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Growth and Mortality of Dogwood Cultivars in Alabama[1]

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Abstract

An open-field evaluation of 38 dogwood (*Cornus*) cultivars was conducted in central Alabama from May 1996 to March 1998. Mortality increased dramatically in giant dogwood (*C. controversa* Hemsl.), kousa dogwood cultivars (*C. kousa* Hance), and kousa x flowering dogwood hybrids (*C. kousa* x *florida*) from August 1996 to August 1997. Little mortality was observed for the flowering dogwood selections (*C. florida* L.) during this same period. Further characterization, based on height and stem diameter increases, was conducted on 23 flowering dogwood cultivars. Greatest average annual height and stem diameter increases for cultivars with white bracts and green foliage were observed in 'Cloud 9', 'Fragrant Cloud', Ozark Spring', 'Springtime', 'Weaver', 'Welch Bay Beauty', and 'World's Fair'. Lowest average annual height and stem diameter increases occurred with 'Autumn Gold' and Wonderberry®. Among the selections with red or pink bracts and green foliage, 'Stoke's Pink' and 'Welch's Junior Miss' had greater annual average increases in height and stem diameter than 'Purple Glory'. Annual average increases in height and final heights were similar among all cultivars with variegated foliage, with 'First lady' showing the greatest annual average increase in stem diameter and final stem diameter.

Index words: height, landscape, flowering trees, stem diameter.

Species used in this study: giant dogwood (*Cornus controversa* Hemsl.); flowering dogwood (*C. florida* L.); kousa dogwood (*C. kousa* Hance); *C. kousa* x *florida*; and *C. nuttallii* x *florida.*

Significance to the Nursery Industry

This study demonstrated flowering dogwood cultivars are better performers in the full sun of the southeastern United States than giant dogwood, kousa dogwood, or kousa x flowering dogwood hybrids, based on plant mortality. Of the flowering dogwood cultivars with white bracts and green foliage, 'Barton', 'Cloud 9', 'Fragrant Cloud', 'Ozark Spring', and 'Welch Bay Beauty' showed the fastest growth rates, while 'Autumn Gold' and Wonderberry® showed the slowest growth rates. 'Cherokee Brave', 'Cherokee Chief', 'Pink Beauty', and f. *rubra* grew the fastest among those cultivars with red or pink bracts and green foliage. Among the cultivars with variegated foliage, 'First Lady' showed better growth and survival than Cherokee Sunset™ or 'Rainbow'.

Introduction

Cornus florida L. (flowering dogwood) is a native, small tree common in landscapes of the Southeastern United States (8). Numerous cultivars are available in the trade (2, 6), but there is little published information comparing mortality or growth in full sun. Windham and Freeland (9) reported differences in bract length, bloom number, and flower development among 10 of the more than 20 cultivars of flowering dogwood they mention being available for cultivation, suggesting there are differences in other characteristics and among other cultivars as well. Montague *et al.* (4) reported differences in height and stem diameter among flowering dogwood cultivars 'Barton', f. *rubra*, 'Weaver', 'Welch Bay Beauty', and 'Welch's Junior Miss' under both full sun and shade conditions in container production. Heatley *et al.* (3) evaluated trees in Michigan grown from seed collected in various northern, central, and southern states within the native range of flowering dogwood. Seedlings originating in northern states were hardier in the open than under shade with the opposite true for those originating in other states. Trees of northern origin also had a longer fall foliar color display, heavier flowering, and less canker in an open stand than those from southern states.

