

ENVIRONMENTAL ADAPTATION AND ORNAMENTAL DISPLAY OF CORNUS FLORIDA ECOTYPES

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Abstract. A flowering dogwood (*Cornus florida*) rangewide provenance study was begun in 1972 in Michigan. One block was planted on an open hilltop and another under the shade of another plantation. Trees from 18 states were rated for fall color; from 15 states for cold hardiness, flowering, and presence of stem cankers. Northern seed sources were hardier when grown in the open than under shade. Fall color was best for northern sources grown in the open; shaded trees developed minimal color. Use of northern seed sources should provide hardier trees with better fall color displays and better flowering in northern landscapes.

Key words: *Cornus florida*, dogwood, cold hardiness, fall color, flowering, provenance, seed source.

The flowering dogwood, *Cornus florida*, is native over much of the eastern United States and possesses many desirable ornamental traits. Many flowering ornamental dogwood cultivars have southern origins(6). It is common practice for southern nurseries to collect seeds in southern areas and sell the resulting seedlings to nurseries in the north. There is some question about how far a species can be moved and still be successful.

Dirr et al(2) observed severe winter freeze damage to flowering dogwood during the winters of 1976-77 and 1977-78 and concluded that "the southern-grown dogwood are too much a part of the northern landscape; plants need to be grown from northern seed sources." If so, do the hardier trees from various sources differ in their ornamental value? The following research was conducted to answer these questions.

Materials and Methods

The flowering dogwood trees in the study were in a rangewide provenance plantation established by J. Kielbaso and J. Wright from seed collections in 1972, and outplanted in 1975 at the W. K. Kellogg Research Forest in Augusta, MI. The approximate collection sites in each state are

shown in Figure 1. Seeds were collected from 191 single trees, or groups of trees, and sown in the Tree Research Center nursery in the fall of 1972. They were collected from points representing the entire range, though this was not a saturated sampling. There were 18 states represented with at least 89 collections. A total of 873 two-year-old trees were planted in four blocks. One of the blocks, containing 274 trees, was on an open hilltop, providing exposed growing conditions. The 298 trees in a second block were growing in the shade of Scotch pines and were therefore more protected, but received less solar radiation. The trees in this block were lost when the overstory of Scotch pine was removed in 1988. The remainder were planted in two blocks, containing 177 and 124 trees respectively, that were partially in frostpockets.



Figure 1. Collection sites for *Cornus florida* seeds. Collection sites are denoted with black dot, W. K. Kellogg Forest with an open square, and East Lansing, Michigan with a black square.

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Trees from 18 different states were rated for fall color in 1979–81. Trees from 15 states were tested for cold hardiness in the winter of 1981–82, and rated for flowering in 1989–91 and presence of canker in 1990. The cold hardiness tests only included trees from the two largest blocks.

Cold hardiness assessment. At several intervals during the dormant season of 1981–82, twig tissues were collected and cold hardiness determined in the lab. Samples were collected from the south side of each selected tree at the same height and tree sector, placed in pre-cooled styrofoam containers, and transported at or near field ambient temperature to the laboratory.

Three-inch twig segments from the basal portion of current season growth were organized as reported elsewhere(3). Following procedures described by McKenzie and Weiser(4), moistened cheesecloth was placed in contact with the twig sections to inoculate the tissues with ice crystals and thereby prevent supercooling. The twig sections were then wrapped in aluminum foil and placed in styrofoam containers. They were suspended by tape to avoid touching the sides of the container. Samples were frozen in a controlled temperature freezer and tissue temperature monitored via a 26 ga. copper constantan thermocouple taped to the side of a representative twig. Twigs were organized into several groups (5-6) and the freezer temperature reduced at 3°C per hour. The range of temperatures was selected so that the warmest temperature would hopefully cause no damage and the coldest temperature would be lethal to all. The test intervals were 3°C (5°F).

When a container, and the twigs in it, reached the selected temperature within the range, it was removed from the freezer and placed in a refrigerator where it slowly returned to 1.5°C over a 24 hour period.

After thawing, the twigs were transferred to humidity chambers at room temperature, approximately 19°C (66°F) and aerated daily for one week. Unfrozen controls had been placed in a humidity chamber at the time samples were prepared for freezing. One week later, samples were evaluated for tissue browning under a binocular scope to determine viability following recognized

procedures(7).

T_{50} values (the temperature at which 50% of the samples are killed) were calculated using the modified Spearman-Kärber equation (1) and were analyzed using Chi square at $p=0.05(5)$ using pairwise comparisons.

