SUSCEPTIBILITY OF CULTIVARS AND HYBRIDS OF KOUSA DOGWOOD TO DOGWOOD ANTHRACNOSE AND POWDERY MILDEW

by Thomas G. Ranney, Larry F. Grand[1], and John L. Knighten[2]

Abstract. Twenty taxa of dogwood including cultivars of kousa dogwood (*Cornus kousa*) and cultivars of hybrids between flowering (*Cornus florida*) and kousa dogwoods were evaluated for susceptibility to dogwood anthracnose (*Discula destructiva*) and powdery mildew (*Microsphaera pulchra*). Trees were grown under the canopy of a native stand of flowering dogwood that was infected with both diseases and were also inoculated artificially with spores of *D. destructiva*. None of the taxa were found to be immune to dogwood anthracnose, yet there was considerable variation in resistance to the disease. *Cornus kousa* 'Steeple', a clone of *C. kousa* 'Milky Way', *C.* x Stardust®, *C.* x Stellar Pink®, and *C.* x Celestial™ were found to be resistant to dogwood anthracnose as indicated by ≤ 1% of total leaf area affected, 100% survival through the following spring, and no detection of *D. destructiva* in woody tissue. The *C. kousa* cultivars 'Wolf Eyes', 'Moonbeam', and 'Autumn Rose' and seedlings of *C. florida* were highly susceptible with 100% of the total leaf area affected and 100% mortality by the following spring. The other taxa were intermediate in susceptibility to *D. destructiva*. Only five of the taxa: *C. kousa* 'Elizabeth Lustgarten' and 'Steeple' and the hybrids *C.* x Stardust®, *C.* x Constellation®, and *C.* x Ruth Ellen® were infected by *M. pulchra*.

Under favorable disease conditions, *D. destructiva* can be an aggressive pathogen of flowering and mountain (*C. nuttallii*) dogwoods (5,6,13,14,21). Since early accounts of the disease in the late 1970s (3), dogwood anthracnose has spread throughout much of the Northeastern and Northwestern United States and has caused extensive mortality in some areas (7,17,20).

Evaluation of several species of dogwood has shown considerable variation in susceptibility to *D. destructiva* (22). Kousa dogwood has generally been found to be more resistant to dogwood anthracnose than is flowering dogwood (8,16); however, variation in resistance among taxa of kousa dogwood has been noted. For example, Windham and Trigiano (22) reported that one selection of kousa dogwood *(C. kousa* var. *chinensis)* was relatively susceptible to *D. destructiva* while another unnamed selection was resistant. Identification of taxa of kousa dogwood and related hybrids with greater resistance to dogwood anthracnose would provide information for selecting disease resistant dogwoods for planting in areas where the disease is prevalent.

Powdery mildews are also common diseases on dogwoods (12). Although powdery mildews generally occur late in the growing season and seldom cause mortality, powdery mildew fungi are obligate parasites that can cause stunted, distorted growth and can be undesirable aesthetically (18). Identification and selection of taxa with natural resistance to powdery mildews would minimize this problem in the landscape.

Kousa dogwood is a popular, large-bracted dogwood valued as a landscape plant (9). There are currently over 80 cultivars of kousa dogwood that have been selected primarily for ornamental characteristics (9,15,19). Selections of hybrids between C. *kousa* and *C. florida* have also been made (11). Little information, however, is available on variations in disease resistance among these plants. The objective of this research was to evaluate 20 different taxa of dogwood including cultivars of C. *kousa* and hybrids of *C. kousa* x *florida* for resistance to dogwood anthracnose and powdery mildew.

