Disease Resistance and Adaptability of Stellar and Flowering Dogwood Cultivars at Two Alabama Sites[1]

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Abstract

Stellar® dogwood (*Cornus florida* × *kousa*) cultivars Aurora®, Constellation®, Celestial™, Ruth Ellen®, and Stellar Pink® were compared with selected flowering dogwood (*Cornus florida*) cultivars Cherokee Brave®, 'Cherokee Princess', 'Cloud 9', and 'Rubra' in a simulated landscape planting at sites in southwest (USDA Hardiness Zone 8a) and northeast Alabama (USDA Hardiness Zone 7a) for their reaction to the diseases spot anthracnose, powdery mildew, and Cercospora leaf spot. Tree longevity as influenced by the occurrence of the dogwood borer (*Synanthedon scitula*) and an ambrosia beetle (*Xylosandrus* sp.) was also assessed at both sites. All Stellar® dogwood cultivars generally proved resistant to the bract and leaf spot phases of spot anthracnose as well as powdery mildew and Cercospora leaf spot. While Cherokee Brave® was the only flowering dogwood with partial resistance to powdery mildew at both sites; this and the other flowering dogwood cultivars were equally susceptible to spot anthracnose and Cercospora leaf spot. Insect damage levels were higher at the southwest site than the northeast Alabama site. Within 3 years of establishment at the southwest Alabama site, incidence of tunneling damage attributed to dogwood borer and an ambrosia beetle was higher on the Stellar® dogwood than flowering dogwood cultivars, which also had higher values for tree longevity. In contrast, tree longevity was equally high and insect damage equally low at the northeast Alabama site for both the Stellar® and flowering dogwood cultivars. Superb resistance to the diseases spot anthracnose, powdery mildew, and Cercospora leaf spot translated into superior aesthetics and fall color for the Stellar® compared with the flowering dogwood cultivars at the northeast Alabama site. Hardiness of Stellar® dogwood cultivars in Alabama and possibly other southern states below USDA Hardiness Zone 7a is questionable due to tree vulnerability to the dogwood borer and ambrosia beetle.

Index words: *Cornus florida*, *Cornus florida* × *kousa*, hybrid dogwood, *Elsinoe corni*, *Erysiphe pulchra*, *Pseudocercospora cornicola*, *Synanthedon scitula*, *Xylosandrus* sp.

Species used in this study: *Cornus florida* × *kousa* Aurora®, Constellation®, Celestial™, Ruth Ellen®, and Stellar Pink®; *C. florida* Cherokee Brave®, 'Cherokee Princess', 'Cloud 9', and 'Rubra'.

Significance to the Nursery Industry

With few exceptions, Stellar dogwood cultivars Aurora®, Constellation®, Celestial™, Ruth Ellen®, and Stellar Pink® displayed superior resistance when compared with selected dogwood cultivars to the bract spot and leaf spot phases of spot anthracnose, powdery mildew, and Cercospora leaf spot in field trials at sites in southwest and northeast Alabama. Cherokee Brave® proved nearly as resistant to powdery mildew as the Stellar® dogwood cultivars but was as susceptible to spot anthracnose and Cercospora leaf spot as were the flowering dogwood cultivars 'Cherokee Princess', 'Cloud 9', and 'Rubra'. Over the 3 years at the Brewton Agricultural Research Unit [BARU] (USDA Hardiness Zone 8a) in southwest Alabama site, the length of tree longevity was at least 1 year shorter and percentage of dogwood borer and/or ambrosia beetle damaged trees higher for the Stellar® than flowering dogwood cultivars. In contrast, little damage attributed to the dogwood borer was noted on any of the Stellar® dogwoods and the flowering dogwood cultivars at the Sand Mountain Research and Extension Center [SMREC] (USDA Hardiness Zone 7a) in northeast Alabama. Reduced occurrence of spot anthracnose, powdery mildew, and Cercospora leaf spot at SMREC, superior aesthetics were observed for the Stellar® compared with flowering dogwood cultivars. Based on the results of this and a previous Alabama study (4), Stellar® dogwood cultivars are not adapted below USDA Hardiness Zone 7a due to increased vulnerability to dogwood borer and ambrosia beetle.

