Influence of Nitrogen Fertilization Rate on Disease Incidence, Flower Bud Set, and Growth of Flowering Dogwood in Alabama

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Cover images: At all nitrogen application rates, control of Cercospora leaf spot with the fungicide Heritage on 'Cherokee Chief' flowering dogwood (left) resulted in a sharp decline in premature leaf loss and greatly enhanced fall color when compared with the untreated trees (right). (Photos taken in November 2005)

Influence of Nitrogen Fertilization Rate on Disease Incidence, Flower Bud Set, and Growth of Flowering Dogwood in Alabama

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INTRODUCTION

Nitrogen is a key component for plant growth *(24)*, yet relatively little is known of its impact on the development of diseases of shrubs and trees *(15)*. Increased severity of powdery mildew diseases has often been stimulated by lush top growth produced by excessive nitrogen fertilization *(2)*. Elevated levels of nitrogen fertilization also increased the severity of fire blight on apple *(25)* and Phytophthora dieback on rhododendron *(13)*. In contrast, resistance of black walnut to anthracnose was enhanced by supplemental applications of nitrogen *(18,19)*. Severity of Alternaria leaf spot and leaf spot diseases incited by bacteria in the genera *Xanthomonas* and *Pseudomonas* on several tropical herbaceous and woody plants declined sharply with increasing rates of nitrogen *(4)*. On flowering dogwood (*Cornus florida* L.), increasing rates of nitrogen may have reduced the severity of dogwood anthracnose when weather patterns were unfavorable for disease development *(1)*. However, nothing is known of the impact about nitrogen fertility on other common diseases of flowering dogwood such as spot anthracnose, powdery mildew, and Cercospora leaf spot.

Despite the popularity of flowering dogwood, little is known of the impact of nitrogen application rate on its growth and health. In a forest setting, Curlin *(5)* reported that increasing nitrogen rates from 0 to 600 pounds per acre corresponded to an increase in the trunk diameter of flowering dogwood. However, no increase in growth of southern magnolia and oak was seen at nitrogen rates above 360 pounds per acre per year in a fine sandy soil *(7)*. Smith and Gilliam *(23)* reported that 130 pounds of nitrogen per acre per year was sufficient to maintain the health and beauty of most landscape trees and shrubs. Currently, fertilization recommendations for established landscape trees range from 44 to 130 pounds per acre for quick-release forms of nitrogen and from 87 to 174 pounds per acre for slow-release forms of nitrogen *(22)*. For field-grown nursery stock, including flowering dogwood, optimum annual nitrogen fertilization rate is approximately 250 pounds per acre *(14)*. An extensive review of shade tree nitrogen fertility research was recently published by Stuve *(24)*.

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Diseases not only mar the floral and foliage display of flowering dogwood but may also slow tree growth or threaten tree health. Bract spotting and distortion were the most notable symptoms of spot anthracnose, caused by *Elsinore corni* Jenkins and Bitanic, which is a common and damaging disease on flowering dogwood grown in full sun *(6)*. Powdery mildew, caused by the fungus *Erysiphe pulchra* (Cooke & Bechke) U. Braum and S. Takamatsu comb. nov. [syn. = *Microsphaera pulchra, M. penicillata]*, slowed the growth of container-grown flowering dogwood *(10,17)*. Cercospora leaf spot, caused by *Pseudocercospora cornicola* (Tracy and Earle) Guo and Lin [syn. = *Cercospora cornicola*], greatly accelerated the rate of leaf abscission to the point that heavily defoliated flowering dogwoods show little if any fall color *(9)*.

The purpose of this study was to determine the influence of nitrogen fertilization rate on the development of spot anthracnose, powdery mildew, and Cercospora leaf spot of flowering dogwood in a simulated landscape planting. Also investigated were (1) the relationship between the occurrence of spot anthracnose, powdery mildew, and Cercospora leaf spot and the rate of tree growth and (2) the impact of nitrogen fertilization rate on tree growth and flower bud set.

MATERIALS AND METHODS

Plant maintenance. Before planting, the mineral nutrient status and pH of a Benndale (A) fine sandy loam (<1 percent organic matter) was adjusted according to the results of a soil fertility assay done by the Auburn University Soil Fertility Laboratory. A drip irrigation system with a single emitter per tree was installed at planting and the trees were watered as needed. Container-grown 'Cherokee Chief' and 'Cloud 9' flowering dogwoods were transplanted on February 12, 2001. Approximately 1 inch of aged pine bark was evenly distributed in a 6-foot diameter circle around each tree. Approximately 3 ounces of murate of potash (0-0-60 K_2O) was evenly distributed over the mulched area around each tree on February 26, 2003 and March 9, 2004. A separate application of super phosphate (0-0-46 P_20_4) at the rate of 3 ounces per tree was made on March 9, 2004. Directed applications of 1 pound per acre of Gallery DF and 2 quarts per acre of Surflan T/O were made to the mulched area once or twice each year for pre-emergent annual weed control. Hand weeding and spot applications of Finale herbicide at 2 fluid ounces per gallon of spray volume were used to control escaped weeds. Trunk sprays of Dursban 4E insecticide were made to control dogwood borer on May 14, 2002 as well as March 24 and April 27, 2004.

Design and fungicide program. A split-split plot design consisting of six replications with nitrogen rate as the main plot, dogwood cultivar as the split plot, and fungicide treatment as the split-split plot was used. Ammonium nitrate (33N-0P_2O_5-0K_2O) was applied at 37.5, 75, 150, 300, and 600 pounds of actual nitrogen per treated acre per year beginning in 2001 and ending in 2005. In April and June, a half rate of each nitrogen treatment was evenly applied around the base of each tree. Each main plot included of a pair of 'Cherokee Chief' and 'Cloud 9' flowering dogwoods. Heritage 50W fungicide was applied at 4 ounces per 100 gallons of spray volume to one of the 'Cherokee Chief' and 'Cloud 9' flowering dogwoods in each plot while the second tree was left untreated. Applications were made with a CO_2-pressurized sprayer at two-week intervals from April 20 to July 27, 2001; April 10 to July 10, 2002; March 21 to July 10, 2003; April 1 to July 7, 2004; and April 19 to July 27, 2005.

