmanthus heterophyllus* 'Rotundifolius' were killed, but the stems and buds were not injured and new shoots were evident by May following the devastating 1983–84 winter (3).

Previous work (8) has shown a strong relationship between observed cold hardiness in the field and laboratory testing when plants were evaluated on multiple dates throughout the fall, winter and spring seasons; the results from which might be used to predict low temperature geographical adaptability of both established and newly introduced broadleaf evergreen taxa.

This study determined the seasonal cold hardiness of leaves and stems of 9 *Ilex*, 5 *Osmanthus* and 3 *Prunus laurocerasus* taxa.

Materials and Methods

Shoots were collected from established outdoor plantings at Athens, Georgia on December 8, 1988, January 12, February 15, March 22, April 19, and May 16, 1989. *Ilex* taxa

[1]Received for publication September 11, 1989; in revised form December 28, 1989. The research reported here was supported, in part, by a grant from the Horticultural Research Institute, Inc., 1250 I Street, NW, Suite 50, Washington, DC 20005.

[2]Professor, Department of Horticulture

[3]Assistant Professor, Department of Horticulture, Georgia Experiment Station, Griffin, GA 30223.

were not collected on May 16. Ten cm (4 in) long shoots of current season's growth were removed from each plant on each day tested. Samples were placed in plastic bags moistened with wet paper towels and placed on ice for transport to Griffin, Georgia. Within 4 hrs of collection the plant samples were prepared for the freezing test. The leaves were removed and the terminal 7 cm (2.75 in) of each stem severed, wrapped in moist cheesecloth and placed into test tubes. Whole leaves were treated like the stems. The tubes were then submerged in ethylene glycol in a Forma Scientific Model 2425 temperature bath preset to -1.5 ± 0.5°C (29 ± 1°F). Stem temperatures were measured by thermocouples placed next to the stem or leaf and recorded by a Model CR7-X Campbell Scientific datalogger. The cheesecloth was nucleated with ice crystals and the temperature held constant at -1.5 ± 0.5°C (29 ± 1°F) for overnight (about 14 h), then the temperature was lowered at a rate of 4°C (7°F) per hour. Samples were removed from the bath at 3°C (5°F) intervals. Controls were prepared and kept on ice for the duration of the freezing test. Each tube contained 4 stem and leaf segments from each taxon sampled, thus each taxon was replicated 4 times at each temperature.

After thawing at 0° (32°F), the samples were removed from the tubes and incubated at room temperature and 100% R.H. for 10 to 14 days. At this time stems and leaves were visually evaluated for injury (6, 7, 10, 11, 13). Tissues showing brown discoloration and breakdown of cells in the cambium and phloem were rated as dead. The number of leaves and stems killed at each temperature was recorded and from these data the lowest survival temperature (LST) was determined. The LST (9) is the lowest temperature at which little or no injury is observed. The low temperature limit of the temperature bath was −30°C (−22°F), therefore, several taxa in midwinter were not killed and are reported as having a LST < −30°C (−22°F).

Results and Discussion

Ilex taxa showed large variations in cold hardiness (Table 1). The stems, with the exception of *I.* × *koehneana* 'Wirt L. Winn', *I. latifolia* and *Ilex* 'Lydia Morris' were as cold hardy or more so than the leaves. The differences between leaves and stems were greatest on the *Ilex* × *attenuata* and *I. opaca* taxa during the January and February tests. *Ilex opaca* was completely defoliated at −29°C (−20°F) in a protected courtyard on the Illinois campus, but refoliated the following spring (4). The same relationship occurred on 'Foster's #2' at Spring Grove in Cincinnati (4) after −32°C (−25°F). 'Foster's #2' is considered the most cold hardy of the *I.* × *attenuata* group and these data support this observation. 'Savannah' is popular in Zones 8 and 9 (12) and based on these data would not be suitable for Zone 6 and lower. *Ilex cassine* the other parent of the *Ilex* × *attenuata* grex along with *I. opaca*, is cold hardy to Zone 7 (−18 to −12°C) (0 to +10°F) (2,5). The increased hardiness in the hybrids is due to *I. opaca*.