Materials and Methods

Plants were propagated in 1992. Kousa dog-

1. Departments of Plant Pathology and Forestry, North Carolina State University, Raleigh, NC 27695
2. USDA Forest Service, Forest Pest Management, Asheville, NC 28804

woods and hybrids between flowering and kousa dogwood were grafted onto seedling rootstocks of kousa dogwood. Flowering dogwoods were grown from seed. Cultivars of kousa dogwood included: 'Autumn Rose', 'Big Apple', 'China Girl', 'Elizabeth Lustgarten', 'Gay Head', 'Greensleeves', 'Julian', 'Milky Way', 'Milky Way Select', 'Moonbeam' (P.P. No. 3482), 'Steeple', 'Temple Jewel', and 'Wolf Eyes' (syn. 'Princeton Varigated'). See Jaynes et al. (9), Orton (11), and Santamour and McArdle (15) for cultivar descriptions. The cultivar designation 'Milky Way' does not necessarily represent an individual clone (10). 'Milky Way' is a cultivar name given to a group of seedlings grown from open pollinated sources. 'Milky Way' has since become a common plant in the nursery industry and is propagated by sexual and asexual means resulting in an ambiguous cultivar designation describing variable genotypes. The 'Milky Way' plants included in this experiment were clonal and were propagated from a single 'Milky Way' tree. Similarly, 'Milky Way Select' is a clonal selection originating from a seedling of 'Milky Way' (9).

Hybrids between kousa and flowering dogwoods included: Aurora® (*C. x* 'Rutban', P.P. No. 7205), Constellation® (*C. x* 'Rutcan', P.P. No. 7210), Celestial™ (*C. x* 'Rutdan', P.P. No. 7204; formerly called Galaxy), Ruth Ellen® (*C. x* 'Rutlan', P.P. No. 7732), Stardust® (*C. x* 'Rutfan', P.P. No. 7206), and Stellar Pink® (*C. x* 'Rutgan', P.P. No. 7207). See Orton (11) for descriptions. In addition, seedlings of flowering dogwood were included for comparison.

In the spring of 1993 trees were transplanted

Table 1. Disease severity ratings including: percent of leaves infected per plant (P), average percent of area affected on infected leaves (L), and percent of total leaf area affected per plant (P x L) for *Discula destructiva* evaluated on 20 taxa of dogwoods during a 4 month period in 1993.

	May 27			June 24			Aug. 2			Sept. 7			Oct. 20		
Taxa	P	L	P x L	P	L	P x L	P	L	P x L	P	L	P x L	P	L	P x L*
C. k. 'Steeple'	0	0	0	3	2	0	7	12	2	7	5	0	10	5	0
C. x Stardust®	0	0	0	1	2	0	2	10	0	5	5	0	7	7	1
C. x Stellar Pink®	0	0	0	1	2	0	1	8	0	12	8	1	12	5	1
C. k. 'Milky Way'	0	0	0	0	0	0	6	22	2	10	7	1	8	7	1
C. k. 'Milky Way Select'	0	0	0	1	15	0	4	10	1	8	8	1	15	5	1
C. x Celestial™	0	0	0	2	7	0	2	7	0	17	5	1	20	5	1
C. k. 'Gay Head'	0	0	0	0	1	0	5	13	1	17	20	6	30	8	2
C. x Constellation®	0	0	0	2	4	0	2	10	1	23	8	2	38	7	3
C. k. 'Julian'	0	0	0	0	0	0	0	0	0	15	7	1	35	10	3
C. k. 'Temple Jewel'	0	0	0	1	5	0	7	22	2	22	10	2	35	15	6
C. *k.* 'Eliz. Lustgarten'	0	0	0	10	15	1	20	30	6	85	15	13	95	15	14
C. *k.* 'Big Apple'	0	0	0	11	14	2	39	20	9	64	22	15	96	25	24
C. x Aurora®	0	0	0	2	3	0	3	5	0	38	10	5	52	38	35
C. *k.* 'China Girl'	0	0	0	3	9	0	5	18	1	42	10	7	53	40	35
C. x Ruth Ellen®	0	0	0	6	9	1	21	23	5	55	32	25	62	40	37
C. *k.* 'Greensleeves'	0	0	0	35	17	5	40	22	8	83	48	45	100	55	55
C. *k.* 'Autumn Rose'	22	12	8	22	22	7	65	17	16	100	72	72	100	100	100
C. *k.* 'Moonbeam'	0	0	0	47	20	12	82	50	46	100	77	77	100	100	100
C. florida	2	2	0	7	22	2	100	100	100	100	100	100	100	100	100
C. k. 'Wolf Eyes'	38	37	24	99	90	89	100	100	100	100	100	100	100	100	100
$LSD_{0.05}$	20	18	15	26	16	10	32	25	20	34	34	34	37	40	42