Disease assessment. Incidences of spot anthracnose, powdery mildew, and Cercospora leaf spot were individually rated using the Horsfall and Barratt rating scale where 1 = 0 percent, 2 = 0 to 3 percent, 3 = 3 to 6 percent, 4 = 6 to 12 percent, 5 = 12 to 25 percent, 6 = 25 to 50 percent, 7 = 50 to 75 percent, 8 = 75 to 87 percent, 9 = 87 to 94 percent, 10 = 94 to 97 percent, 11 = 97 to 100 percent, and 12 = 100 percent of leaves showing signs of powdery mildew colonization or symptoms of spot anthracnose and/or Cercospora leaf spot. Cercospora leaf spot-related defoliation was also rated using the above rating scale. Spot anthracnose ratings on the bracts were taken on April 7 and April 23, 2003; March 24 and April 4, 2004; and April 4 and April 11, 2005. Damage ratings for the leaf spot phase of spot anthracnose were recorded on April 23, May 27, June 13, and July 16, 2003; April 20, May 7, and June 16, 2004; and April 22, May 12, June 20, and July 24, 2005. Powdery mildew incidence was rated on May 27, June 13, and July 16, 2003; May 20, June 16, and July 8, 2004; and May 12, June 20, and July 24, 2005. Incidence of leaf spotting and defoliation due to Cercospora leaf spot were evaluated on August 19, September 20, October 1, October 15, October 30, and November 15, 2003; July 8, August 2, August 24, September 30, October 27, November 9, and November 30, 2004; and July 8, August 2, August 24, September 30, October 27, and November 6, 2005.

Tree growth. Tree height and trunk diameter measurements were taken on February 13, 2001, December 3, 2001, February 17, 2003, January 13, 2004, January 8, 2005, and January 10, 2006. Flower buds on each tree were counted on February 17, 2003, January 13, 2004, January 31, 2005, and January 18, 2006.

RESULTS

Bract spot phase of spot anthracnose. In 2003, 2004, and 2005, nitrogen fertilization rate had little noticeable affect on the incidence of the bract spot phase of spot anthracnose on the untreated 'Cloud 9' flowering dogwood (Table 1). Similar results were also seen under heavy disease pressure in 2005 on 'Cherokee Chief'. Under moderate disease pressure in 2003 and 2004, the percentage of blooms with diseased bracts on 'Cherokee Chief' jumped from about 10 percent to more than 80 percent when nitrogen application rate increased from 37.5 to 150 pounds per acre. In both years, bract spot ratings were also lower at the 300- and 600-pounds-per-acre rates compared with the 75- and 150-pounds-per-acre rates of nitrogen. For 2005, but not 2003 and 2004, bract damage on the fungicide-treated 'Cloud 9' but not the 'Cherokee Chief' flowering dogwoods declined from 25 percent at the lowest to about 8 percent at the highest nitrogen fertilization rate (data not shown).

When averaged across nitrogen rates, bract spot ratings for the untreated 'Cherokee Chief' were lower than the ratings for the 'Cloud 9' flowering dogwoods in 2003 and 2004, but cultivar ratings were similar in 2005 when nearly 100 percent of the blooms on both 'Cherokee Chief' and 'Cloud 9' were damaged (Table 2). In 2003

Table 1. Incidence of the Bract Spot Phase of Spot Anthracnose on Two Cultivars of Flowering Dogwood as Influenced by Nitrogen Fertilization Rate[1,2,3]

Nitrogen rate	'Cherokee Chief'			'Cloud 9'		
(lb/A)	2003	2004	2005	2003	2004	2005
37.5	4.5	4.5	12.0	9.3	9.3	12.0
75	8.0	7.5	11.0	8.8	9.0	11.7
150	7.0	7.0	12.0	9.2	9.2	11.8
300	5.6	5.7	11.8	9.4	9.4	11.8
600	6.3	6.3	12.0	8.4	8.4	11.2

[1]Disease ratings were taken on April 7, 2003; April 4, 2004; and April 4, 2005.
[2]Spot anthracnose incidence was visually assessed using the 1 to 12 Horsfall and Barratt rating scale. [3]Dogwoods were not treated with Heritage 50W fungicide.

and 2004, approximately 90 percent of the blooms on the untreated 'Cloud 9' trees suffered noticeable bract spotting compared to less than 40 percent on the untreated 'Cherokee Chief' flowering dogwoods. For the fungicide-treated trees, bract spot ratings for 'Cloud 9' and 'Cherokee Chief' were similar in 2003 and 2004 but were higher for the latter cultivar in 2005. Regardless of nitrogen fertilization rate, Heritage 50W fungicide gave 29 to 52 percent and 46 to 64 percent control of the bract spot phase of spot anthracnose on 'Cloud 9' and 'Cherokee Chief' flowering dogwoods, respectively. In addition, fewer individual lesions or spots and very little distortion or twisting were seen on the bracts of the fungicide-treated trees.

Leaf spot phase of spot anthracnose. As previously noted for the bract spot phase of spot anthracnose, nitrogen fertilization rate did not greatly influence the incidence of the leaf spot phase of this disease on either flowering dogwood cultivar (Table 3). While the level of spot anthracnose-related leaf spotting varied from year to year, the 'Cloud 9' flowering dogwood was more susceptible to the leaf spot phase of spot anthracnose than 'Cherokee Chief' (Table 3). In two of three years, disease ratings for the fungicide-treated 'Cloud 9' and the untreated 'Cherokee Chief' flowering dogwoods were similar (Table 3). On the fungicide-treated 'Cherokee Chief' flowering dogwoods, the percentage of diseased leaves never exceeded an unobtrusive 5 percent. Also, fewer leaf spots and less leaf distortion were seen on the leaves of the fungicide-treated 'Cherokee Chief' and 'Cloud 9' flowering dogwoods.

