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DISEASE RESISTANCE AND SURVIVAL OF FLOWERING AND HYBRID DOGWOODS AT TWO LOCATIONS IN ALABAMA

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Introduction

Flowering dogwood (*Cornus florida*) is among the most popular small flowering trees in southern landscapes. Spot anthracnose, powdery mildew, and *Cercospora* leaf spot often have a detrimental impact on the aesthetics and occasionally the health of flowering dogwood. While fungicides give some protection from the above diseases (2), establishment of resistant cultivars is the preferred method of managing the above diseases. Previous studies (4,5,7) have focused on the reaction of flowering dogwood cultivars to spot anthracnose and/or powdery mildew but not *Cercospora* leaf spot. Differences in the rate of *Cercospora* leaf spot development has been seen in a landscape planting of 'native' flowering dogwood (Hagan, *personal observation*).

The Stellar® dogwood (*C. kousa* x *florida*) series were released in the early 1990's. In North Carolina, Ranney et al (6) noted that the Stellar® dogwoods 'Stellar Pink' and 'Celestial' were highly resistant to dogwood anthracnose, while 'Constellation', 'Aurora', and 'Ruth Ellen' were intermediate in their reaction to that disease. In addition, 'Stellar Pink', 'Celestial', and 'Aurora' but not 'Ruth Ellen' and 'Constellation' had a high level of resistance to powdery mildew (6). Among the Stellar® dogwoods, 'Ruth Ellen' proved most susceptible to *E. pulchra*-incited powdery mildew (5). In an Alabama study, the Stellar® dogwood cultivars showed good resistance to spot anthracnose and powdery mildew but their survival rate was far below that of the flowering dogwood cultivars (4). In this study, the reaction of selected cultivars of flowering and Stellar® dogwood to spot anthracnose, powdery mildew, and *Cercospora* leaf spot, as well as their adaptability was assessed at locations in South and North Alabama.

Material and Methods

In February 2004, cultivars of flowering dogwood (*Cornus florida*) and Stellar® dogwood (*Cornus kousa* x *florida*) were planted in full sun at the Sand Mountain Research and Extension Center [SMREC] in Northeast Alabama and at the Brewton Agricultural Research Unit [BARU] in Southwest Alabama. The newly released *C. florida* cultivar 'Appalachian Spring' was included in the BARU but not SMREC study. Otherwise, the cultivar list for both locations was identical. Immediately after planting, the trees were mulched with aged pine bark and a drip irrigation system was installed. Ammonium nitrate was applied to the mulched area around each tree at a rate of 150 pounds of actual nitrogen per treated acre per year. Supplemental applications of murate of potash at 60 pounds per acre were made as needed. Surflan AS alone or in a tank mixture with Gallery was applied for pre-emergent weed control. Escape weeds were controlled either by hand or with spot applications of Finale or MSMA. The experimental design

was a randomized complete block with four replications with two plants per replicate at BARU and five single plant replications at SMREC. Spot anthracnose, powdery mildew, and *Cercospora* leaf spot intensity was assessed using the Horsfall and Barratt 1 to 12 rating scale where 1 = no disease, 2 = 0 to 3%, 3 = 3 to 6%, 4 = 6 to 12%, 5 = 12 to 25%, 6 = 25 to 50%, 7 = 50 to 75%, 8 = 75 to 87%, 9 = 87 to 94%, 10 = 94 to 97%, 11 = 97 to 100 %, and 12 = 100% of the leaves diseased or prematurely shed on the dates listed in the table. *Cercospora* leaf spot-induced defoliation was also assessed using the above rating scale. Trees at BARU were harvested on 31 September 2007 to assess insect damage to their trunks. Significance of treatment effects were tested by analysis of variance and Fisher's protected least significant difference (LSD) test ($P=0.05$).