Introduction

Flowering dogwood (*Cornus florida*) is among the most popular small flowering trees in southern landscapes. In Alabama, spot anthracnose, powdery mildew, and Cercospora leaf spot often have a detrimental impact on the aesthetics, growth, and occasionally the health of flowering dogwood (3, 4). While fungicides provide some protection (2), establishment of disease resistant cultivars is the preferred control strategy in commercial and residential landscapes. Previous studies (4, 8, 17, 18), which have focused on the reaction of flowering dogwood cultivars to spot anthracnose, caused by *Elsinoe corni* Jenkins and Bitanic, and powdery mildew, caused by *Erysiphe pulchra* (Cooke & Bechke) U. Braum & S. Takamatsu comb. nov. [syn. = *Microsphaera pulchra*, *M. penicillata*], ignored Cercospora leaf spot caused by *Pseudocercospora cornicola* (Tracy & Earle) Guo & Lin [syn. = *Cercospora cornicola*], a disease linked with reduced growth of flowering dogwood (3). Conner and Bowen (1) reported that the flowering dogwood cultivars 'Little Princess', 'Red Pygmy', and 'Pumpkin Patch' were free of Cercospora leaf spot, while minor disease symptoms were observed on Cherokee Brave®, 'Cherokee Chief', 'Cherokee Princess', and 'Cloud 9'. In a previous southwest Alabama study (3), Cercospora leaf spot intensity was lower on field-grown 'Cherokee Chief' than 'Cloud 9' flowering dogwood.

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Stellar® dogwoods are *Cornus florida* × *C. kousa* interspecific hybrids characterized by an upright growth habit, numerous flower heads with showy white to pink bracts, sterile flowers, flowering period intermediate between the parents, and resistance to the dogwood borer (*Synanthedon scitula*) and dogwood anthracnose caused by *Discula destructiva* (9, 10, 11, 12, 13, 14). In addition to confirming dogwood anthracnose resistance in the Stellar® dogwoods, Ranney *et al.* (17) also noted a high level of resistance to powdery mildew in Stellar Pink® and Aurora®, while Ruth Ellen®, Celestial™, and Constellation® suffered heavy leaf colonization. Subsequently, Aurora®, Constellation®, Celestial™, and Stellar Pink® have demonstrated a high level of resistance to powdery mildew (4, 8). While Mmbaga and Sauve (8) noted some powdery mildew on Ruth Ellen®, Hagan *et al.* (4) did not. In addition to powdery mildew resistance, minimal bract and leaf spotting attributed to spot anthracnose was noted on all Stellar® dogwoods except for Constellation® and to a lesser extent Ruth Ellen® (4). While Conner and Bowen (1) noted that Stellar Pink® was highly susceptible to Cercospora leaf spot, sensitivity of other Stellar® dogwood cultivars to this disease was not reported. While Stellar® hybrid dogwood cultivars showed good resistance to spot anthracnose and powdery mildew in a previous central Alabama study (USDA Hardiness Zone 7b) (4), their survival rate was far below that of flowering dogwood cultivars.

The objective of this study was to compare the reaction of Stellar® dogwood cultivars with that of selected flowering dogwood cultivars to spot anthracnose, powdery mildew, and Cercospora leaf spot as well as assess their adaptability across Alabama.