Powdery mildew. Powdery mildew incidence on both cultivars of flowering dogwood was lower in 2003 and 2004 than in 2005 (Table 2). In 2003 and 2004, the average level of leaf colonization on the untreated 'Cherokee Chief' and 'Cloud 9' flowering dogwoods did not exceed 5 percent compared with about 80 percent colonization of the leaves on both cultivars in 2005. Typically, powdery mildew colonies first appear on the leaves in late April to early May. Little disease intensification was seen after the June rating date (data not shown).

Since powdery mildew incidence on the untreated 'Cloud 9' and 'Cherokee Chief' flowering dogwoods was similar, disease ratings for 2003, 2004, and 2005 were averaged across dogwood cultivar. Although nitrogen fertilization rate did not have a tremendous impact on the incidence of powdery mildew, some differences in the incidence of this disease were seen. In 2003, powdery mildew incidence gradually increased as actual nitrogen fertilization rate rose from 75 to 600 pounds per acre (Figure 1). However, the disease rating for the trees receiving 37.5 pounds of nitrogen per

TABLE 2. IMPACT OF CULTIVAR SELECTION AND FUNGICIDE TREATMENT ON THE INCIDENCE OF THE BRACT AND LEAF SPOT PHASES OF SPOT ANTHRACNOSE AND POWDERY MILDEW[1]

	Spot anthracnose[2]						Powdery mildew[2]		
	Avg. bract rating			Avg. leaf rating			Avg. rating		
Fungicide	2003	2004	2005	2003	2004	2005	2003	2004	2005
Cherokee Chief									
Fungicide Treated[3]	3.5	3.3	4.2	2.8	1.4	3.4	1.1	1.0	1.2
Untreated	6.4	6.3	11.8	4.8	2.1	6.9	2.5	3.5	6.2
Cloud 9									
Fungicide Treated[3]	6.2	6.4	7.0	3.9	1.9	6.7	1.1	1.0	1.1
Untreated	9.0	9.1	11.7	7.6	3.6	9.7	2.4	3.8	5.8

[1]Bloom ratings taken April, 7 2003; April 4, 2004; and April 4, 2005.
[2]Ratings for leaf spot phase of spot anthracnose and powdery mildew were averaged across rating dates. [3]Treated with Heritage 50W fungicide.

TABLE 3. OCCURRENCE OF THE LEAF SPOT PHASE OF SPOT ANTHRACNOSE ON TWO CULTIVARS OF FLOWERING DOGWOOD AS INFLUENCED BY NITROGEN FERTILIZATION RATE[1,2]

Nitrogen rate	'Cherokee Chief'			'Cloud 9'		
(lb/A)	2003	2004	2005	2003	2004	2005
37.5	3.7	2.2	7.2	6.8	3.8	9.8
75	5.0	3.3	7.0	7.7	4.0	10.8
150	4.3	2.5	7.5	7.3	4.3	10.5
300	4.3	2.0	7.4	8.0	4.2	10.2
600	4.3	2.0	8.0	7.7	3.7	10.3

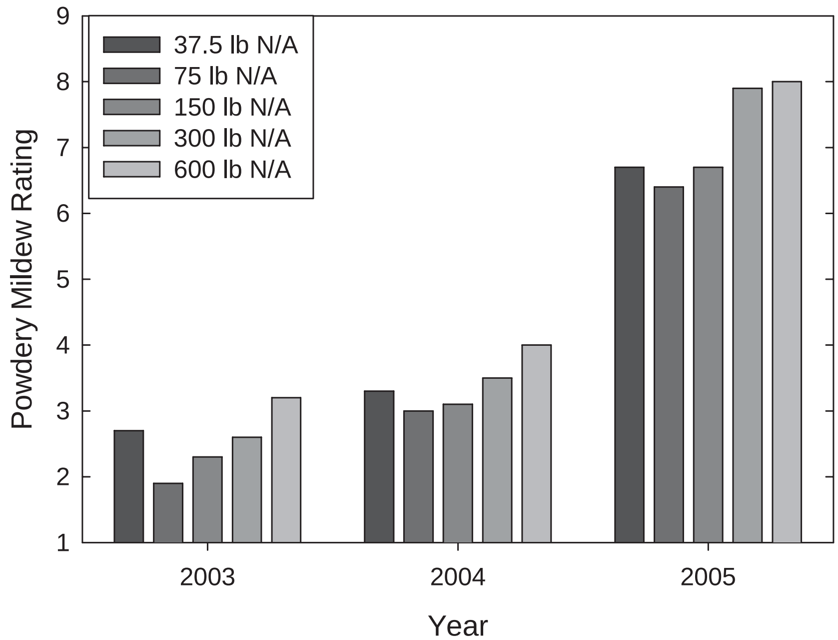
[1]Disease ratings, which were for trees that were not treated with Heritage 50W fungicide, were taken on May 27, 2003; May 7, 2004, and May 12, 2005.
[2]Spot anthracnose incidence was visually assessed using the 1 to 12 Horsfall and Barratt rating scale.

acre was higher than the disease rating for the trees receiving 75 pounds per acre and similar to those receiving 300 pounds per acre. Regardless of nitrogen fertilization rate in 2003, the overall level of leaf colonization, which ranged from less than 3 percent to slightly more than 4 percent, was very low. For 2004, nitrogen fertilization rate again had a minor impact on powdery mildew incidence. Disease ratings for trees receiving 600 pounds of nitrogen per acre were slightly higher compared with the lower nitrogen fertilization rates. However, the difference in the percentage of leaves colonized by the powdery mildew fungus between the lowest and highest rated nitrogen fertilization rates was only 3 percent. Due to higher disease pressure in 2005, differences in powdery mildew incidence among nitrogen fertilization rates were larger than differences seen in previous years. Trees receiving 300 and 600 pounds of nitrogen per acre suffered 85 to 90 percent leaf colonization compared with 35 to 40 percent colonization at the three lower nitrogen fertilization rates.