C. kousa Hance (kousa dogwood) is hardy from U.S.D.A. Hardiness Zones 5 to 8. Dirr (2) indicated that kousa dogwood's flower buds are more cold hardy than those of flowering dogwood, and kousa dogwood's hardiness range should be expanded to include Zone 4b. In addition, kousa dogwood is more drought tolerant and requires more sunlight than flowering dogwood. Clones derived from crosses of flowering and kousa dogwoods have also been released including the Stellar Series (Aurora®, Celestial™, Constellation®, Ruth Ellen®, Stardust®, and Stellar Pink®) introduced by Elwin R. Orton, Jr. in 1992. These cultivars are reported to be genetically resistant to dogwood borer (*Synanthedon scitula* Harris) and dogwood anthracnose (*Discula destructiva* Redlin) (5). Little is known about the performance of kousa dogwood and kousa x flowering dogwood hybrids in full sun in the southeastern United States. However, Orton believes the hybrids to be intermediate in cold hardiness (5). In New Jersey, they have tolerated temperatures of –23.3C (–10F). Although the hybrids were probably not as cold hardy as kousa dogwood, Orton predicted them to be more cold hardy than flowering dogwood.

The western counterpart of flowering dogwood is *C. nuttallii* Audub. (Pacific dogwood), whose native range extends from southern California northward into British Columbia, Canada (2). Pacific dogwood is not reliably winter hardy in the eastern United States. *C. controversa* Hemsl. (giant dogwood), native to Japan and China, is hardy in USDA Hardiness Zones 5 (possibly 4) to 8. Dirr (2) suggested the possibility of giant dogwood having more tolerance of urban settings than other dogwoods. The species grows in subtropical and frigid areas of Japan, suggesting its suitability for much of the United States (1).

There is little information comparing dogwood cultivars in full sun. The objective of this study was to conduct a comprehensive assessment of mortality and growth of dogwood cultivars grown in full sun in the southeastern United States.

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Materials and Methods

Bare-root liners, 0.62–0.91 m (2–3 ft) tall, of 38 cultivars of giant dogwood, flowering dogwood, kousa x flowering dogwood hybrids, kousa dogwood, and Pacific x flowering dogwood hybrids were planted in March 1993 in Auburn, AL. Plants were spaced 6.1 m (20 ft) apart in rows with 7.6 m (25 ft) between rows in a Marvyn loamy sand soil in full sun. The experimental design was a randomized complete block with six replications of two trees each. Irrigation was provided as needed with two drip emitters per tree. Each tree was topdressed within a 0.6 m (2 ft) radius of the trunk with 90.8 g (0.2 lb) of 13N–5.7P–10.8K (13–13–13) on May 26 and June 24, 1994. In November 1995, trees were fertilized with 680.4 g (1.5 lb) per 2.5 cm (1 in) of stem diameter using a 13N–5.7P–10.8K (13–13–13) fertilizer. Based on soil test recommendations, trees were fertilized in November 1996 using a 15N–0P–12.5K (15–0–15) fertilizer at the rate of 680.4 g (1.5 lb) per 2.5 cm (1 in) of stem diameter. Pinebark mulch, 5.7 cm (2–3 in) deep and 1.8 m (5 ft) in diameter, was applied around each tree in the summer of 1995. Princep® 4 L herbicide (Novartis Crop Protection, Greensboro, NC), and Surflan® A.S. specialty herbicide (Dow AgroSciences LLC, Indianapolis, IN) were applied in a 1.8 m (5 ft) band down the centers of each row in March 1995, 1996 and 1997 for preemergent weed control, and Roundup® Weed and Grass Killer (Monsanto Company, San Ramon, CA) was applied as needed for postemergent weed control. The field was periodically mowed and the mulched areas weeded manually. *Synanthedon scitula* Harris (dogwood borer) was controlled using Dursban® 50W (Dow AgroSciences LLC) according to label recommendations.

Fifteen cultivars were evaluated for mortality and are listed followed by site and date of introduction to the United States or first description in parentheses (Table 1). Mortality and growth were evaluated for 23 additional flowering dogwood cultivars, which were divided into three categories for presentation based on bract and foliage colors: 1) white bracts and green foliage; 2) red or pink bracts and green foliage; and 3) variegated foliage. Cultivars are listed followed by site and date of introduction or first description in Table 1. Mortality was determined in May and August 1996 and 1997. Height and stem diameter at 15.2 cm (6 in) above the soil line were determined annually in November 1994, 1995, 1996 and March 1998 prior to bud break. Growth increases were calculated by taking the difference between measurement in consecutive years.