No logical explanation for the apparent greater leaf cold hardiness of the earliest and latest samples of 'Wirt L. Winn', *I. latifolia*, and 'Lydia Morris' is known. *Ilex latifolia* is the other parent of 'Wirt L. Winn'. Unfortunately, the stem and leaf hardiness of *I. aquifolium* was not determined. Possibly the leaves of *I. aquifolium* are more cold hardy than the stems and this trait is transmitted to the hybrid progeny.

Ilex opaca and 'Greenleaf' were the most cold hardy taxa surveyed which parallels the species distribution in nature (5). 'Greenleaf', a light green leaf form with large brilliant red fruits is as cold hardy as the species. In mid-January the stems were cold hardy to −30°C (−22°F) or lower which suggests Zone 5 or greater adaptability. Over 1000 *Ilex opaca* cultivars are known (1). Logically, cold hardiness testing of new releases would prove valuable to nurserymen and gardeners.

'Nellie Stevens' is an outstanding tree type, lustrous dark green leaved, large red fruited holly that is hardy into Zone 6 to 7. (2). Currently, it is the most popular tree type evergreen holly in southern nursery production. The laboratory test results parallel the observed cold adaptability in the landscape (2).

Although these *Ilex* data varied from sample date to date, the relative differences among taxa within a specific date held true. Observed *Ilex* injury during the 1983–84 winter (3) essentially parallels the laboratory test results.

Osmanthus and *Prunus*. The cold hardiness of the various *Osmanthus* taxa was not as clear-cut as the *Ilex* taxa (Table 2). Generally, leaves were as cold hardy or hardier than stems. *Osmanthus americanus* acclimated earlier exhibiting the greatest hardiness on December 8 and January

Table 1. Lowest survival temperatures (LST) in °C(°F) for stems and leaves of 9 *Ilex* taxa from December 1988 to April 1989.

Ilex taxa	Dec. 8, 88		Jan. 12, 89		Feb. 15, 89		Mar. 22, 89		Apr. 19, 89	
	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves
	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)
× *attenuata* 'East Palatka'	−24[z](−11)	−18(0)	−24(−11)	−18[y](0)	−27[z](−17)	−9[y](16)	C[x]	—	—	—
× *attenuata* 'Foster's #2'	−24[z](−11)	−21(−6)	−30[z](−22)	−21(−6)	−27[z](−17)	−15(5)	−9[y](16)	−9[y](16)	C[x]	C[x]
× *attenuata* 'Savannah'	−21(−6)	−18(0)	−27(−17)	−18[y](0)	−15(5)	−15(5)	−9[y](16)	−9[y](16)	C[x]	C[x]
× *koehneana* 'Wirt L. Winn'	−15(5)	−18(0)	−18[y](0)	−21(−6)	−15(5)	−15(5)	−12(10)	−12(10)	C[x]	−6(21)
latifolia	−12(10)	−18(0)	−18[y](0)	−18[y](0)	−15(5)	−15(5)	−9[y](16)	−9[y](16)	C[x]	C[x]
'Lydia Morris'	−12(10)	−15(5)	−18[y](0)	−18[z](0)	−15(5)	−15(5)	−9[y](16)	−9[y](16)	C[x]	−6(21)
'Nellie R. Stevens'	−21(−6)	−18(0)	−21(−6)	−21(−6)	−18(0)	−15(5)	−15(5)	−12(10)	C[x]	−9(16)
opaca	−24[z](−11)	−18(0)	−30[z](−22)	−24(−11)	−27[z](17)	−15(5)	−9[y](16)	−9[y](16)	C[x]	C[x]
opaca 'Greenleaf'	−24[z](−11)	−18(0)	−30[z](−22)	−21(−6)	−27[z](27)	−15(5)	−9[y](16)	−9[y](16)	C[x]	C[x]

[z]Survived this temperature which was the lowest used on this date.

[y]Killed at this temperature, no samples removed at higher temperatures, other than control.

[x]Only control (C) survived.