Materials and Methods

Tree maintenance. On January 23 and March 5, 2004, flowering and Stellar® dogwood (*C. kousa* × *florida*) cultivars were transplanted from #5 containers into a Benndale fine sandy loam soil at the Brewton Agricultural Research Unit [BARU] in Brewton, AL (USDA Plant Hardiness Zone 8a) and a Hartsell/Wynville soil at the Sand Mountain Research and Extension Center [SMREC] in Crossville, AL (USDA Plant Hardiness Zone 7a), respectively, on 3 m (10 ft) centers with 3.7 m (12 ft) between rows. Prior to planting, soil fertility and pH were adjusted according to the recommendations of the Auburn University Soil Fertility Laboratory. A drip irrigation system was installed after planting and the trees were watered as needed. Newly established trees were mulched with 1 to 2 cm (0.5 to 1.0 in) of aged pine bark. In each study year, ammonium nitrate (33N-0P-0K) was broadcast at a rate of 165 kg·ha^{-1} (150 lb·A^{-1}) and 330 kg·ha^{-1} (300 lb·A^{-1}) of actual nitrogen at BARU and SMREC, respectively. Pre-emergent weed control was obtained with an application of 2.2 kg ai·ha^{-1} (2 qt·A^{-1}) of Surflan (oryzalin, United Phosphorus, 423 Riverview Plaza, Trenton, NJ) broadcast alone or tank mixed with 0.68 kg ai·ha^{-1} (1.0 lb·A^{-1}) of Gallery (isoxaben, Dow AgroSciences LLC, Indianapolis, IN) at SMREC on May 26, 2005; April 17, 2006; May 11, 2007; and April 17, 2008, and at BARU on March 18, 2005, and February 1, 2007. At both sites, directed applications of Poast at 0.11 kg ai·ha^{-1} (8 fl oz·A^{-1}) [sethoxydim, BASF Corporation, Research Triangle, NC], Select at 0.28 kg ai·ha^{-1} (16 oz·A^{-1}) [clethodim, Valent Corp., Walnut Creek, CA], or MSMA at 2.7 kg ai·ha^{-1} (3 pt·A^{-1}) [monosodium acid methanearsonate, Helena Chemical Collierville, TN] were applied as needed to control escaped weeds.

Disease assessment. The experimental design was a randomized complete block with four two-tree replicates and five single-tree replicates at BARU and SMREC, respectively. At both sites, incidence of spot anthracnose on the bracts and leaves as well as powdery mildew and Cercospora leaf spot-associated defoliation was visually rated on each tree using the Horsfall-Barratt rating scale (6) where 0 = no disease, 1 = 0 to 3%, 2 = 3 to 6%, 3 = 6 to 12%, 4 = 12 to 25%, 5 = 25 to 50%, 6 = 50 to 75%, 7 = 75 to 87%, 8 = 87 to 94%, 9 = 94 to 97%, 10 = 97 to 100 %, and 11 = 100% of the leaves with signs or symptoms of each disease. Spot anthracnose ratings on the bracts on dogwood blooms were taken at BARU on April 13, 2006, and at SMREC on April 20, 2006; April 17, 2008; and April 14, 2009. Due to low bloom counts, spot anthracnose on the bracts was not rated at BARU in 2005 and 2007 and SMREC in 2006 and 2007. Leaf spot phase of spot anthracnose was rated at BARU on April 22, May 19, and June 20, 2005; May 8, 2006; and May 2 and May 31, 2007, and at SMREC on April 14, May 17, and July 8, 2005; April 20 and May 5, 2006; April 19 and May 16, 2007; May 12, 2008; and April 29, 2009. Powdery mildew incidence was assessed at BARU on April 22, May 19 and June 20, 2005; May 8 and June 6, 2006; and May 2, May 31, and July 3, 2007, and at SMREC on May 17 and July 8, 2005; May 5, June 7, and July 7, 2006; May 16, June 1, and August 14, 2007; May 1, May 27, June 23, and July 24, 2008; and April 29, May 26, and July 6, 2009. Defoliation due to Cercospora leaf spot was evaluated at BARU on August 22, October 5, October 18, and October 31, 2005, and at SMREC on July 8, August 29, September 14, October 20, 2005; July 24, September 4, and October 22, 2008; and August 13 and September 25, 2009. Due to an extended summer drought in 2006 and 2007 at both study sites, ratings for Cercospora leaf spot were not taken. At BARU, tree trunks were cut at the soil line on September 15, 2007, and examined for tunneling damage associated with the dogwood borer (*Synanthedon scitula*) and ambrosia beetle (*Xylosandrus* sp.).

Horsfall and Barratt numerical values for the bract and leaf spot phases of spot anthracnose, powdery mildew, and Cercospora leaf spot at each rating date were transformed to percentage values for analysis and presentation (7). Spot anthracnose and powdery mildew ratings were compared among years using PROC MIXED procedure in SAS 9.1.3. Analysis of variance indicated that year effect on all diseases was significant, so subsequent analyses were done segregated by year for each of these variables. Means were separated using Fisher's least significant difference (LSD) test ($P \leq 0.05$).