Heritage 50W fungicide proved highly effective in all three years in controlling powdery mildew on both 'Cherokee Chief' and 'Cloud 9' flowering dogwoods (Table 2). When powdery mildew pressure peaked in 2005, 81 to 83 percent control of this disease was obtained with Heritage 50W on both flowering dogwood cultivars.

Cercospora leaf spot. During the study period, the level of leaf spotting and defoliation attributed to Cercospora leaf spot on untreated 'Cloud 9' and 'Cherokee

Figure 1. Nitrogen fertilization rate and the incidence of powdery mildew on untreated flowering dogwood.



Chief' flowering dogwoods did not greatly differ. As a result, data were averaged across cultivars but separated by fungicide treatment (Table 4).

On the untreated flowering dogwoods, nitrogen fertilization rate had an effect on the level of leaf spotting due to Cercospora leaf spot in 2004 and 2005 but not in 2003 (Table 4). In 2004 and 2005, leaf spot ratings progressively declined as fertilization rates increased from 37.5 to 600 pounds of nitrogen per acre. However the decline in the percentage of spotted leaves amounted to about 8 to 10 percent in 2004 and half that amount in 2005. For the fungicide-treated flowering dogwoods, leaf spot ratings were similar over all nitrogen fertilization rates in two of three years. As was noted on the untreated trees, the level of leaf spotting due to Cercospora leaf spot in 2005 declined with increasing nitrogen fertilization rates. The impact of nitrogen rate on the level of leaf spotting was more noticeable on the fungicide-treated compared with the untreated flowering dogwoods. At the two lowest nitrogen rates, the percentage of spotted leaves approached 90 percent compared with about 60 percent and 30 percent at the 300- and 600-pounds-per-acre rates.

Defoliation levels caused by Cercospora leaf spot declined incrementally on the untreated trees in response to increasing nitrogen fertilization rates only in 2004 (Table 4). While nearly 90 percent defoliation was seen at the lowest nitrogen fertilization rate on September 27, 2004, trees receiving 600 pounds of nitrogen per acre suffered approximately 40 percent defoliation on that same date. As was noted with the untreated trees, defoliation levels for the fungicide-treated flowering dogwoods

Table 4. Impact of Nitrogen Fertilization Rate on the Level of Leaf Spotting and Premature Defoliation Attributed to Cercospora Leaf Spot on Flowering Dogwood[1]

Nitrogen rate	Leaf spot rating[2]						Defoliation rating[2]					
	2003		2004		2005		2003		2004		2005	
lb/A	Untreated	Treated[3]	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated	Untreated	Treated
37.5	7.1	5.7	10.9	6.1	10.6	8.1	4.8	3.5	9.1	5.8	8.2	6.7
75	7.6	5.6	10.6	6.1	10.5	8.1	4.7	2.9	8.7	4.3	7.5	6.6
150	7.3	5.6	9.8	5.6	10.6	7.8	4.6	2.8	8.0	4.2	7.8	6.4
300	7.4	5.4	9.5	5.4	9.7	7.3	3.9	2.3	6.7	3.9	7.5	5.8
600	7.5	5.4	8.9	5.6	9.6	6.2	4.5	2.4	6.5	3.7	7.8	4.6

[1] Cercospora leaf spot ratings for leaf spotting and defoliation were recorded on October 1, 2003; September 27; and October 5, 2005. [2] The level of leaf spotting and premature defoliation due to Cercospora leaf spot was visually rated using the Horsfall and Barratt 1 to 12 rating scale. [3] Trees were treated each year with Heritage 50W fungicide at the dates specified in the text.

declined stepwise in 2004 and 2005 with each increase in nitrogen fertilization rate. In 2004, the biggest decline in defoliation levels was seen between the 37.5- and 75-pounds-per-acre rates of nitrogen. At 75 pounds per acre and above, defoliation levels did not greatly differ. In contrast, little difference in defoliation levels was noted between the three lowest nitrogen rates in 2005. On October 5, 2005, trees receiving 600 pounds per acre lost approximately 10 percent of their leaves compared with 40 percent or more at the three lowest rates of nitrogen.

While applications of the fungicide Heritage 50W were timed to control the leaf spot phase of spot anthracnose and powdery mildew, this fungicide slowed the development of Cercospora leaf spot on both cultivars of flowering dogwood in 2003, 2004, and 2005. The most noticeable impact of the Heritage 50W treatments was greatly enhanced leaf retention and brilliant deep red to maroon fall color in October and November on the fungicide-treated trees compared with the nearly bare limbs of the untreated flowering dogwoods.

The leaf spot phase of spot anthracnose and Cercospora leaf spot slowed the growth of flowering dogwood. Increased Cercospora leaf spot incidence and defoliation in 2003, 2004, and 2005 were both correlated with a reduction in tree height and trunk diameter. While the intensification of the leaf spot phase of spot anthracnose was related with lower tree heights in all three years, disease-related reductions in trunk diameter were noted only in 2003. Unlike the above diseases, powdery mildew incidence had relatively little impact on tree growth. Powdery mildew was negatively associated with tree height in only 2005, but had no influence on trunk diameter.

Tree dimensions and fungicide use. During the 2001 to 2006 study period, the collective control of spot anthracnose, powdery mildew, and Cercospora leaf spot with the fungicide Heritage 50W was sometimes reflected in differences in trunk diameter and height between the fungicide-treated and untreated ‘Cherokee Chief’ and ‘Cloud 9’ flowering dogwoods. When compared with the untreated trees, an increase in trunk diameter of ‘Cloud 9’ but not ‘Cherokee Chief’ flowering dogwood was obtained with applications of the fungicide Heritage 50W (Figure 2A). On ‘Cloud 9’, differences of about 0.4 inch in trunk diameter between the fungicide-treated and untreated trees were first seen in 2003 and persisted throughout the study. Increased tree height was linked with fungicide use on ‘Cloud 9’ but not on ‘Cherokee Chief’ flowering dogwood (Figure 2B). Differences in height between the fungicide-treated and untreated ‘Cloud 9’ flowering dogwoods first appeared in January 2004. By 2006, the fungicide-treated ‘Cloud 9’ flowering dogwoods were just over 1 foot taller than their untreated counterparts.