Fall color evaluation. During the autumn of 1979, 1980 and 1981, the trees were rated for the amount of foliage showing fall color, color intensity and leaf abscission. The rating for each characteristic was 0-9. The ratings began in early September and continued at weekly intervals until either 100% abscission or leaf freezing had occurred.

Fall color display was rated having three components: 1) the percentage of leaves colored, 2) the leaf color developed, and 3) the percentage of leaf abscission. "Best" fall color display was subjectively determined to occur when 70% of the leaves were colored, when the color was red (7,8, or 9 ratings), but prior to 60% leaf abscission.

Flowering evaluation. Flower production of trees on the open hilltop was rated in 1989, 1990, and 1991. Flower production was rated using a 1-5 rank system. Trees rated a 5 had exceptional flower displays, with trees rated 1 having no flowers.

Canker evaluation. The number of cankers on the open hilltop trees was observed and rated during 1990. Trees were rated 1 if they had no cankers, 2 if there was moderate infection and 3 if the infection was heavy. No dogwood anthracnose was observed or identified from samples taken.

Results

Cold hardiness assessment. The results of the cold temperature tests are presented in Table 1, which compares data for seed sources grouped by state and region growing on the open hilltop or shaded by Scotch pines. Trees from all sources had developed little hardiness by early September, when the hardiest trees survived -6°C but not -9°C (data not shown).

The February 1, 1982 data provide information about maximum low temperature hardiness (Table 1). All controls were alive except for two from Illinois (data not shown), which suggests that some winter injury had occurred prior to February

Table 1. A comparison of open hilltop and shade grown trees. T_{50} of *Cornus florida* twigs sampled from trees grown from seeds of different geographic origin. Trees were grown in a provenance planting in Kalamazoo County Michigan. 2-1-82.

Origin (Seed source)	T_{50}	
	Open hilltop	Shade grown
Northern and northern Appalachian states		
Pennsylvania	-34.5a	-33.0ab
Michigan	-34.5a	-33.0ab
Virginia	-34.5a	-26.5 b
W. Virginia	-34.5a	-26.0 b
Ohio	-34.5a	-34.5a
mean	-34.5	-30.6
Central and coastal plain states		
Maryland	-34.5a	
Connecticut	-25.5 c	-28.5ab
Missouri	-27.5 bc	-34.5a
Illinois	-26.5 bc	-34.5a
New Jersey	-34.5a	-34.5a
Kentucky	-33.5ab	-34.5a
mean	-30.3	-33.3
Southern states		
Georgia	-28.5abc	-30.0ab
Tennessee	-30.5ab	-30.0ab
mean	-29.5	-30.0

a) T_{50} 's were separated by Chi-Square at $p=.05$. T_{50} 's followed by the same letter are not significantly different.

1. The northern trees were completely hardy to -33°C (-27°F), while some others were killed at all test temperatures colder than -27°C (-17°F), notably Connecticut, Missouri, Georgia, and Illinois. Trees from all sources were killed at the -36°C (-33°F) test temperatures.

Louisiana, Mississippi and Texas trees were not included in the cold hardiness assessments. Trees from these three states were observed to be injured by autumn frosts and died back to the ground or snow line each winter, thus providing ample evidence of their lack of adaptability to Michigan growing conditions. They actually survived under the snow and assumed a modified, vine-like growth habit.

Flowering dogwood is considered to be an understory tree, most suitable for use in the shade, but not on exposed sites. The data in Table 1 do not support this assumption. Northern trees

were hardiest on the open hilltop. The southern, central and coastal-plain-state trees were hardier when grown in the shade.

Fall color evaluation. Using the criteria described earlier, length of fall color display was assessed. Table 2 presents the mean number of days of fall color display for flowering dogwood trees from various geographic origins growing on an open hilltop. Trees from the northern and northern Appalachian states had the longest fall color display.

The poor fall color display of the Indiana and Illinois sources, as compared to Ohio trees, may be explained by the fact that collection sites for seeds in these states were along their southern borders (Figure 1). Ohio collection sites were farther north.

The data in Table 2 are for open grown trees only. Shaded trees from all seed sources failed to develop a significant red fall color display. Shaded trees had a yellow fall color with only a small portion of red on some leaves.

Flowering. Flowers are the main ornamental display of *Cornus florida*. The flowering data, presented in Table 2, indicate that at this Michigan site the best flower displays are generally obtained from northern trees, especially those from Pennsylvania and Ohio, followed by Maryland, New Jersey, West Virginia and Michigan. Southern trees produced no or only scattered flowers.