*P x L was calculated as the mean of the products of P and L for each replicate. For that reason, the product of the mean P and mean L will not necessarily equal P x L.

into 19 liter (5 gal) containers with a 10:1 (v:v) pine bark : river sand substrate, amended with 4 kg/m^3 (7 lb/yd^3) dolomitic limestone and 3 kg/m^3 (5 lb/yd^3) of 13N - 2.6P - 5K fertilizer (Pro-Start, 13-6-6, Sta-Green Plant Food Co., Inc., Sylacauga, AL). At the time of transplanting, plants ranged in height from 45 - 90 cm (18-35 in).

On May 11, 1993 plants were moved to the U.S. Forest Service, Bent Creek Experimental Forest, Asheville, NC and placed in a mixed hardwood forest beneath the canopy of a grove of native flowering dogwoods that were infected with *D. destructiva* and powdery mildew. The containerized plants were arranged in a completely randomized design, with 3 - 4 replicate trees per taxa. Photosynthetically active radiation was approximately 10 - 15% of full sunlight as measured with a quantum sensor (LI-COR, Inc., Lincoln, Neb.). Plants were fertilized with an additional 13 g (0.46 oz) / tree of 12N - 2.6P - 5K (Nursery Special, 12-6-6, Sta-Green Plant Food Co., Inc.) in mid May 1993 and irrigated as needed.

In addition to naturally occurring inoculum, plants were artificially inoculated with a suspension of *D. destructiva* spores (conidia) in water applied with a hand held sprayer on May 27 and June 24, 1993 with 10,000 and 20,000 spores/ml, respectively. Spores were obtained from infected flowering dogwoods growing at the Bent Creek Experimental Forest.

Plants were periodically rated for disease severity throughout the growing season based on a rating system used by Anderson et al. (1). Ratings included visual estimates of 1) the percentage of leaves showing symptoms per plant (P) and 2) average percent of leaf area affected on diseased leaves (L). The product of these two factors (P x L) was also calculated to provide an estimate of the percent of total leaf area affected per plant.

Infection by *D. destructiva* was confirmed on symptomatic tissue based on morphology of acervuli and conidia (13). Leaf samples were examined during the 1993 growing season while twig samples were examined in the spring of 1994. If acervuli were not present on symptomatic tissue, samples were placed on wet towels in plastic boxes in an incubator at 20°C to induce sporulation. Identification of powdery mildew was confirmed based on morphology of cleistothecia, conidia, and host specificity (2,4). Symptomatic leaves were collected and examined periodically during Oct. and Nov. 1993.

In Nov. of 1993, plants were moved to an overwintering structure covered with polypropylene fabric for the winter. On Jan. 31, 1994 the plants were moved into a heated greenhouse at day / night temperatures of 24°C (75°F) / 18°C (65°F), with natural photoperiod, to force growth and to evaluate survival and shoot infection for dogwood anthracnose.

Results and Discussion

Dogwood anthracnose. Disease symptoms of dogwood anthracnose were first observed in

Table 2. Percent plant survival and confirmation of Discula destructiva from leaves (1993) and stems (1994).