Flower bud set. Although the level of flower bud set varied from year to year, flower buds were often two to nearly three times more numerous on ‘Cloud 9’ than on ‘Cherokee Chief’ flowering dogwood (Table 5). Flower bud counts on both cultivars rose steadily in three of four years as nitrogen fertilization rate increased. In addition, the largest increase in bud counts was often noted between the 150- and 300-pounds-per-acre nitrogen fertilization rates. Lowest and highest bud counts were recorded for trees receiving the 37.5- and 600-pounds-per-acre rates of nitrogen, respectively.

Fungicide treatments also influenced the formation of flower buds on both flowering dogwood cultivars (Figure 3). On ‘Cloud 9’, buds counts ranged from 10 to 20 percent higher for the Heritage 50W-treated compared with the untreated trees. While a sizable difference in the number of flower buds was seen on the fungicide-treated and untreated ‘Cherokee Chief’ flowering dogwoods in 2006, bud counts for the treated and untreated trees were fairly similar in the other study years.

Trunk diameter and tree height. Since the ranking of the nitrogen rate treatments for both flowering dogwood cultivars with respect to trunk diameter and tree height was similar, data for each growth parameter at each rating period were averaged.

Between the 2001 planting date and 2004 rating date, nitrogen fertilization rate had no influence on trunk diameter (Figure 4A). In 2005, trunk diameter was noticeably higher for trees receiving 600 pounds of nitrogen per acre than at the two lowest nitrogen rates while the trunk diameter for trees maintained at 150 and 300 pounds of nitrogen per acre was intermediate. For 2006, the impact of nitrogen fertilization rate on trunk diameter was similar to that seen the previous year. Trees receiving 600 pounds of nitrogen per acre had thicker trunks compared with other nitrogen fertilization rates. Also, trunk diameter at 150 and 300 pounds per acre was higher than at the two lowest nitrogen fertilization rates.

Tree height was not noticeably affected by nitrogen fertilization rate in 2002 and 2003 (Figure 4B). In 2004, trees receiving 600 pounds per acre of actual nitrogen were taller except for the lowest 37.5-pounds-per-acre rate. In that same year, trees receiving 300 pounds of nitrogen per acre had the smallest stature. Trees receiving 600 pounds per acre of actual nitrogen were taller compared with all other nitrogen fertilization rates by approximately 6 and 8 inches in 2005 and 2006, respectively.

Figure 2. Trunk diameter and height of untreated and fungicide-treated ‘Cherokee Chief’ and ‘Cloud 9’ flowering dogwoods from 2001 to 2006.

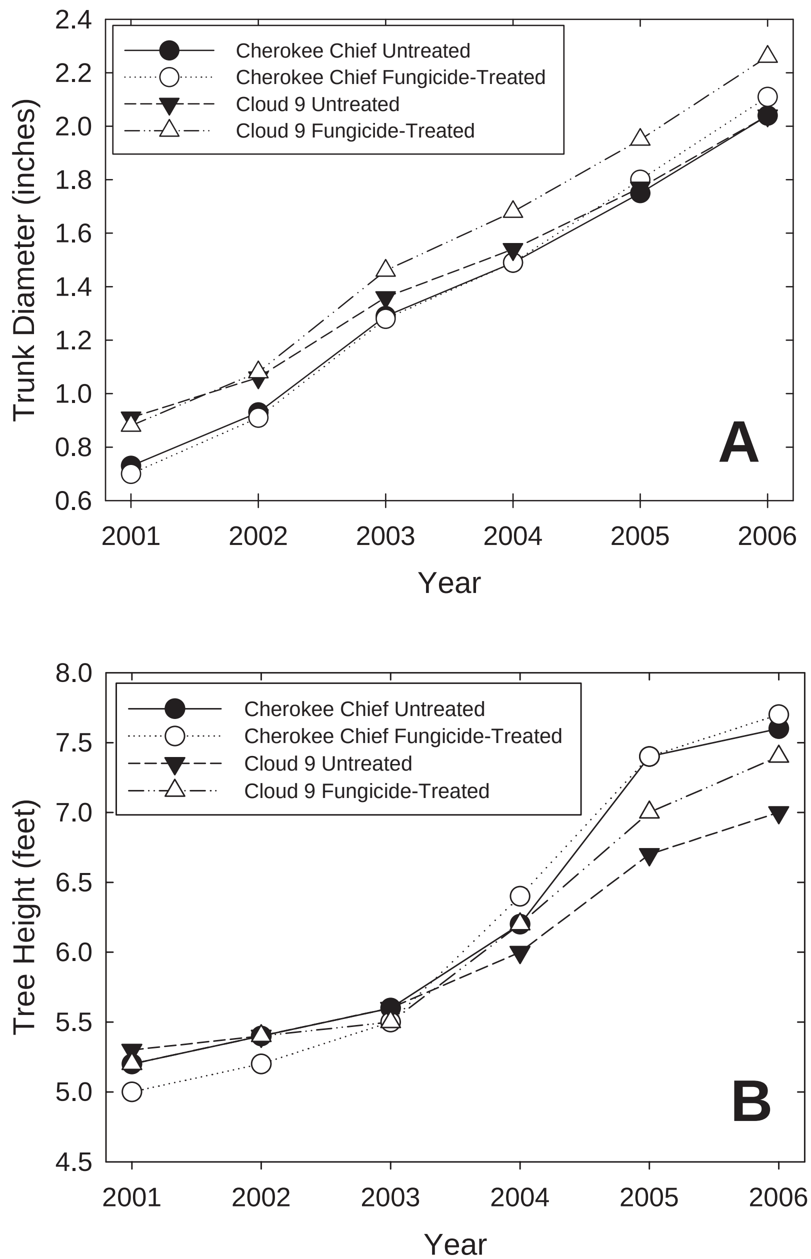
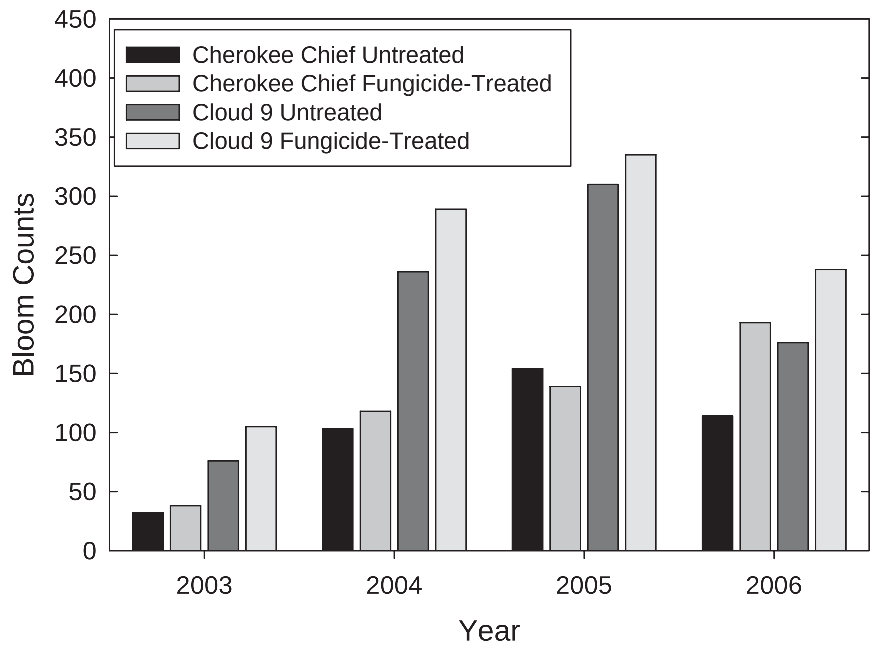