Results and Discussion

SMREC Trial: In 2005, symptoms of spot anthracnose were first noted on 13 April as the leaves on unfurled. By 17 May, spot anthracnose ratings were higher for 'Cherokee Brave', 'Cherokee Princess', 'Cloud 9', and 'Rubra' than for the Stellar® dogwoods (Table 1). 'Cherokee Princess' had a lower spot anthracnose rating compared with the other flowering dogwood cultivars. Little if any spot anthracnose damage was seen on leaves of the Stellar® dogwoods. Powdery mildew incidence was higher on the flowering than the Stellar® dogwoods. Nearly all of the leaves on the 'Rubra' and 'Cherokee Princess' flowering dogwood were colonized by the powdery mildew fungus *Erysiphe pulchra*. While 'Cherokee Brave' and 'Cloud 9' had lower powdery mildew ratings than 'Rubra' and 'Cherokee Princess', over 50% of the leaves on latter trees were also heavily colonized. In contrast, powdery mildew incidence on the Stellar® dogwoods ranged from 0% to 8% and the area colonized on individual leaves was small. *Cercospora* leaf spot appeared on the flowering dogwoods between the 8 July and 29 August 2005 rating dates. By 29 August, heaviest defoliation was noted on the 'Cherokee Princess' flowering dogwood. On 'Cherokee Princess' and 'Cherokee Brave', defoliation exceeded 50% on 14 September compared with less than 6% on 'Stellar Pink', 'Ruth Ellen', 'Celestial', and 'Aurora' on the same date. By 20 October, moderate to heavy defoliation was seen on all flowering and Stellar® dogwoods except for 'Celestial' and 'Stellar Pink'. Heaviest defoliation was recorded on 'Cherokee Princess' and 'Cherokee Brave'. Defoliation levels for 'Ruth Ellen', 'Aurora', and 'Constellation' were similar.

As was noted in the previous year, spot anthracnose damage was higher in 2006 on the flowering than the Stellar® dogwoods. Among the flowering dogwood cultivars, 'Cherokee Princess' suffered the least spot anthracnose-related leaf spotting (Table 1). Spot anthracnose ratings for flowering dogwoods 'Cherokee Brave', 'Cloud 9', and 'Rubra' were similar. Characteristic symptoms of spot anthracnose were found on no more than 3% of the leaves of any Stellar® dogwood cultivar. Again, the Stellar® dogwood cultivars had noticeably lower powdery mildew ratings than the flowering dogwood cultivars. While little if any leaf colonization of the Stellar® dogwoods was noted on 6 June 2006 rating date, at least 90% of the leaves of 'Rubra' flowering dogwood were colonized. While 'Cherokee Brave' had the lowest powdery mildew ratings among the flowering dogwood cultivars, leaf colonization was higher compared with all Stellar® dogwood cultivars. Due to heavy drought-related leaf scorch, *Cercospora* leaf spot development was minimal in 2006 on all trees.

For 2007, spot anthracnose ratings for all of the Stellar® dogwood cultivars except 'Celestial' were lower than those of the heavily damaged flowering dogwood cultivar 'Cherokee Princess' (Table 1). The low level of spot anthracnose damage on 'Cherokee Chief' was similar to that on the Stellar® hybrid dogwood cultivars 'Ruth Ellen', 'Constellation', and 'Aurora'. For the third

‘Constellation’, and ‘Aurora’. For the third consecutive year, powdery mildew incidence was noticeably higher on all of the flowering than the Stellar® dogwood cultivars. Among the flowering dogwood cultivars, the level of leaf colonization was lower on ‘Cherokee Brave’ than on ‘Rubra’, ‘Cherokee Princess’, and ‘Cloud 9’. For the second consecutive year, dry summer and early fall weather in 2007 suppressed the development of Cercospora leaf spot. By the 1 November rating date, symptoms of this disease were restricted to light to moderate leaf spotting with little if any premature defoliation. Cercospora leaf spot ratings were higher for ‘Rubra’ flowering dogwood than the Stellar® dogwoods ‘Aurora’, ‘Celestial’, and ‘Stellar Pink’. Among the flowering dogwood cultivars, disease intensity was lower on ‘Cherokee Princess’ than ‘Cloud 9’ and ‘Rubra’ but not ‘Cherokee Brave’.

Overall, the leaf spot phase of spot anthracnose was less damaging in 2008 than in the previous three years (Table 1). Among the flowering dogwood cultivars, ‘Cherokee Princess’ has the lowest spot anthracnose rating. As was noted on the above flowering dogwood cultivar, symptoms on all Stellar® dogwood cultivars were limited to scattered leaf spots on a few leaves. Higher leaf colonization was again recorded on the flowering than Stellar® dogwood cultivars. Powdery mildew development on all the Stellar® cultivars was restricted to a scattered colony or two on no more than a few of the immature leaves. Among the flowering dogwood, powdery mildew incidence on ‘Rubra’ and ‘Cherokee Princess’ compared with ‘Cherokee Brave’ and ‘Cloud 9’, which had similar disease ratings.