Results and Discussion

BARU RESULTS

Spot anthracnose on flower bracts (BARU). In 2006, incidence of the bract spot phase of spot anthracnose on the flowering dogwood cultivars was significantly higher compared with the Stellar® dogwood cultivars except for Aurora®, which had similar ratings (Table 1). Among flowering dogwood cultivars, bract spot ratings were higher for 'Rubra' than Cherokee Brave®, while the ratings for 'Cherokee Princess' and 'Cloud 9' were intermediate.

Table 1. Occurrence of spot anthracnose, powdery mildew and Cercospora leaf spot on Stellar and flowering dogwood cultivars at BARU.

	Spot anthracnose						
	% Diseased blooms	% Diseased leaves			Powdery mildew (% diseased leaves)		Cercospora leaf spot (% defoliation)
Dogwood taxa	**2006**	**2005**	**2006**	**2007**	**2005**	**2006**	**2005**
Stellar® dogwood (*Cornus kousa* × *florida*)							
Aurora	86ab	16bc	4cd	2b	0d	0b	30c
Celestial	9c	7c	3cd	5b	0d	0b	3d
Constellation	1c	16bc	2d	2b	0d	0b	38c
Ruth Ellen	5c	10c	2d	5b	0d	0b	32c
Stellar Pink	1c	9c	2d	3b	0d	0b	5d
Flowering dogwood (*C. florida*)							
Cherokee Brave	70b	36ab	11abc	28a	0d	0b	69b
Cherokee Princess	86ab	55a	6bcd	16ab	85ab	9b	83ab
Cloud 9	86ab	53a	13ab	36a	64bc	0b	75b
Rubra	100a	50a	18a	34a	99a	61a	97a

[z]Incidence of spot anthracnose, powdery mildew, and Cercospora leaf spot was assessed using the 0 to 11 Horsfall and Barratt rating scale, and transformed to the percentage (%) of diseased blooms or leaves.

[y]Ratings for spot anthracnose were taken on the blooms on April 13, 2006, and the leaves on May 19, 2005, May 8, 2006, and May 31, 2007. Powdery mildew ratings were recorded on June 20, 2005, and June 6, 2006. Cercospora leaf spot defoliation ratings from October 18, 2005, are presented.

[x]Means followed by the same letter are not significantly different according to Fisher's protected least significant difference (LSD) test ($P \leq 0.05$).

Spot anthracnose on the leaves. Incidence of the leaf spot phase of spot anthracnose was consistently lower for the Stellar® than flowering dogwood cultivars 'Cloud 9' and 'Rubra' (Table 1). In 2005, Stellar® dogwood cultivars had significantly lower disease ratings than all flowering dogwood cultivars except Cherokee Brave®, which had similar percentage of spot anthracnose damaged leaves as 'Cherokee Princess', 'Cloud 9', and 'Rubra'. In 2006 and 2007, spot anthracnose ratings for the Stellar® dogwood cultivars and 'Cherokee Princess' were similar. Also, spot anthracnose leaf ratings for the Stellar® dogwood cultivars Aurora® and Celestial™ did not differ from Cherokee Brave®. Results confirm previous observations that spot anthracnose resistance is superior for Stellar® than for flowering dogwood cultivars (4).

Powdery mildew. Powdery mildew at BARU was never observed on leaves of the Stellar® dogwood cultivars (Table 1). In 2005, powdery mildew incidence was higher on 'Rubra', 'Cherokee Princess', and 'Cloud 9' than Cherokee Brave®, which was disease free. While 'Rubra' had higher disease ratings compared with 'Cloud 9', leaf colonization levels on 'Cherokee Princess' were intermediate. While two of the three flowering dogwood cultivars were largely free of powdery mildew in 2006, 61% of the leaves on 'Rubra' displayed signs or symptoms of powdery mildew. A similarly low incidence of powdery mildew was noted in 2007 on 'Rubra', 'Cherokee Princess', 'Cloud 9', and Cherokee Brave® (data not shown).