Table 1. Introduction site and date and percent mortality of dogwood (*Cornus*) cultivars.

		Introduction		Mortality (%)	
Species	**Cultivar**	**Site**	**Date**	**May 1997**	**August 1997**
C. controversa		China and Japan	1880	92a[z]	100a
C. florida	Autumn Gold	Winchester, TN	1993	50bcde	50cdefgh
	Barton	Winchester, TN	1969	0g	17ghi
	Cherokee Brave	Winchester, TN	1993	8fg	8hi
	Cherokee Chief	Winchester, TN	1957	8fg	17ghi
	Cherokee Daybreak®	Decherd, TN	1988	73abc	73abcde
	Cherokee Princess	Tullahoma, TN	1959	8fg	17ghi
	Cherokee Sunset™	Decherd, TN	1980	20defg	30fghi
	Cloud 9	Chase, AL	1961	25defg	33efghi
	First Lady	McMinnville, TN	1969	0g	17ghi
	Fragrant Cloud	Chase, AL	1968	0g	0i
	Ozark Spring	Wichita, KS	1993	8fg	8hi
	Pink Flame	Fairview, OR	1978	73abc	73abcde
	Pink Beauty	Winchester, TN	1993	17efg	17ghi
	Plena	Knoxville, TN	1937	25defg	25ghi
	Purple Glory	McMinnville, TN	1981	17efg	17ghi
	Pygmy	Tullahoma, TN	1962	92a	92ab
	Rainbow	Boring, OR	1968	8fg	8hi
	Red Beauty®	New Brunswick, NJ	1993	17efg	42defghi
	f. *rubra*	London	1770	8fg	33efghi
	Springtime	Wyoming, OH	1957	42cdef	42defghi
	Stokes' Pink	Unknown		58abcd	58bcdefg
	Weaver	Glen Saint Mary, FL	1941	50bcde	50cdefgh
	Welch Bay Beauty	Wilmer, AL	1978	0g	0i
	Welch's Junior Miss	Mobile County, AL	1969	22defg	22ghi
	Wonderberry®	New Brunswick, NJ	1993	17efg	17ghi
	World's Fair	McMinnville, TN	1984	17efg	33efghi
C. kousa x *florida*	Aurora®	New Brunswick, NJ	1992	75abc	83abc
	Celestial®	New Brunswick, NJ	1992	58abcd	75abcd
	Constellation®	New Brunswick, NJ	1992	67abc	75abcd
	Ruth Ellen®	New Brunswick, NJ	1992	58abcd	67abcdef
	Stardust®	New Brunswick, NJ	1992	50abcde	58bcdefg
	Stellar Pink®	New Brunswick, NJ	1992	83ab	92ab
C. kousa	Milky Way	Mentor, OH	1961	40cdefg	50cdefgh
	Milky Way Select	Middleton, WI	Unknown	75abc	92ab
	National	Winchester, TN	1988	42cdef	42defghi
	Satomi	Japan	Unknown	75abc	75abcd
C. nuttalii x *florida*	Eddie's White Wonder	Mentor, OH	1964	18efg	27fghi

[z]Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

Table 2. Height increases of flowering dogwood (*Cornus florida* L.) cultivars.