TABLE 5. NITROGEN FERTILIZATION RATE AND FLOWER BUD NUMBERS ON TWO CULTIVARS OF FLOWERING DOGWOOD TREATED WITH THE FUNGICIDE HERITAGE 50W[1]

Nitrogen rate	'Cherokee Chief'				'Cloud 9'			
(lb/A)	2003	2004	2005	2006	2003	2004	2005	2006
37.5	3	130	24	133	56	245	46	165
75	40	158	90	133	75	243	309	105
150	18	79	185	155	53	297	266	198
300	39	85	197	292	147	313	488	297
600	88	145	228	280	181	333	601	410

[1]Counts of flower buds were made on February 17, 2003; January 13, 2004; January 31, 2005; and January 18, 2006.

Figure 3. Impact of fungicide treatment on the number of flower buds on two cultivars of flowering dogwood.

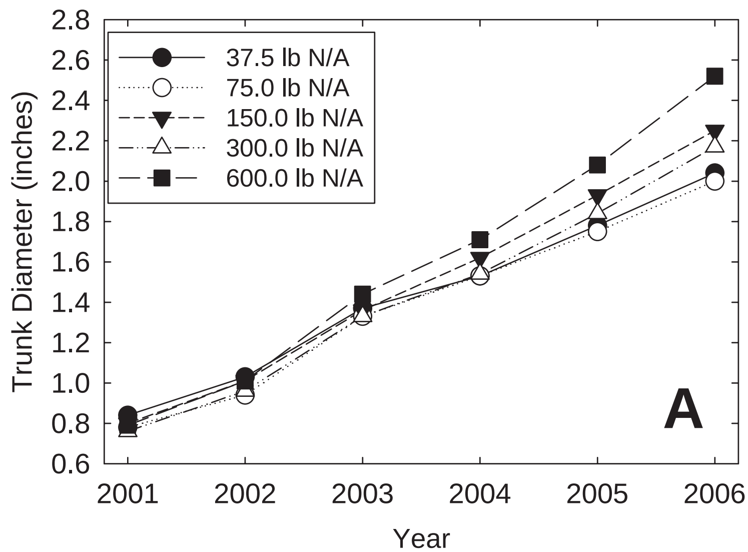


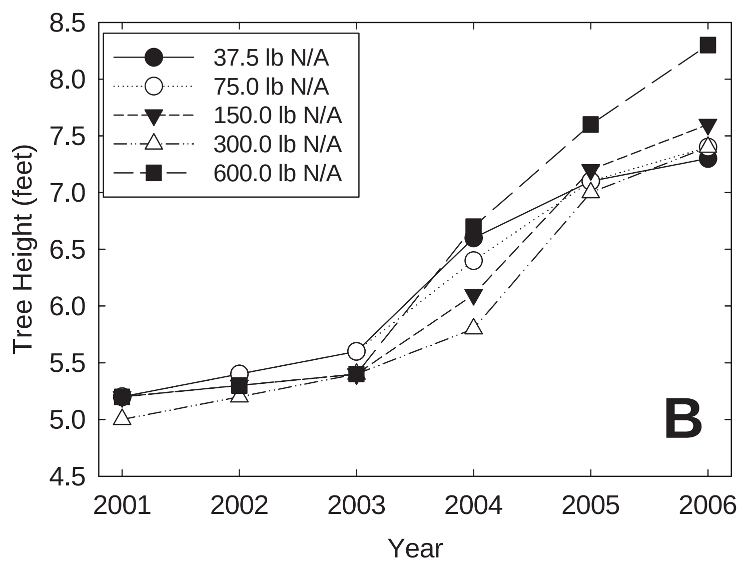
DISCUSSION

Few studies have examined the impact of nitrogen fertilization rate on the development of tree and shrub diseases. In this study, we showed that nitrogen fertilization rate on flowering dogwood had more influence on the development of powdery mildew and Cercospora leaf spot than on spot anthracnose.