Cercospora leaf spot. In 2005, Cercospora leaf spot defoliation ratings were higher for the flowering than for the Stellar® dogwood cultivars (Table 1). For the Stellar® dogwood cultivars, less defoliation was recorded for Celestial™ and Stellar Pink® than Aurora®, Constellation®, and Ruth Ellen®, which had similar defoliation ratings. Among the flowering dogwoods, 'Rubra' suffered greater defoliation than all flowering dogwood cultivars except 'Cherokee Princess', which had defoliation ratings similar to those of Cherokee Brave® and 'Cloud 9'.

In the three years after establishment, dogwood borer and/or ambrosia beetle tunneling damage was noted on 63 to 75% of the trunks of the Stellar® dogwood cultivars compared with 13% or less of the flowering dogwood cultivars (Table 2). The level of insect damage is also reflected in shorter period of tree longevity for the Stellar® than for the flowering dogwood cultivars. Stellar® dogwood survival, which ranged between 0.8 and 1.8 years after tree establishment, was shorter when compared with all flowering dogwoods except for 'Rubra', which had a longer survival period than

Table 2. Extent of insect-incited tree damage and subsequent survival period for Stellar and flowering dogwood at BARU.

Dogwood taxa	Insect damaged %[z]	Tree survival yr[y]
Stellar® dogwood (*Cornus kousa* × *florida*)		
Aurora	75a[x]	1.8bc
Celestial	75a	1.3c
Constellation	75a	0.8c
Ruth Ellen	63a	0.8c
Stellar Pink	75a	1.8bc
Flowering dogwood (*C. florida*)		
Cherokee Brave	0b	3.0a
Cherokee Princess	13b	3.0a
Cloud 9	13b	3.0a
Rubra	13b	2.8ab

[z]Percentage of trees exhibiting damage attributed to the dogwood borer and/or ambrosia beetle was assessed after the trees were harvested on September 15, 2007.

[y]Average length of tree survival in years over the 3 year study period when the trees were harvested.

[x]Means separation within columns was according to Fisher's protected least significant difference test ($P \leq 0.05$).

Table 3. Occurrence of spot anthracnose on the blooms and leaves of Stellar® and flowering dogwood cultivars at SMREC.

	Spot anthracnose[z]							
	Diseased blooms (%)[y]			Diseased leaves (%)[y]				
Dogwood selection	2005	2008	2009	2005	2006	2007	2008	2009
Stellar hybrid dogwood (*Cornus kousa* × *florida*)								
Aurora	20ab	4c	2c	0b	0c	2c	1ab	0b
Celestial	—	0c	4c	0b	2c	29bc	1ab	1b
Constellation	31ab	5c	11c	2b	2c	3c	1ab	1b
Ruth Ellen	9ab	4c	5c	1b	2c	14bc	1ab	0b
Stellar Pink	9ab	0c	0c	3ab	1c	20bc	0b	0b
Flowering dogwood (*C. florida*)								
Cherokee Brave	54a	15abc	42b	10a	43a	1c	11ab	5a
Cherokee Princess	68a	35ab	68a	16a	10b	66a	3ab	15a
Cloud 9	8b	44a	69a	29a	28ab	42ab	5ab	20a
Rubra	5b	28abc	86a	16a	56a	37b	12a	19a

[z]Incidence of spot anthracnose on the blooms leaves, was assessed using the 0 to 11 Horsfall and Barratt rating scale, and transformed to percentage of spot anthracnose-damaged blooms or leaves.

[y]Spot anthracnose ratings were recorded on the blooms on April 17, 2008, and April 14, 2009, and on the leaves on May 17, 2005, May 5, 2006, April 19, 2007, May 17, 2008, and April 29, 2009.

[x]Means separation within columns was according to Fisher's protected least significant difference test ($P \leq 0.05$).

Celestial™, Constellation®, and Ruth Ellen® but not Aurora® and Stellar Pink®. Survival period for all Stellar® dogwood cultivars was similarly short while that of the flowering dogwood cultivars was equally long.