Taxa	Survival (%)		Pathogen confirmation	
	Fall 1993	Spring 1994	Leaves	Stem
C. k. 'Steeple'	100	100	+	-
C. x Stardust®	100	100	+	-
C. x Stellar Pink®	100	100	+	-
C. k. 'Milky Way'	100	100	-	-
C. k. 'Milky Way Select'	100	66	-	+
C. x Celestial™	100	100	+	-
C. k. 'Gay Head'	100	33	+	+
C. x Constellation®	100	33	+	+
C. k. 'Julian'	100	50	-	+
C. k. 'Temple Jewel'	100	66	-	+
C. k. 'Eliz. Lustgarten'	100	100	+	-
C. *k.* 'Big Apple'	100	75	-	-
C. x Aurora®	100	66	+	-
C. *k.* 'China Girl'	66	66	-	+
C. x Ruth Ellen®	66	33	+	+
C. *k.* 'Greensleeves'	66	33	+	+
C. *k.* 'Autumn Rose'	33	0	+	+
C. *k.* 'Moonbeam'	0	0	+	+
C. florida	0	0	+	-
C. k. 'Wolf Eyes'	0	0	+	+
$LSD_{0.05}$	45	71	N/A	N/A

*+ indicates confirmation of the presence of *Discula destructiva* and - indicates that *D. destructiva* was not confirmed.

May of 1993 on three taxa (Table 1). From May to the end of October, all plants eventually developed symptoms of dogwood anthracnose. The kousa dogwood cultivars 'Wolf Eyes', 'Moonbeam', and 'Autumn Rose' and the flowering dogwood seedlings were found to be highly susceptible with 100% of the total leaf area affected per plant by Oct. 20, 1993. These susceptible plants were typically infected early and suffered from rapid spread of the disease. Plant survival in the fall of 1993 for 'Wolf Eyes', 'Moonbeam', 'Autumn Rose', and C. *florida* was 0, 0, 33, and 0%, respectively (Table 2). Dogwood anthracnose was confirmed on leaves of all of these taxa (Table 2). Following overwintering, there were no surviving plants of these four taxa and dogwood anthracnose was confirmed in stems of all these taxa except flowering dogwood which was severely decomposed. In contrast, the taxa 'Steeple', Stardust®, Stellar Pink®, 'Milky Way', and Celestial™ were more resistant to dogwood anthracnose as indicated by ≤ 1% of total leaf area affected, 100% survival through the following spring, and no detection of the *D. destructiva* in stem tissue. The remaining cultivars including 'Milky Way Select', 'Gay Head', Constellation®, 'Julian', 'Temple Jewel', 'Elizabeth Lustgarten', 'Big Apple', Aurora®, 'China Girl', Ruth Ellen®, and 'Greensleeves' were intermediate in resistance.

Disease pressure in this experiment was relatively heavy as indicated by rapid infection, disease progression, and death of flowering dogwood and some cultivars of kousa dogwood. Although none of the taxa were immune to the disease, infection on the more resistant cultivars was confined to localized lesions and did not appear to invade woody tissue.

Many trees died during the winter period suggesting that the disease continued to progress during this time. This is supported by confirmation

Table 3. Disease severity ratings for powdery mildew evaluated on dogwood taxa during 1993 including: percent of leaves infected per plant (P), average percent of leaf area affected on infected leaves (L), and percent of total leaf area affected per plant (P x L) .

	Sept. 8			Sept. 29			Oct. 25		
Taxa	P	L	Px L*	P	L	Px L	P	L	Px L
C. x Stellar Pink®	0	0	0	0	0	0	0	0	0
C. k. 'Milky Way Select'	0	0	0	0	0	0	0	0	0
C. k. 'Milky Way'	0	0	0	0	0	0	0	0	0
C. x. Celestial™	0	0	0	0	0	0	0	0	0
C. k. 'Gay Head'	0	0	0	0	0	0	0	0	0
C. k. 'Julian'	0	0	0	0	0	0	0	0	0
C. k. 'Temple Jewel'	0	0	0	0	0	0	0	0	0
C. k. 'Big Apple'	0	0	0	0	0	0	0	0	0
C. x Aurora®	0	0	0	0	0	0	0	0	0
C. k. 'China Girl'	0	0	0	0	0	0	0	0	0
C. k. 'Greensleeves'	0	0	0	0	0	0	0	0	0
C. k. 'Elisabeth Lustgarten'	0	0	0	0	0	0	7	10	1
C. k. 'Steeple'	0	0	0	27	25	12	40	20	12
C. x Stardust®	27	33	13	93	60	57	95	75	71
C. x Constellation®	70	80	56	100	73	73	100	90	90
C. x Ruth Ellen®	100	80	80	100	95	95	100	98	98
$LSD_{0.05}$	16	11	12	13	12	10	18	9	8