Canker susceptibility. Cankers were seen in at least some trees from all states but were most numerous on southern trees. Samples of the cankers were identified as *Phomopsis* and *Diplodia* by the MSU Diagnostic Laboratory

Survival. Table 2 lists the percentage of trees planted on the open hilltop that were still alive in 1991 based on the number planted in 1975. The trees most resistant to cold injury, as measured by T_{50} , had higher percentages of survival than less cold resistant trees. An exception is the group of trees from West Virginia which had excellent cold resistance but only 67% survival and Missouri trees that had 100% survival despite a lesser T_{50} .

Discussion

Northern dogwoods have about 5°C (9°F) more cold tolerance than the southern dogwoods,

Table 2 Summary of ratings for *Cornus florida* growing on an open hilltop in Michigan, ranked by T₅₀.

Origin (Seed source)	Feb T ₅₀ 1982	Canker rating ^a	Flower rating ^b	Fall leaf color ^c	% Alive ^d
New Jersey	-34.5	1.0	3.7	14	100
Michigan	-34.5	1.8	3.5	15	92
Pennsylvania	-34.5	1.8	4.3	12	80
Ohio	-34.5	1.9	4.0	9	88
Virginia	-34.5	2.0	3.2	16	95
Maryland	-34.5	2.1	3.8	13	88
W. Virginia	-34.5	2.4	3.7	12	67
Kentucky	-33.5	2.4	2.4	11	88
Tennessee	-30.5	2.3	2.5	0	71
Georgia	-28.5	2.4	1.3	2	27
Missouri	-27.4	2.0	3.3	2	100
Illinois	-26.6	2.6	3.3	2	91
Connecticut	-25.5	1.3	2.6	11	86
Alabama	—	2.8	1.9	11	50
Texas	—	2.9	1.3	—	39
Louisiana	—	—	—	—	0
Mississippi	—	—	—	—	0

a. 1990

b. 1989,1990,1991

c. Mean number of days with red leaves, 1979,1980,1981

d. Trees were counted as dead if they were killed back to the ground each year but sent up sprouts each spring, 1991.

based on the February T₅₀s of the trees on the open hilltop. Trees from the central and coastal plain states groups were intermediate, with some individual trees closer to the northern or southern group, but not significantly different overall from the southern group.

Only one southern seed source (Alabama) developed a significant color display, but it also had significant cankering and a low flower rating. Trees from central seed sources were intermediate in display. The display was less than half as long as trees from northern seed sources (Table 2).

Using northern seed sources should provide hardier trees that consistently produce substantially longer red fall color displays and better flowering in northern landscapes.

These results suggest that the best seed source for flowering dogwood will be found near the collection sites indicated in Figure 1 in one of the

top six or seven states. The New Jersey seed source unfortunately represents only a single tree collection site, and is therefore suspect, whereas the other five states are better represented.

It appears that we should rethink the notion that dogwood is only an understory tree, especially in light of the cold hardiness work and fall color display, which were both better in open stands, and the fact that good flowering occurs in the open.

Literature Cited

1. Bittenbender, H. C., and G.S. Howell, Jr. 1974. *Adaptation of the Spearman-Kärber method for estimating the T50 of cold stressed flowers buds.* J. Am. Soc. Hort. Sci. 99(2):187-190.
2. Dirr, M. A., E. Friedhoff, and T. Smith. 1978. *Plant hardiness evaluations.* American Nurseryman 148(5):12
3. Heatley, R. C. 1986. Genetic variation of *Cornus florida* in a Michigan provenance test. Ph.D. Dissertation, Michigan State University.

4. McKenzie, J. S., and C.J. Weiser. 1975. *Technique to inoculate woody plant stem sections with ice during artificial freezing*. Can. J. Plant Sci. 55:651–653.
5. Meddis, R. 1975. *A Statistical Handbook for Non-statisticians*. pp.83–85. McGraw–Hill Book Company (UK) Limited. Maidenhead, Berkshire, England.
6. Santamour, F. A. and A.J. McArdle. 1985. *Cultivar checklist of the large-bracted dogwoods: Cornus florida, C. kousa, and C. nuttallii*. J. Arboric. 11(1):29–36.
7. Stergios, B. G., and G.S. Howell. 1973. *Evaluation of viability tests for cold stressed plants*. J. Amer. Soc. Hort. Sci. 98:325–330.

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