BARU Trial: All Stellar® dogwood cultivars had lower spot anthracnose ratings in 2005 than the flowering dogwood cultivars ‘Cloud 9’, ‘Cherokee Princess’, and ‘Rubra’ (Table 2). Spot anthracnose ratings for the flowering dogwood cultivars ‘Appalachian Spring’ and ‘Cherokee Brave’ were similar to those of the Stellar® dogwoods ‘Ruth Ellen’, ‘Stellar Pink’, ‘Aurora’, and ‘Constellation’ but higher than those for ‘Celestial’. No differences in spot anthracnose ratings were noted among the five Stellar® dogwood cultivars. Although considerable powdery mildew development was noted on the leaves of all of the flowering dogwood cultivars in 2005, minimal leaf colonization was seen on the Stellar® dogwoods. Of the flowering dogwood cultivars, ‘Rubra’ and ‘Cherokee Brave’ had the highest and lowest, respectively, powdery mildew ratings. Powdery mildew incidence was higher on ‘Cherokee Brave’ than all of the Stellar® dogwoods. On 22 August, Cercospora leaf spot induced-defoliation was higher on ‘Cherokee Princess’ than nearly all of the flowering and Stellar® dogwoods. By 10 October, defoliation levels for the Stellar® dogwood cultivars were significantly below those of all the flowering dogwood cultivars. As indicated by defoliation ratings of 6.8 and 9.3, respectively, ‘Cherokee Brave’ suffered nearly 50% defoliation at the above rating date compared with almost 93% for ‘Rubra’. In contrast, the Stellar® dogwoods ‘Ruth Ellen’, ‘Constellation’, and ‘Stellar Pink’, which had defoliation ratings ranging from 4.4 to 4.9, suffered only 8 to 12 % premature leaf loss. Defoliation ratings for ‘Celestial’ and ‘Aurora’ were below those of ‘Stellar Pink’ and ‘Constellation’. By 11 November 2005, defoliation ratings for Stellar® dogwoods ‘Ruth Ellen’, ‘Stellar Pink’, and ‘Constellation’ were similar to those recorded for ‘Appalachian Spring’, ‘Cloud 9’, and ‘Cherokee Princess’ flowering dogwoods. On the above rating date, ‘Rubra’ flowering dogwood was almost completely defoliated. Among the Stellar® dogwoods, ‘Celestial’ and ‘Aurora’ had the lowest Cercospora leaf spot defoliation ratings.

Except for ‘Cherokee Princess’, spot anthracnose incidence on 8 May 2006 was significantly lower for the Stellar® than for the flowering dogwood cultivars (Table 2). Among the flowering dogwood cultivars, spot anthracnose ratings for ‘Appalachian Spring’ and ‘Rubra’ were higher than ‘Cherokee Princess’ but not ‘Cloud 9’ and ‘Cherokee Brave’. Similar spot anthracnose ratings were recorded for all Stellar® dogwood cultivars. In 2006, noticeable

powdery mildew development was found only on 'Rubra' flowering dogwood. Powdery mildew development was minimal on the remaining flowering dogwood cultivars and all the Stellar® dogwood cultivars. Cercospora leaf spot development was not assessed in 2006 due to severe wounding of the leaves by hail.

In 2007, incidence of the leaf spot phase of spot anthracnose did not differ among flowering dogwood cultivars (Table 2). Spot anthracnose incidence on the flowering dogwood cultivars 'Cherokee Princess' and 'Cherokee Brave' as well as the Stellar® dogwood cultivars 'Ruth Ellen' and 'Aurora' were similar. Leaves of the Stellar® dogwoods 'Stellar Pink', Celestial, and Constellation remained free or largely free of spot anthracnose symptoms. Due to hot, dry weather patterns, powdery mildew development was very limited on both flowering and Stellar® dogwood cultivars. While the highest level of powdery mildew was noted on 'Rubra' flowering dogwood, colonies of the causal fungus as indicated by a rating of 3.3 were found on approximately 4% of the leaves. Powdery mildew was not observed on the leaves of any of the Stellar® dogwood cultivars. Cercospora leaf spot intensity did not significantly differ between flowering dogwood cultivars. Disease ratings for 'Ruth Ellen' and 'Aurora' were similar to those of the flowering dogwood cultivars.