*P x L was calculated as the mean of the products of P and L for each replicate. For that reason, the product of the mean P and mean L will not necessarily equal PxL.

of *D. destructiva* in stem tissue of the majority of dead trees. Hibben and Daughtrey (6) observed that the rate of canker progression accelerated during winter and may account for the increased mortality during this time. In addition to *D. destructiva*, fungi in the genera *Colletotrichum, Phomopsis*, and *Alternaria* were routinely found on dead twigs.

Powdery mildew. Powdery mildew was first observed in early September on some cultivars and appeared to result from natural inoculation from native flowering dogwood infected with powdery mildew in the experimental area. By late October, five taxa including 'Elizabeth Lustgarten', 'Steeple', Stardust®, Constellation®, and Ruth Ellen® were infected (Table 3). Three of the hybrid cultivars (Stardust®, Constellation®, and Ruth Ellen®) were most heavily infected with over 70% of the total leaf area affected per plant. No data were collected for 'Autumn Rose', 'Moonbeam', 'Wolf Eyes', or flowering dogwood because they were severely defoliated or dead by that time.

Despite regular inspection of leaves infected with powdery mildew, cleistothecia were only observed on one plant of Constellation®. Several asci, but no ascospores, were present in the cleistothecia. The disease organism was identified as *Microsphaera pulchra*.

Summary

Results from this study demonstrate considerable variation in resistance of kousa dogwood cultivars and hybrids to both dogwood anthracnose and powdery mildew. Where these diseases are prevalent, selection of resistant taxa is recommended. Taxa found to be resistant to dogwood anthracnose include: *C. kousa* 'Steeple', a clone of *C. kousa* 'Milky Way' used in this study, *C.* x Stardust®, *C.* x Stellar Pink®, and *C.* x Celestial™. Taxa found to be resistant to powdery mildew included the kousa dogwood cultivars 'Milky Way Select', the clone of 'Milky Way' used in this experiment, 'Gay Head', 'Julian', 'Temple Jewel', 'Big Apple', 'China Girl', and 'Greensleeves' as well as the hybrids Stellar Pink®, Celestial™, and Aurora®.

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Department of Horticultural Science
Mountain Horticultural Crops Research and Extension Center
North Carolina State University
2016 Fanning Bridge Rd.
Fletcher, NC 28732

Résumé. Vingt taxons de cornouillers qui incluaient des cultivars de cornouillers de kousa (*Cornus kousa*) et des cultivars d'hybrides entre les cornouillers de Floride (*Cornus florida*) et de kousa ont été évalués en regard de leur sensibilité à l'anthracnose du cornouiller (*Discula destructiva*) et au blanc des feuilles (*Microspaera pulchra*). Les arbres ont été élevés sous un couvert indigène de cornouillers de Floride qui étaient infectés par les deux maladies et qui étaient aussi inoculés artificiellement avec les spores de *D. destructiva*. Aucun des taxons était immunisé contre l'anthracnose du cornouiller bien qu'il ait eu des variations très importantes de résistance à la maladie.

Zusammenfassung. Zwanzig Hartriegelproben, einschließlich Kultivare von Jap. Blumen-Hartriegel (*Cornus kousa*) und Kultivare von Hybriden aus Blumen-Hartriegel (*Cornus florida*) und Jap. Hartriegel wurden auf ihre Anfälligkeit gegenüber Hartriegel-Anthracnose (*Discula destructiva*) und Mehltau (*Microsphaera pulchra*) untersucht. Es wurden Bäume unter einem natürlichen Stand von Blumen-Hartriegel gepflantzt, welcher mit beiden Krankheiten infiziert war. Zusätzlich wurden die Bäume künstlich mit Sporen von *D. destructiva* infiziert. Keine der Proben zeigte sich immun gegenüber der Anthracnose, obwohl sich in der Resistenz erhebliche Variationen zeigten.