Cultivar	Height increase (cm)[z] 1995	1996	1998	Annual average	Final height 1998 (cm)
White bracts and green foliage					
Autumn Gold	16.1c[y]	22.0b	47.0c	27.1c	217c
Barton	45.4ab	32.0b	33.2abcd	38.3abc	269b
Cherokee Princess	36.9abc	38.8ab	22.0bcde	32.3bc	253bc
Cloud 9	45.4ab	47.6ab	30.2abcde	43.1ab	296ab
Fragrant Cloud	46.6ab	43.6b	20.9abc	37.1ab	267ab
Ozark Spring	43.9ab	46.0ab	41.1abc	43.7abc	293ab
Plena	27.6bc	39.8ab	9.9de	26.1c	222c
Springtime	33.8abc	27.8b	53.9a	43.4ab	292ab
Weaver	49.9ab	60.6a	41.3abc	49.6a	277ab
Welch Bay Beauty	56.5a	44.5ab	24.4bcde	42.5ab	302a
Wonderberry®	35.4abc	31.8b	7.5e	24.9c	174d
World's Far	52.6ab	36.7ab	47.4ab	46.5ab	282ab
Red or pink bracts and green foliage					
Cherokee Brave	26.0b[y]	33.1ab	38.8a	32.6ab	258ab
Cherokee Chief	29.5ab	45.4ab	21.7abc	33.3ab	238bc
Pink Beauty	39.2ab	38.3ab	11.2bc	29.6ab	244abc
Purple Glory	34.6ab	26.4b	8.9c	23.3b	208c
Red Beauty®	32.7ab	37.9ab	35.1a	34.1ab	233bc
f. *rubra*	33.5ab	28.2b	29.9ab	33.1ab	243abc
Stokes' Pink	47.5a	48.4ab	8.0c	34.7a	237bc
Welch's Junior Miss	45.9a	53.4a	11.7bc	38.4a	283a

[z]Growth increases were determined as the difference between the current and previous season's measurements taken in November; 1998 data were collected in March prior to bud break.

[y]Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

All data were subjected to analyses of variance. Mean separations were determined by Duncan's multiple range test, $P = 0.05$ (7).

Results and Discussion

No mortality occurred for the flowering dogwood cultivars 'Fragrant Cloud' or 'Welch Bay Beauty' (Table 1). By May 1997, at least 50% of the kousa x flowering dogwood hybrids Aurora® (75%), Celestial™ (58%), Constellation® (58%), Ruth Ellen® (58%), Stardust® (50%), and Stellar Pink® (83%) had died. A year earlier, none of these cultivars had any mortality with the exceptions of Stardust® (17%) and Stellar Pink® (8%) (data not shown). Many of the kousa x flowering dogwood hybrids did not die until after they had fully leafed out and bloomed in the spring. Leaves gradually turned brown with death occurring one to two months later. There have been similar reports of dieback and death among kousa x flowering dogwood hybrids in southern Tennessee (Donna Fare; Don Shadow; Mark Windham; Will Witte, personal communications). Several other dogwoods had mortalities of ≥50% by August 1997: *C. controversa* (100%), flowering dogwood cultivars 'Autumn Gold' (50%), Cherokee Daybreak™ (73%), 'Pink flame' (73%), 'Pygmy' (92%), 'Stokes' Pink' (58%), and 'Weaver' (50%), and kousa dogwood cultivars 'Milky Way' (50%), 'Milky Way Select' (92%), and 'Satomi' (75%). 'Cherokee Brave', 'Ozark Spring', 'Pink Beauty', 'Purple Glory', and 'Welch's Junior Miss' had no mortality after initial losses of ≤25% following transplanting. These cultivars appeared to have acclimated well to the full sun site. 'Stokes' Pink' had a high initial mortality (50%), but only one tree died thereafter. In contrast, increases in mortality were observed for giant dogwood, kousa dogwood, and kousa x flowering dogwood hybrids from August 1996 to May 1997.

Among the flowering dogwood cultivars with white bracts and green foliage, 'Cloud 9' , 'Ozark Spring', 'Springtime', 'Weaver', 'Welch Bay Beauty', and 'World's Fair' averaged over 40 cm (16 in) of height increase per year from 1994 to 1997 (Table 2). All other cultivars were similar except 'Autumn Gold', 'Plena', and Wonderberry®, which had average annual height increases of less than 30 cm (12 in). At the end of 1997, 'Welch Bay Beauty' had a final height of 302 cm (119 in), while 'Barton', 'Cloud 9' , 'Fragrant Cloud', 'Ozark Spring', 'Springtime', 'Weaver', and 'World's Fair' were similar, all having heights over 265 cm (104 in). The only cultivar with a final average height less than 200 cm (79 in) was Wonderberry® (174 cm (69 in)).