When compared with 'Cloud 9' flowering dogwood, survival of all Stellar® dogwood cultivars was very poor over the three-year study period (Figure 1). Similarly poor survival pattern for Stellar® dogwoods were seen in a previous Alabama field study (4). In contrast, the survival rate for the remaining four flowering dogwood cultivars was similar to the 100% level noted for 'Cloud 9' (data not shown). Trunk damage attributed to the Asian ambrosia beetle (*Xylosandrus crassiusculus*) was first noted in March 2006. When study was terminated in September 2007, Asian ambrosia beetle, dogwood borer (*Synanthedon scitula*), or a combination of these two insects had damaged approximately 75% of the trunks of each of the Stellar® dogwood cultivars compared with 16% or fewer of the trunks of the flowering dogwood cultivars (data not shown). The involvement of the dogwood borer in the death of two trees at SMREC was not assessed. No tunneling or other damage attributed to the Asian ambrosia beetle has been noted at the SMREC site.

As seen in previous field trial (4,5,6), Stellar® dogwood cultivars demonstrated superior resistance to spot anthracnose and powdery mildew to most flowering dogwood cultivars at both study sites. Differences in the level of spot anthracnose and powdery mildew resistance between the Stellar® dogwoods 'Aurora', 'Celestial', 'Constellation', 'Ruth Ellen', and 'Stellar Pink' usually were minor. In addition, significantly less Cercospora leaf spot-induced premature defoliation and to a lesser extent leaf spotting was noted on the Stellar® than the flowering dogwood cultivars. At the two study locations, the least premature defoliation was seen on 'Celestial' and 'Aurora', while 'Ruth Ellen' and 'Stellar Pink' had equally low defoliation ratings at one study location. Enhanced leaf retention due to superior Cercospora leaf spot resistance of the Stellar® dogwood cultivars usually resulted in superior fall color.

Among the flowering dogwood cultivars, 'Rubra' proved to be susceptible at both study locations to the leaf spot phase of spot anthracnose and powdery mildew. While spot anthracnose incidence was often lower on 'Cherokee Princess', particularly at SMREC, this cultivar proved highly susceptible to powdery mildew at the same location. 'Cherokee Brave' and 'Cloud 9', which have some resistance to powdery mildew, were susceptible to spot anthracnose. The dogwood anthracnose-resistant Appalachian Spring flowering dogwood was as susceptible to spot

anthracnose as 'Rubra' but showed some resistance to powdery mildew. When compared with most of the Stellar® dogwood cultivars, flowering dogwood cultivars were more susceptible to *Cercospora* leaf spot. Differences in the reaction of flowering dogwood cultivars to *Cercospora* leaf spot, however, were noted. At both locations, 'Cloud 9' was less susceptible to *Cercospora* leaf spot than 'Rubra'. When compared with 'Rubra', a reduction in premature defoliation was also noted at one of two sites for 'Cherokee Princess', 'Appalachian Spring', and to a lesser extent 'Cherokee Brave'. Recently, development of *Cercospora* leaf spot was shown to be slightly slower on 'Cherokee Chief' than 'Cloud 9' (3). Conner and Bowen (1) reported that the flowering dogwood cultivars 'Pygmy', 'Red Pygmy', and 'Pumpkin Patch' were free of *Cercospora* leaf spot, while minor disease development was seen on 'Cherokee Brave', 'Cherokee Chief', 'Cherokee Princess', and 'Cloud 9'.

In summary, the Stellar® dogwoods 'Aurora', 'Celestial', 'Constellation', 'Ruth Ellen', 'Stellar Pink' demonstrated good to excellent resistance to common dogwood diseases. Of these, 'Celestial', which suffered little damage from spot anthracnose, powdery mildew, and *Cercospora* leaf spot, may have the best disease resistance package. Despite their high level of disease resistance, Stellar® dogwoods have proven extremely vulnerable in South and Central Alabama (4) to the Asian ambrosia beetle, dogwood borer, and possibly winter injury. As a result, plantings of Stellar® dogwoods should be limited to the northern third of Alabama. Among the flowering dogwood cultivars, 'Cherokee Brave' proved most resistant to powdery mildew but was vulnerable to spot anthracnose and *Cercospora* leaf spot.