SMREC RESULTS

Spot anthracnose on flower bracts. In contrast to a previous Alabama study (4), incidence of the bract spot phase of spot anthracnose was not consistently lower on the Stellar® compared with flowering dogwood cultivars. While similar bract spot ratings were reported for both dogwood taxa in 2005 (Table 3), significantly fewer spot anthracnose-damaged blooms were noted on the Stellar® compared with flowering dogwood cultivars in 2009. In 2008 the flowering dogwood cultivars 'Cherokee Princess' and 'Cloud 9', but not Cherokee Brave® and 'Rubra' had higher bract spot ratings than all Stellar® dogwood cultivars. Incidence of the bract spot phase of spot anthracnose was similar over the study period for all Stellar® dogwood cultivars. For the flowering dogwood cultivars, fewer spot anthracnose-damaged blooms were noted in 2005 on 'Cloud 9' and 'Rubra', compared with Cherokee Brave® and 'Cherokee Princess'. While all flowering dogwood cultivars had similar bract ratings in 2008, incidence of the bract spot phase of spot anthracnose was higher in 2009 for 'Rubra' than for Cherokee Brave®, while ratings for 'Cherokee Princess' and 'Cloud 9' were intermediate. Overall, incidence of the bract spot phase of spot anthracnose on all the Stellar® dogwood cultivars was significantly lower in 2 of 3 years compared with 'Cloud 9' and 'Cherokee Princess', which previously were identified as susceptible to spot anthracnose (4), and in 1 of 3 years compared with 'Rubra' and Cherokee Brave®.

Spot anthracnose on the leaves. Consistent with the results of a previous Alabama study (4), incidence of the leaf spot phase of spot anthracnose was lower for the Stellar® than for the flowering dogwood cultivars. Over the study period, no significant differences in the leaf spot phase of spot anthracnose were noted among Stellar® dogwood cultivars (Table 3). Response of Stellar® dogwood cultivars to the leaf spot phase of spot anthracnose in this and a previous central Alabama study (4) was similar. While leaf spot incidence on the flowering dogwood cultivars and Stellar Pink® did not significantly differ in 2005, disease ratings for all of the other Stellar® dogwood cultivars were lower. Among flowering dogwood selections in 2006, fewer spot anthracnose-damaged leaves were noted on 'Cherokee Princess' compared with Cherokee Brave® and 'Rubra' but not 'Cloud 9'. In contrast, 'Cherokee Princess', 'Cloud 9', and 'Rubra' had a higher percentage of spot anthracnose-damaged leaves than Cherokee Brave® in 2007, which had similar disease ratings as the Stellar® dogwood cultivars. Under low disease pressure in 2008, a higher percentage of spot anthracnose-damaged leaves was recorded for 'Rubra' than for Stellar Pink®. Otherwise, ratings for cultivars in both dogwood taxa were similar. For 2009, incidence of the leaf spot phase of spot anthracnose was similarly higher for all flowering dogwood selections compared with the Stellar® dogwood cultivars. While some differences in the incidence of the leaf spot phase of spot anthracnose among the flowering dogwood selections were seen during the study period, all proved as susceptible to spot anthracnose as previously noted (4).

Powdery mildew. As has been previously reported (4, 8), Stellar® dogwood cultivars proved highly resistant to *Erysiphe pulchra*-incited powdery mildew. With a few exceptions, powdery mildew incidence was lower for the Stellar® than nearly all flowering dogwood selections except for Cherokee Brave® in 2006 and 2007 (Table 4). All Stellar® dogwoods had similarly low levels of powdery mildew in all 5 study years. When powdery mildew was observed on Stellar® dogwood cultivars, *E. pulchra* colony formation occurred from late spring through mid-summer along the mid- and lateral veins on juvenile leaves at the shoot tips, but not on

Table 4. Occurrence of powdery mildew and Cercospora leaf spot on Stellar® and flowering dogwood cultivars at SMREC.