With powdery mildew, the level of *E. pulchra* leaf colonization intensified in two of three years as nitrogen fertilization rate increased. In 2003 and 2005, the most noticeable increase in disease levels was seen between the 300- and the 600-pounds-per-acre rates of nitrogen. The link between increasing nitrogen rates and powdery

Figure 4. Impact of nitrogen fertilization rate on the (A) trunk diameter and (B) height of fungicide-treated, field-grown flowering dogwoods.





mildew intensity was more noticeable on the untreated flowering dogwoods. Increased powdery mildew severity on Kentucky bluegrass *(2)*, wheat *(21)*, and barley *(20)* has also been associated with excessively high rates of nitrogen fertilizers that stimulated lush but vulnerable top growth. Disease response to nitrogen fertilizers may have been greater in 2003 and 2004 had powdery mildew incidence in those years been as high as that seen in 2005.

In contrast to powdery mildew, Cercospora leaf spot declined as nitrogen fertilization rates increased. Increasing nitrogen fertilization rates have also been linked with reduced occurrence of walnut anthracnose *(18,19)* along with leaf spot diseases of tropical herbaceous and woody plants incited by the fungi in the genus *Alternaria* and bacteria in the genera *Xanthomonas* and *Pseudomonas (4).* Nitrogen fertilization rate noticeably impacted Cercospora leaf spot-related leaf spotting and defoliation. Fungicide-treated trees that received the two lowest rates of nitrogen had more leaf spot and greater defoliation than those receiving the 600-pounds-per-acre rate. In one and two of these years, defoliation levels for trees receiving the 150- and 300-pounds-per-acre rates, respectively, were similar to those seen at the highest nitrogen rate. On the fungicide-treated trees, the increased leaf retention seen at the higher rates compared with the lower nitrogen fertilization rates clearly enhanced fall color into November. For the untreated flowering dogwoods, nitrogen fertilization rate had an impact on leaf spotting and defoliation attributed to Cercospora leaf spot in two of three years. The same pattern of increased leaf spotting and defoliation levels that was seen on the fungicide-treated trees was also seen on the untreated flowering dogwoods at the two lowest rates compared with the highest nitrogen fertilization rates

The link between reduced disease and increasing nitrogen fertilization rates was weaker for spot anthracnose than for Cercospora leaf spot on flowering dogwood. For the trees not treated with Heritage 50W fungicide, nitrogen fertilization rate had little impact on the incidence of the bract spot phase of spot anthracnose on the ‘Cloud 9’ but in 2003 and 2004 bract spotting was much higher on the ‘Cherokee Chief’ flowering dogwood at annual nitrogen fertilization rates of 75 and 150 pounds per acre compared with the 37.5-pounds-per-acre rate. The impact of nitrogen application rate on the bract spot phase of spot anthracnose may have been influenced by cultivar susceptibility to this disease. A response to nitrogen inputs was seen on the partially resistant ‘Cherokee Chief’ flowering dogwood under moderate disease pressure in 2003 and 2004 but not under heavy disease pressure in 2005. In contrast, heavy bract damage on ‘Cloud 9’ flowering dogwood, which is highly susceptible to spot anthracnose *(11)*, overwhelmed any response due to nitrogen application rate. When a response to nitrogen fertilization rate was noted on the fungicide-treated trees, the lowest level of bract spotting on either cultivar was seen at the 600-pounds-per-acre rate of nitrogen. Similar ratings for the leaf spot phase of spot anthracnose were noted across all nitrogen fertilization rates in 2003 and 2005. While a trend toward a reduction in the incidence of this phase of spot anthracnose at the higher nitrogen fertilization rates was noted on the untreated and somewhat on fungicide-treated trees in 2004, the reduction in leaf damage noted at the higher fertilization rates did not visibly enhance tree aesthetics.

Cultivar selection had a significant impact on incidence of all three diseases. As was reported in an earlier Alabama study *(11)*, ‘Cloud 9’ was more susceptible to spot anthracnose than ‘Cherokee Chief’, but both cultivars proved equally susceptible to powdery mildew. Mmbaga and Sauve *(17)* also noted similar powdery mildew ratings for ‘Cloud 9’ and ‘Cherokee Chief’. During early stages of Cercospora leaf spot development, ‘Cherokee Chief’ suffered slightly less leaf spotting and premature leaf loss than ‘Cloud 9’. By mid-fall, however, defoliation levels on both cultivars were so high that there was no fall color display. Recently, ‘Cloud 9’, while less susceptible to Cercospora leaf spot than several other popular flowering dogwood cultivars, still suffered much heavier leaf spotting and premature defoliation when compared with several Stellar® series hybrid dogwoods *(8)*.

Heritage 50W, which has good activity against powdery mildew on container-grown flowering dogwood *(10,16)*, also controlled the bract and leaf spot phases of spot anthracnose. Although a few disease-related spots were seen on the bracts of the Heritage-treated trees, the overall floral display on these trees far exceeded that of the untreated flowering dogwoods. While fungicide applications were terminated by mid-July, leaf spotting and premature defoliation attributed to Cercospora leaf spot was suppressed on both dogwood cultivars for several months. In fact, an intense deep red to maroon fall color display was noted into late October to mid-November on the Heritage 50W-treated trees of both cultivars, while adjacent untreated trees were almost totally defoliated.

Impact of severe disease outbreaks on the growth of trees and shrubs is not well documented. Powdery mildew on flowering dogwood as well as black spot and Cercospora leaf spot on rose are among the few exceptions. When compared with the fungicide-treated roses, a 20 to 40 percent reduction in the growth of untreated shrub roses was related to severe black spot or Cercospora leaf spot outbreaks *(12)*. Similar reductions in shoot growth along with reduced flowering of hybrid tea roses were linked with black spot-induced leaf spotting and defoliation *(3)*. Powdery mildew outbreaks have been associated with reduced tree height and/or trunk diameter of container-grown flowering dogwood *(10,17)*. Previously, powdery mildew-related reduced trunk diameter and tree height were noted when 100 percent of the leaves of ‘First Lady’ flowering dogwood were heavily colonized by the causal fungus *(10)*. Reductions in tree height were seen in this study only in 2005 when leaf colonization levels approached 50 percent. When disease incidence was very low in 2003 and 2004, powdery mildew had no impact on tree height. Incidence of powdery mildew was never high enough to slow trunk growth. In contrast to powdery mildew, the leaf spot phase of spot anthracnose and Cercospora leaf spot were linked with a decline in tree height and/or trunk diameter. Previously, these diseases were thought to negatively impact the aesthetics and not the growth of flowering dogwood *(5,11)*.