Average stem diameter increases for cultivars with white bracts and green foliage were numerically greatest for 'Ozark Spring', 'Weaver', and 'Welch Bay Beauty' and least for 'Autumn Gold' and Wonderberry® (Table 3). 'Welch Bay Beauty' also had the greatest final diameter, over 9.0 cm (3.5 in), with 'Cloud 9', 'Ozark Spring', and 'Springtime' being similar, and 'Autumn Gold' and Wonderberry® the smallest, less than 5.0 cm (2.0 in).

Results suggest that although 'Weaver' is a fast grower, it may be harder than some other cultivars to establish. Trees were planted one year and eight months before the first measurements were taken in 1994, therefore growth rate was unknown during this time. However, the high mortality rate for 'Weaver' at the study's initiation supports this hypoth-

Table 3. Stem diameter increases of flowering dogwood (*Cornus florida* L.) cultivars.

Cultivar	Diameter increase (cm)[z] 1995	1996	1998	Annual average	Final diameter 1998 (cm)
White bracts and green foliage					
Autumn Gold	0.5c[y]	0.8e	0.6d	0.7d	4.9d
Barton	1.4b	1.5bcd	0.7bcd	1.2bc	6.8bc
Cherokee Princess	1.3b	1.3cde	0.7bcd	1.1c	6.1c
Cloud 9	1.8ab	1.6bc	1.2abc	1.6ab	7.8ab
Fragrant Cloud	1.5b	2.0ab	0.7bcd	1.4abc	7.3bc
Ozark Spring	1.8ab	1.8abc	1.4a	1.7a	8.1ab
Plena	1.6ab	2.0ab	0.8bcd	1.4abc	7.4bc
Springtime	1.3b	1.2cde	1.6a	1.5ab	7.8ab
Weaver	1.6ab	2.3a	1.5a	1.8a	7.2bc
Welch Bay Beauty	2.2a	2.0ab	1.0abcd	1.7a	9.0a
Wonderberry®	0.6c	0.9de	0.5d	0.7d	3.7d
World's Fair	1.6ab	1.6bc	1.3ab	1.6ab	7.5b
Red or pink bracts and green foliage					
Cherokee Brave	1.4bc	1.6a	1.2ab	1.4a	7.2ab
Cherokee Chief	1.9c	2.0	0.8b	1.3ab	6.3b
Pink Beauty	1.4bc	1.6a	1.0ab	1.3ab	6.8ab
Purple Glory	1.2bc	1.4a	0.6b	1.1b	6.3b
Red Beauty®	1.3bc	1.6a	1.5a	1.4a	7.0ab
f. *rubra*	1.1bc	1.2a	1.1ab	1.2ab	6.1b
Stokes' Pink	2.5a	1.2a	0.8b	1.4a	7.3ab
Welch's Junior Miss	1.7b	1.7a	0.9ab	1.4a	7.7a

[z]Growth increases were determined as the difference between the current and previous season's measurements taken in November; 1998 data were collected in March prior to bud break.

[y]Mean separation within columns by Duncan's multiple range test, $P = 0.05$.

esis. Furthermore, 'Weaver' had more increase in height in 1996 from 1995, and remained one of the faster growing cultivars in 1997. Many cultivars did not show a greater increase in 1996, indicating initial growth was faster followed by slower growth. 'Springtime' was the only cultivar to have a greater numerical increase in 1997 compared to 1996. In a study by Montague *et al.* (4) using container-grown flowering dogwood cultivars, trees were evaluated for growth in full sun and under different degrees of shade. 'Weaver' had the greatest height and stem diameter increases, regardless of light exposure, compared to 'Welch Bay Beauty'and 'Barton'. In our study, 'Welch Bay Beauty' had the greatest final stem diameter, 9 cm (3.5 in).