Dogwood taxa	Powdery mildew (% diseased leaves)[z] 2005	2006	2007	2008	2009	Cercospora leaf spot[y] (% defoliation) 2005	2009
Stellar® dogwood (*Cornus kousa* × *florida*)							
Aurora	4c[x]	0c	1b	1d	2c	1c[y]	0d
Celestial	4c	0c	0b	1d	0c	1c	0d
Constellation	7c	0c	1b	2d	5c	19bc	0d
Ruth Ellen	2c	0c	1b	1d	21c	8c	0d
Stellar Pink	13c	0c	0b	2d	2c	6c	0d
Flowering dogwood (*C. florida*)							
Cherokee Brave	61b	3c	6b	38c	69a	67a	63a
Cherokee Princess	95a	88a	63a	91a	79a	65a	16c
Cloud 9	59b	36b	58a	64b	45b	19bc	17c
Rubra	98a	88a	55a	93a	75a	34b	46b

[z]Incidence of powdery mildew was assessed using the 0 to 11 Horsfall and Barratt rating scale and transformed to percentage (%) of colonized leaves on July 8, 2005, June 7, 2006, June 1, 2007, June 23, 2008, and July 6, 2009.

[y]Cercospora leaf spot-incited defoliation was assessed using the 0 to 11 Horsfall and Barratt rating scale on September 14, 2005, and September 25, 2009, and transformed to percent (%) defoliation values.

[x]Means separation within columns was according to Fisher's protected least significant difference test ($P \leq 0.05$).

the mature leaves in the inner canopy. Elevated powdery mildew susceptibility of Ruth Ellen® and Constellation® as reported by Ranney *et al.* (17) was not observed in this and other recent studies (4, 8).

In contrast to the Stellar® dogwoods, the majority of the leaves on the flowering dogwood cultivars with the exception of Cherokee Brave® were heavily colonized by *E. pulchra* by late-June. Powdery mildew incidence was significantly higher on 'Cherokee Princess' and 'Rubra' compared with Cherokee Brave® in 3 and 4 of 5 years, respectively, and 'Cloud 9' in 4 of 5 years (Table 3). Powdery mildew incidence on Cherokee Brave® was generally higher as compared with previous Alabama (4) and Tennessee (8) studies. In contrast, 'Cherokee Princess', 'Rubra', and to a lesser extent 'Cloud 9' proved equally susceptible to powdery mildew here as previously noted (4, 8).

Cercospora leaf spot. Cercospora leaf spot-incited premature defoliation was observed only in 2005 and 2009 (Table 4). Unusually dry weather in 2006, 2007, and 2008 not only suppressed disease development but also caused an interveinal scorch on the leaves of cultivars in both dogwood taxa. The level of Cercospora leaf spot-related defoliation was generally higher for most of the flowering compared with Stellar® dogwood cultivars, which had similarly low disease ratings in 2005 and 2009 (Table 3). In 2005, defoliation levels on the flowering dogwood cultivars Cherokee Brave® and 'Cherokee Princess' were not only higher than on 'Cloud 9' and 'Rubra', but were also higher than on all Stellar® dogwood cultivars. While similar defoliation ratings were noted for 'Rubra' and the Stellar® dogwood cultivar Constellation®, 'Cloud 9' and all other Stellar® dogwood cultivars had equally low defoliation ratings. While light to heavy defoliation was noted on all of the flowering dogwood cultivars in 2009, no Cercospora leaf spot-induced defoliation was observed on any Stellar® dogwoods. Among flowering dogwood cultivars, higher defoliation levels were noted for Cherokee Brave® and 'Rubra' compared with 'Cherokee Princess' and 'Cloud 9', which had similar defoliation ratings. With the exception of 'Cloud 9', the flowering dogwood cultivars evaluated in this study are susceptible to Cercospora leaf spot, while the Stellar® dogwood cultivars displayed good disease resistance. In contrast, higher Cercospora leaf spot damage was noted by Conner and Bowen (1) on Stellar Pink® than on flowering dogwood cultivars including Cherokee Brave®, 'Cherokee Princess', and 'Cloud 9'.

When compared with flowering dogwood cultivars, survival of all Stellar® dogwood cultivars in a previous central Alabama field planting was poor, but cause for their rapid decline and death was not determined (4). At the SMREC site in north Alabama, the high survival rate for Stellar® dogwood cultivars, despite a severe summer drought in 2006 and 2007, was comparable to Cherokee Brave® and 'Cloud 9'. Due to the greatly reduced disease occurrence, particularly powdery mildew, Stellar® dogwood cultivars had superior aesthetics compared with the flowering dogwood cultivars. Damage from the dogwood borer (*Synanthedon scitula*) was noted on only one Stellar Pink® tree, while two 'Rubra' and one 'Cherokee Princess' flowering dogwoods may have succumbed to this pest.