Table 2. **Lowest survival temperatures (LST) in °C(°F) for stems and leaves of 5 *Osmanthus* and 3 *Prunus laurocerasus* taxa from December 1988 to May 1989.**

Osmanthus and *Prunus* taxa	Dec. 8, 88		Jan. 12, 89		Feb. 15, 89		Mar. 22, 89		Apr. 19, 89		May 16, 89	
	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves	Stems	Leaves
	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)	°C(°F)
Osmanthus americanus	−21(−6)	−21(−6)	−21(−6)	−21(−6)	$-15^y(5)$	$-15^y(5)$	−12(10)	$-9^y(16)$	C^x	C^x	—	—
Osmanthus x *fortunei*	−12(10)	−15(5)	$-18^y(0)$	$-18^y(0)$	−18(0)	−18(0)	−12(10)	−12(10)	C^x	−12(10)	C^x	C^x
Osmanthus heterophyllus	−15(5)	−15(5)	$-18^y(0)$	$-18^y(0)$	−18(0)	−18(0)	$-9^y(16)$	−18(0)	−6(21)	−9(16)	C^x	C^x
'Gulf Tide'	−12(10)	−18(0)	−21(−6)	$-21^y(-6)$	−24(−11)	−24(−11)	−15(5)	−18(0)	C^x	−12(10)	C^x	C^x
'Rotundifolius'	−15(5)	−15(5)	$-18^y(0)$	−18(0)	$-15^y(5)$	$-15^y(5)$	$-9^y(16)$	$-9^y(16)$	C^x	$-9^y(16)$	C^x	C^x
Prunus laurocerasus												
'Otto Luyken'	−15(5)	−18(0)	$-18^y(0)$	$-18^y(0)$	$-15^y(5)$	−21(−6)	−12(10)	−18(0)	−6(21)	−12(10)	C^x	C^x
'Schipkaensis'	−12(10)	−18(0)	$-18^y(0)$	$-18^y(0)$	−21(−6)	−21(−6)	−15(5)	−18(0)	−6(21)	−12(10)	C^x	−3(27)
'Zabeliana'	−15(5)	$-24^z(-11)$	$-18^y(0)$	$-18^y(0)$	−21(−6)	−24(−11)	$-9^y(16)$	−18(0)	−9(16)	−12(10)	C^x	C^x

[z]Survived this temperature which was the lowest used on this date.

[y]Killed at this temperature, no samples removed at higher temperatures, other than control.

[x]Only control (C) survived.

12. On January 12 and later, *O. heterophyllus* 'Gulf Tide' displayed equal or greater cold hardiness than *O. americanus. Osmanthus americanus* is considered the most cold hardy species and is growing successfully in Cincinnati, Ohio (2,3). During the 1983–84 winter, the leaves of *O.* × *fortunei* and *O. heterophyllus* 'Rotundifolius' were damaged or killed (3). However, stems and buds were not injured since new growth developed during spring. These data indicated the stems may be slightly less cold hardy than leaves. The reason for the superior cold tolerance of 'Gulf Tide' is unclear; however, the seed source is unknown and provenance was shown to affect cold hardiness of a particular plant (8). It is morphologically different than *O. heterophyllus* with a spinier leaf and a more upright habit.

Prunus. The laboratory tests indicated little difference among the *Prunus laurocerasus* cultivars although under landscape conditions, 'Schipkaensis' is considered the most cold hardy (2). 'Zabeliana' was the most cold hardy in our tests with 'Schipkaensis' next. Both 'Schipkaensis' and 'Zabeliana' were killed in outdoor plantings after exposure to −32°C (−25°F) in 1983–84 (3).

Literature Cited

1. ARS, USDA. 1973. International checklist of cultivated *Ilex*. Superintendent of Documents, U.S. Govt. Printing Office, Washington, D.C., 84 p.

2. Dirr, M.A. 1983. Manual of Woody Landscape Plants. Stipes Publishing Co., Champaign, Illinois, pp 826.

3. Dirr, M.A., G.E. Smith, D. Ehrlinger, T. Smith, and L. Thomas. 1984. Casualties and survivors of 1983–84's freeze. American Nurseryman 160(12):33–55.

4. Dirr, M.A., E. Friedhoff, and T. Smith. 1978. Plant hardiness evaluations. American Nurseryman 148(5):12–69.

5. Elias, T.S. 1980. Trees of North America. Van Nostrand Reinhold Co., New York, pp 948.

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

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

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

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

10. Smithberg, M.H. and C.J. Weiser. 1968. Patterns of variation among climatic races of redosier dogwood. Ecology 49:495–505.

11. 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.

12. U.S. Department of Agriculture. 1960. Plant hardiness zone map. USDA Misc. Publ. 814.

13. 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.