Susceptibility of Flowering Dogwood of Various Provenances to Dogwood Anthracnose

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ABSTRACT

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Seedlings from 20 provenances of flowering dogwood (*Cornus florida*) showed progressive development of leaf spot and dieback when subjected to natural infection by *Discula* sp., the causal agent of dogwood anthracnose. Following exposure for two growing seasons, 88 of 120 provenance seedlings (73.3%) were dead, as were 35 of 54 seedlings (64.8%) from intraspecific crosses. Main stems of the remaining seedlings had died back, and the only leaves produced were on epicormic shoots. These results indicate that there may be no host genetic barriers to the continued expansion of the geographic range of the disease. Seedlings of the Chinese dogwood (*C. kousa*) exhibited leaf spot but no dieback.

Dogwood anthracnose, caused by a fungus in the genus *Discula*, has become a major disease of native and planted flowering dogwood (*Cornus florida* L.) in the northeastern United States (1,2,3,5). A similar malady, probably caused by the same pathogen, has been reported on native *C. nuttallii* Aud. in the Pacific Northwest (6). In both areas, the Asiatic *C. kousa* Hance has been observed to be far less susceptible than the native American species (2,6).

Mielke and Langdon (4) provided data showing the potential destructiveness of this disease on *C. florida*. They surveyed native trees in Catoctin Mountain Park, Thurmont, Maryland, in 1984, 1 yr after the disease was diagnosed there. In their sample, nearly one-third of all dogwoods were dead, and only 3% were free of symptoms. From the progression of tree decline over 3 yr in one study plot, they predicted that most of the native dogwoods in the park would be dead within the next 3 yr.

On 17 October 1985, we established in Catoctin Mountain Park two test plots with seedlings of *C. florida* of known geographic origins and seedlings from controlled intraspecific pollination. Inasmuch as the disease had been reported from only a few states in the northeastern portion of the range of this species, we wanted to determine if variation in natural resistance might be found when a wide range of diverse germ plasm was tested.

MATERIALS AND METHODS

Seeds of *C. florida* from various areas throughout its range were selected from among the hundreds of seed collections sent to the U.S. National Arboretum in 1982 by scientists and private citizens as part of a dogwood and cherry seed exchange between the United States and Japan. Seedlings from 38 sources were planted at Beltsville, Maryland, in 1983. In October 1985, enough seedlings remained from each of 20 provenances to be used in tests of susceptibility to anthracnose. These seedlings were 3 yr old from seed and were growing in 1-L plastic containers in a soil-peat-vermiculite mixture (2:1:1).

Each provenance group consisted of seedlings from one tree in each collection area, with single seed lots from Alabama, Arkansas, Connecticut, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, New Jersey, North Carolina, Ohio, Pennsylvania, and Virginia, and two seed lots apiece from Michigan, Missouri, and Oklahoma. Thus, although these progenies represented a wide range of potential genetic variation, they were not indicative of the full range of variability that might be present in any locality.

Another group of seedlings was derived from controlled intraspecific crosses that we made in 1983. Container-grown seedlings (2 yr old) of nine progenies were used in the anthracnose tests. In addition, seedlings from one seed lot of *C. kousa*, obtained in the exchange program, were available for testing.

The test was conducted in two replicate plots, each overhung by the dying crown of at least three anthracnose-affected dogwoods, in a natural area. Three seedlings from each of the 30 seed lots were completely randomized in each plot. Because of the rocky terrain and the absence of sufficient soil, we could not plant the seedlings in the normal fashion. Instead, the containerized seedlings, with the bottoms of the plastic containers removed, were placed in nine rows of 10 trees directly on the forest floor, with about 10 cm between containers. Open-bottom wood frames 3.1 × 3.7 m with sides 46 cm high were constructed around the trees, and the entire framed area was heavily mulched with hardwood chips. A deer-proof wire enclosure was erected around each replicate.

Observations and disease ratings were made on 27 May, 24 June, 23 July, and 4 September 1986; 24 June and 4 September 1987; and 23 June 1988. Confirmation of identification of the fungus as *Discula* sp. was made by Craig R. Hibben (Brooklyn Botanic Garden Research Center, Ossining, NY) from specimens supplied in 1988.

RESULTS AND DISCUSSION

No anthracnose symptoms were observed on the test seedlings and the native trees in May and June 1986. Possibly the dry weather during the spring months was not conducive to the spread of the pathogen. Widespread infection was noted on 23 July 1986; it was obvious that symptoms were progressing rapidly, and critical scoring was deferred until later. Some blighted leaves had already dropped or were falling from the branches in July. Leaf drop has not been considered a typical symptom of dogwood anthracnose in larger plants, but the massive infection of the seedlings after heavy rains in late June and early July did result in leaf loss.

Evaluations made in September 1986 were confined to the leader and the upper whorl of branches on each seedling, an average of 13 nodes per seedling. The number of leaves that had been lost following infection was easily calculated because of the normal opposite branching pattern of dogwood. Leaves remaining on the seedlings were rated healthy or infected (with leaf spots). The percentage of leaves lost and the percentage of leaves infected were calculated for each seedling, and the data were subjected to a square root transformation and analyzed by ANOVA. Data for the provenance seedlings were analyzed separately from data for the controlled-pollination progenies.