In contrast to spot anthracnose and powdery mildew, Cercospora leaf spot has not been recognized until recently as a damaging disease on dogwood. Not only are Cercospora leaf spot-damaged trees often so heavily defoliated by early October that there is no fall color display but severe disease outbreaks are negatively correlated with tree height and trunk diameter of flowering dogwood (3). While fungicides will largely prevent Cercospora leaf spot-incited defoliation, thereby greatly enhancing fall color, establishment of disease resistant cultivars is the preferred mode of disease control, particularly in residential and commercial landscapes (2).

These studies not only demonstrated that all Stellar dogwood cultivars (Celestial™, Stellar Pink®, Aurora®, Constellation®, and Ruth Ellen®) have superior resistance to Cercospora leaf spot, but also confirmed previous observations of limited development of both phases of spot

anthracnose and powdery mildew when compared with the flowering dogwood cultivars Cherokee Brave®, 'Rubra', 'Cherokee Princess', and 'Cloud' (4, 8). Increased leaf retention on the Cercospora leaf spot-resistant Stellar® dogwood cultivars often resulted in greatly enhanced fall color display, while adjacent flowering dogwood cultivars were partially to wholly defoliated by early October. In contrast, Cherokee Brave®, 'Cherokee Princess', and 'Cloud 9' proved more susceptible to Cercospora leaf spot than previously reported by Conner and Bowen (1). In years when significant Cercospora leaf spot development occurred, all of the above dogwood cultivars as well as 'Rubra' suffered higher defoliation than all Stellar® dogwood cultivars, which had similarly low defoliation ratings. Overall, 'Cloud 9' often suffered less Cercospora leaf spot-incited defoliation than 'Rubra' while the reaction of 'Cherokee Princess' and Cherokee Brave® was intermediate.

With a few exceptions, spot anthracnose on the blooms and leaves of the Stellar dogwood cultivar at both sites was limited to scattered, tiny red to purple lesions with no bract or leaf deformation in contrast to the discolored and distorted bracts and leaves often noted on flowering dogwood. Differences in disease severity between the Stellar and flowering dogwood cultivars were most noticeable in years when the bract spot and leaf spot pressure was high. Cherokee Brave®, which previously suffered less spot anthracnose damage than 'Cherokee Princess' and 'Cloud' (4, 8), proved here to be equally vulnerable to this disease. Over the study period, powdery mildew development on all Stellar® dogwood cultivars was restricted to scatted colonies on scattered juvenile leaves in mid- to late-summer. Similarly low levels of powdery mildew development on Stellar® dogwood cultivars were noted by Hagan *et al.* (4) and Mmbaga and Sauve (8). Among flowering dogwood cultivars, only Cherokee Brave® occasionally matched the low powdery mildew ratings reported for the Stellar® dogwood cultivars. With a few exceptions, 'Cherokee Princess', 'Cloud 9', and 'Rubra' proved as susceptible to powdery mildew as previously reported (4, 8).

Despite their exceptional disease-resistance package, Stellar® dogwoods are better adapted to the upper than lower South. At sites in central and southwest Alabama [USDA Hardiness Zone 7b and 8a, respectively], tree survival was poor as compared with sites in north Alabama [SMREC], Tennessee (8), and North Carolina (17), which are in USDA Hardiness Zones 7a, 6b, and 6a, respectively, where differences in tree survival between the two dogwood taxa were not observed. While Orton (14) previously noted that Stellar® dogwoods are highly resistant to the dogwood borer in New Jersey [USDA Hardiness Zone 6a], high mortality rates for these trees was attributed to dogwood borer (*Synanthedon scitula*) and/or ambrosia beetle (*Xylosandrus* sp.), both of which are aggressive pests on trees stressed by factors such as heat, drought, or cold (5, 15, 16).

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