Among the flowering dogwood cultivars with red or pink bracts and green foliage, all cultivars, except 'Purple Glory', were similar in average annual height increase (Table 2). Following two years of having the greatest numerical average height increases, 'Stokes' Pink' and 'Welch's Junior Miss' had noticeably smaller increases in 1997. Trees of 'Welch's Junior Miss' were tallest, 283 cm (111 in) following the 1997 growing season, with 'Cherokee Brave', 'Pink Beauty', and f. *rubra* being similar.

Trends were similar for average annual stem diameter increase, with 'Purple Glory' having the lowest numerical annual average increase, but similar to 'Cherokee Brave', 'Cherokee Chief', 'Pink Beauty', and f. *rubra* (Table 3). 'Cherokee Brave', 'Welch's Junior Miss', and 'Stokes' Pink' were the only cultivars with red or pink bracts and green foliage with final stem diameters >7 cm (3 in). Montague *et al.* (4) reported container-grown 'Welch's Junior Miss' to be faster growing than f. *rubra* in full sun.

Cultivars with variegated foliage had similar average annual height increases and final heights (data not shown). Average annual height increases ranged from 18 cm (7 in) for 'Rainbow' to 24 cm (9.5 in) for 'First Lady'. Among the three cultivars evaluated, 'First Lady' had the greatest average annual stem diameter increase of 1.2 cm (0.5 in) and the greatest final stem diameter of 6.6 cm (2.6 in). Annual stem diameter increases and final stem diameter for 'Rainbow' and Cherokee Sunset™ were similar. In general, cultivars with variegated foliage grew slower than cultivars with white bracts and green foliage and red or pink bracts and green foliage.

This study indicated that over a three-year period, flowering dogwood cultivars performed better under full sun conditions of central Alabama than did giant dogwood, kousa dogwood, and kousa x flowering dogwood hybrids, based on mortality. Flowering dogwood cultivars 'Barton', 'Cloud 9', 'Fragrant Cloud', 'Ozark Spring', and 'Welch Bay Beauty' showed the most growth of cultivars with white bracts and green foliage. 'Autumn Gold' and Wonderberry® were slow growers. Several superior cultivars with red or pink bracts and green foliage were 'Cherokee Brave', 'Cherokee Chief', 'Pink Beauty', and f. *rubra*. 'First Lady' was the best cultivar among those with variegated foliage, compared to Cherokee Sunset™ and 'Rainbow'.

Literature Cited

1. Creech, J. 1985. *Cornus controversa.* Amer. Nurs. 162(3):102.

2. Dirr, M.A. 1998. Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation and Uses. 5th Edition. Stipes Pub. Champaign, IL.

3. Heatley, R.C., J.J. Kielbaso, and G.S. Howell. 1994. Environmental adaptation and ornamental display of *Cornus florida* ecotypes. J. Arboriculture 20:305–309.

4. Montague, D.T., D.J. Eakes., C.H. Gilliam, K.M. Tilt, and H.G. Ponder. 1992. Shade during container production of flowering dogwood increases growth. Proc. Southern Nurserymen's Assoc. Res. Conf. 37:19–21.

5. Orton, E.R., Jr. 1993. A family of dogwoods. Fine Gardening. March/April:35–39.

6. Santamour, F.S., Jr. and A.J. McArdle. 1985. Cultivar checklists of the large-bracted dogwoods: *Cornus florida*, *C. kousa*, and *C. nuttallii*. J. Arboriculture 11:29–36.

7. SAS Institute, Inc. 1988. SAS/STAT User's Guide. Release 6.03 Edition. Cary, NC.

8. Williams, J.D., H.G. Ponder, and C.H. Gilliam. 1987. Response of *Cornus florida* to moisture stress. J. Arboriculture 13:98–101.

9. Windham, M. and R. Freeland. 1990. Disease and frost resistance and certain horticultural characteristics of ten dogwood cultivars. Tenn. Farm and Home Sci., Summer:25–31.