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Figure 1. Survival of Stellar® dogwood cultivars at the Brewton Agricultural Research Center from 2005 through 2007.

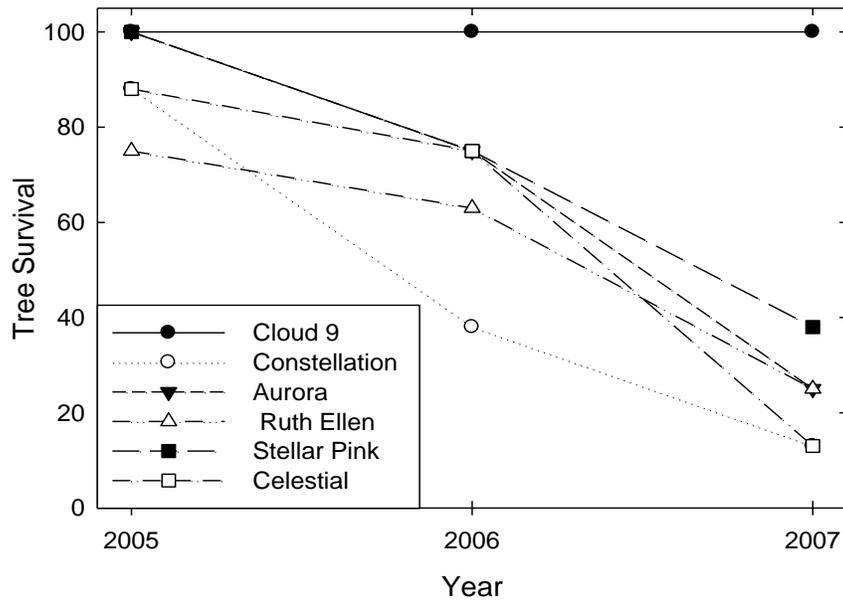


Table 1. Sensitivity of selected cultivars of flowering (*C. florida*) and Stellar (*C. florida* x *kousa*) dogwood to leaf spot phase of spot anthracnose, powdery mildew, and Cercospora leaf spot at SMREC in 2005, 2006, 2007 and 2008.

| Dogwood Selection | Spot Anthracnose ^z | | | | Powdery Mildew ^y | | | | Cercospora Leaf Spot ^x | | |
|--------------------------|-------------------------------|-------|--------|--------|-----------------------------|--------|-------|-------|-----------------------------------|-------------|-----------|
| | 2005 | 2006 | 2007 | 2008 | 2005 | 2006 | 2007 | 2008 | 2005 | 2007 | |
| Flowering dogwood | | | | | | | | | Intensity | Defoliation | Intensity |
| Rubra | 4.2 ab ^w | 6.2 a | 5.8 ab | 3.7 a | 11.4 a | 10.0 a | 6.8 a | 9.3 a | 12.0 a | 8.4 abc | 4.0 a |
| Cherokee Brave | 4.0 ab | 6.2 a | 2.6 d | 3.6 a | 7.0 b | 3.2 c | 3.6 b | 6.2 b | 10.8 bc | 9.0 a | 3.0 abc |
| Cloud 9 | 5.4 a | 5.4 a | 5.6 ab | 3.0 ab | 8.4 b | 5.6 b | 6.8 a | 6.8 b | 9.4 de | 7.4 bc | 3.4 ab |
| Cherokee Princess | 3.6 b | 4.0 b | 7.2 a | 2.0 bc | 10.8 a | 8.3 a | 7.3 a | 9.0 a | 11.4 ab | 9.6 a | 1.5 cd |
| Stellar dogwood | | | | | | | | | | | |
| Ruth Ellen | 1.4 c | 2.0 c | 3.0 cd | 1.4 c | 1.8 cd | 1.2 d | 1.2 c | 1.6 c | 11.2 ab | 4.8 de | 2.8 abcd |
| Stellar Pink | 1.6 c | 1.4 c | 4.8 bc | 1.2 c | 1.0 d | 1.0 d | 1.0 c | 2.0 c | 8.4 e | 3.8 ef | 1.6 cd |
| Celestial | 1.2 c | 2.0 c | 5.4 ab | 1.4 c | 2.4 cd | 1.0 d | 1.0 c | 1.4 c | 8.8 e | 2.4 f | 1.2 d |
| Aurora | 1.2 c | 1.2 c | 2.2 d | 1.4 c | 2.6 cd | 1.2 d | 1.2 c | 1.4 c | 10.0 cd | 4.8 de | 1.8 bcd |
| Constellation | 2.0 c | 2.0 c | 2.3 d | 1.5 bc | 3.2 c | 1.0 d | 1.3 c | 1.8 c | 8.8 e | 6.6 cd | 2.5 abcd |