Data for the provenance seedlings are given in Table 1. Aside from *C. kousa*, which appeared to be highly resistant to infection, the various seed lots exhibited significant variability in symptom

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Table 1. Leaf loss and leaf infection in seedlings of progenies of *Cornus florida* and *C. kousa* after one season's exposure to natural infection by the dogwood anthracnose pathogen

Species	State of origin	Leaf loss[x,y] (%)	Leaf infection[x,z] (%)
florida	Maryland	95.0 a	100.0
	Oklahoma	70.3 ab	99.4
	Virginia	60.9 ab	100.0
	Missouri	56.8 ab	96.7
	Michigan	55.1 abc	93.7
	Connecticut	54.4 abc	83.7
	New Jersey	53.5 abc	90.6
	Alabama	43.4 abc	93.1
	Ohio	41.6 bc	96.4
	Pennsylvania	39.2 bc	96.8
	Kentucky	38.1 bcd	90.4
	Michigan	37.6 bcd	98.1
	Florida	33.7 bcd	90.6
	Louisiana	23.0 bcd	83.7
	Mississippi	22.6 bcd	73.8
	North Carolina	21.9 bcd	87.2
	Georgia	21.1 bcd	82.8
	Arkansas	13.6 cd	82.7
	Missouri	11.4 cd	84.8
	Oklahoma	10.5 cd	83.8
kousa		0.0 d	28.8

[x] Data of 4 September 1986.
[y] Means followed by the same letter are not significantly different according to Duncan's multiple range test ($P = 0.05$).
[z] Spotted leaves plus lost leaves.

expression as measured by leaf loss alone but little variability when leaf infection (lost leaves plus spotted leaves) was considered. Of specific interest were the difference in leaf loss between the two seed lots from Missouri and the difference between the two from Oklahoma, indicating that, at least for this factor, the genetic characteristics of the mother tree were probably more important than geographic origin (i.e., genetic variation within provenances was probably greater than variation between them).

From a genetic point of view, we hoped that leaf loss might be a key factor in determining the survival of the plants. Of the 120 provenance seedlings of *C. florida*, 19 sustained no leaf loss; 11 of these seedlings were from seed lots with losses averaging less than 30%, but eight other seed lots had one plant each in this category. Thus, the early data suggested the possibility of a reasonable germ plasm base for further selection and breeding. However, only eight seedlings, one from each of eight different seed lots, had more healthy leaves than infected leaves. There was significant variation in leaf loss among the nine controlled-pollination progenies, but the progeny range was only 6.5–53.1%. Total leaf infection (lost leaves plus spotted leaves) for these progenies averaged 81.5%; only two of the 54 seedlings had more healthy than infected leaves. Leaf infection, in the form of small circular lesions (less than 1 mm in diameter), did occur on *C. kousa*. About 29% of the leaves were spotted, but there were no significant differences among seedlings and no evidence of leaf loss.

The test plots were reevaluated on 24 June 1987. Of the provenance seedlings, 32 were dead, and the 1986 terminal and lateral growth in the upper whorl had died back on all but one of the living seedlings. Mortality tended to be correlated with the percentage of leaves lost as noted in September 1986: 15 of 17 seedlings that had lost 90% or more of their leaves, and 21 of 29 that had lost 70% or more, were dead in June 1987. The other 11 dead trees were rather evenly divided among the other categories of leaf loss, even including three that had been rated 0 for leaf loss. Considerable leaf infection and wilting of the living seedlings were observed, and the plants were rated subjectively in three disease categories (light, moderate, and severe). More than half the remaining seedlings were rated severe. Seedlings of *C. kousa* showed no dieback in June 1987 and were growing vigorously with no apparent leaf spotting. Mortality was lower among the seedlings derived from controlled pollination, with only eight of the 54 plants dead. Again, however, more than half the living plants were given a severe disease rating.

By 4 September 1987 the number of dead provenance seedlings had increased from 32 to 61, and 11 more plants were rated severe. The number of dead progeny seedlings had risen from eight to 12 plants, and 14 plants were given a severe rating. Thus, more than 50% of the *C. florida* seedlings were dead or dying (98 of 174 plants). All leaves of all seedlings (except the youngest pair on each branch) had leaf spots. Leaf spotting of *C. kousa* in 1987 (40%) was slightly higher than in 1986 (29%) but ranged from 5 to 90% among the six seedlings.

Seedling mortality was clearly not attributable to differences in cold-hardiness of plants from the various provenances. Survival after the first winter was 100%. Mortality in the autumn of 1987 was nearly 50% and approximated this level in three groups resulting from a classification of each provenance as northern, southern, or western. Individual seed lots with less than 50% mortality included those from Alabama, Arkansas, Georgia, Ohio, and Michigan.

Our final evaluation was made on 23 June 1988, 32 months and two full growing seasons after the test began. Mortality among the provenance seedlings was 73.3% (88 of 120 plants); among the controlled-pollination seedlings, 64.8% (35 of 54 plants). The only green leaves on the surviving seedlings were on epicormic shoots, which arose from the basal portions of the main stems. Leaf spots were noted on all leaves of *C. florida*. Seedlings of *C. kousa*, even the plant with leaf spots on 90% of its leaves in 1987, were growing vigorously and exhibited no dieback or leaf infection.

These results indicate that there is probably little hope for the selection and development of anthracnose-resistant plants in *C. florida*. Furthermore, if the disease continues to spread throughout the native range of flowering dogwood, growers should be cautioned against premature judgments on the relative resistance of plants that may merely have escaped infection.

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