^zSpot anthracnose leaf ratings are reported for 17 May 2005, 5 May 2006, 19 April 2007, and 1 May 2008.

^yPowdery mildew incidence is reported for 8 July 2005, 7 June 2006, 1 June 2007, and 23 June 2008.

^xCercospora leaf spot incidence is reported for 20 October 2005 and 12 October 2007.

^wMean separation within columns was according to Fisher's protected least significant difference test ($P=0.05$).

Table 2. Susceptibility of selected flowering (*C. florida*) and Stellar® (*C. florida* x *kousa*) dogwood cultivars to spot anthracnose, powdery mildew, and Cercospora leaf spot at BARU in 2005, 2006, and 2007.

| Dogwood Selection | Spot Anthracnose ^z | | | Powdery Mildew ^y | | | Cercospora Leaf Spot ^x | | |
|--------------------------|-------------------------------|--------|---------|-----------------------------|-------|--------|-----------------------------------|-------------|-----------|
| | 2005 | 2006 | 2007 | 2005 | 2006 | 2007 | 2005 | 2007 | |
| Flowering dogwood | | | | | | | Intensity | Defoliation | Intensity |
| Appalachian Spring | 5.0 ab ^w | 4.5 a | 6.7 a | 6.8 c | 1.2 b | 1.2 b | 10.8 ab | 7.3 cd | 4.7 ab |
| Cherokee Brave | 5.7 ab | 4.3 ab | 4.9 abc | 4.7 d | 1.0 b | 1.4 b | 11.1 ab | 9.3 b | 2.4 abcd |
| Cloud 9 | 6.6 a | 4.3 ab | 6.3 ab | 8.0 bc | 1.1 b | 1.8 ab | 11.4 ab | 8.1 cd | 3.8 abcd |
| Cherokee Princess | 6.4 a | 3.3 bc | 5.0 abc | 9.1 b | 2.3 b | 2.5 ab | 11.5 a | 8.3 bc | 4.0 abc |
| Rubra | 6.5 a | 4.9 a | 5.9 ab | 11.6 a | 7.0 a | 3.3 a | 11.9 a | 10.9 a | 4.9 a |
| Stellar dogwood | | | | | | | | | |
| Ruth Ellen | 4.0 bc | 1.9 d | 3.0 cd | 1.0 e | 1.0 b | 1.0 b | 12.0 a | 7.1 d | 2.5 abcd |
| Stellar Pink | 4.1 bc | 2.0 d | 1.2 d | 1.1 e | 1.0 b | 1.0 b | 11.4 ab | 7.8 cd | 1.3 cd |
| Celestial | 2.5 c | 2.1 cd | 1.0 d | 1.1 e | 1.0 b | 1.0 b | 10.3 b | 4.1 e | 2.0 bcd |
| Aurora | 3.6 bc | 2.5 cd | 4.2 bc | 1.0 e | 1.0 b | 1.0 b | 11.6 a | 4.8 e | 1.0 d |
| Constellation | 4.3 bc | 2.3 cd | 1.0 d | 1.0 e | 1.0 b | 1.0 b | 11.1 ab | 8.0 cd | 1.0 d |

^zSpot anthracnose leaf ratings are reported for 19 May 2005, 8 May 2006, and 2 May 2007.

^yPowdery mildew incidence is reported for 23 July 2005, 7 June 2006, and 3 July 2007.

^xCercospora leaf spot ratings are reported for 18 October 2005 and August 31, 2007.

^wMean separation within columns was according to Fisher's protected least significant difference test ($P=0.05$).