Surprisingly, actual nitrogen rates up to 600 pounds per acre per year did not immediately accelerate the growth of field-grown flowering dogwood nor affect trunk diameter or tree height until three and four years, respectively, after planting. Such a delayed growth response by recently transplanted trees to nitrogen inputs is not unusual. When planted in a fine sand soil in central Florida, live oak and southern magnolia did not respond to nitrogen inputs until 18 months and two years, respectively after transplanting *(7)*. In Tennessee, a growth response to nitrogen on sugar maple, yellow popular, and pin oak was not seen until the fourth growing season after planting *(26)*. In contrast, increases in trunk diameter of established flowering dogwood in a forest setting were noted the year following the supplemental application of a nitrogen fertilizer *(5)*. Differences in response to nitrogen inputs between the newly transplanted and established trees may be attributed to the latter trees having a more developed root system that would be more efficient in intercepting nitrogen and acquiring sufficient water resources for increased tree growth.

In 2005 and 2006, trunk diameter was greater at the 600-pounds-per-acre rate compared with the 37.5- and 75-pounds-per-acre nitrogen rates. In addition, trees receiving 150 and 600 pounds per acre of nitrogen had similar trunk diameters in 2005 and 2006, while in 2005 trees receiving 300 and 600 pounds per acre had a similar trunk diameter. Tallest flowering dogwoods were seen in 2004 and 2006 with the 600-pounds-per-acre fertilization rate. Otherwise, nitrogen fertilization rates ranging from 37.5 to 300 pounds per acre had relatively little influence on tree height. Response of southern magnolia to increasing rates of nitrogen differs somewhat from that of flowering dogwood. While greater height and trunk diameter for southern magnolia were obtained with 360 pounds of actual nitrogen per acre compared with 0 and 180 pounds of actual nitrogen per acre after four years, tree growth was not enhanced at nitrogen fertilization rates of 360 to 900 pounds of actual nitrogen per acre *(7)*.

Nitrogen fertilization rate had a more consistent effect on the formation of flower buds on flowering dogwood than on tree height or trunk diameter. While applying excessive nitrogen to flowering dogwood was thought to favor shoot growth over flower bud set *(27)*, higher flower bud counts were often linked with increasing nitrogen fertilization rates. With the exception of 2004 when bud counts were fairly similar across all nitrogen fertilization rates, flower bud counts were noticeably higher on trees receiving 600 pounds of nitrogen per acre compared with the 37.5- to 150-pounds-per-acre rates. At the two highest nitrogen fertilization rates, similar flower bud counts were recorded in 2003, 2005, and 2006. Trees receiving 37.5 to 150 pounds of nitrogen per acre had similar levels of flower bud set in two of three years. Previously, increasing numbers of flower buds on ‘English Roseum’ but not ‘Catawbiense Boursault’ rhododendron were associated with the highest nitrogen fertilization rates *(28)*.

SUMMARY

In summary, the current nitrogen fertilization rates for flowering dogwood in the landscape (40 to 130 pounds per acre per year) *(22)* and field nursery (250 pounds per acre per year) *(14)* may have more influence on occurrence of Cercospora leaf spot than spot anthracnose or powdery mildew. Increased Cercospora leaf spot-related leaf spotting and defoliation is more likely on flowering dogwood maintained at the recommended nitrogen fertilization rates for landscape than for field nursery plantings. In contrast, nitrogen fertilization rates would have to exceed 250 pounds per acre per year of nitrogen before powdery mildew would greatly intensify. Given the weak relationship between the leaf spot phase of spot anthracnose and nitrogen fertility, maintaining recommended nitrogen fertilization rates in either the landscape or field nursery should not greatly influence the occurrence of this disease. In settings where brilliant fall color is desired, protective fungicide applications will have far more impact compared with the manipulation of nitrogen fertilization rates.

For flowering dogwoods in the landscape, applying 130 pounds of actual nitrogen annually may increase flower bud set but would do little to accelerate tree growth. Other than enhanced flower bud set, little advantage would be gained from increasing nitrogen fertilization rates on field-grown nursery stock above those recommended for flowering dogwood in the landscape because the trees would simply not be in the ground a sufficient length of time to benefit from applying the recommended annual 250-pounds-per-acre rate of actual nitrogen.

REFERENCES

1. Anderson, R. L., J. Rauschenberger, J. L. Knighten, S. E. Dowsett, and C. Henson. 1992. Effectiveness of cultural techniques, with emphasis on fertilization to control dogwood anthracnose. p. 53-56. *In* Results of the 1992 dogwood anthracnose impact assessment and pilot test in the Southeastern United States. J. L. Knighten and R. L. Anderson, eds. USDA For. Serv. South Region Prot. Rep R8-PR 24.

2. Britton, M. P. 1969. Turfgrass diseases. p. 309-310. *In* Turfgrass Science. A. A. Hanson and F. J. Juska, eds. Agronomy Monograph 14. ASA, Madson, WI.

3. Bowen, K. L., B. Young, and B. Behe. 1995. Management of black spot in rose in the landscape in Alabama. Plant Disease 79:250-253.

4. Chase, A. R. 1991. Greenhouse ornamental crops, pest management systems for diseases. p. 709-728. *In* Handbook of Pest Management, 2nd ed. Vol.3. D. Pimental, ed. CRC Press, Boca Raton, FL.

5. Curlin, J. W. 1962. Dogwood responds to nitrogen fertilization. J. Forestry 60:718-719.

6. Daughtrey, M. L. and A. K. Hagan. 2001. Dogwood Diseases. p. 124-132. *In* Diseases of Woody Ornamentals and Trees in Nurseries. R. Jones and M. Benson, eds. APS Press. St. Paul, MN.

7. Gilman, E. F., T. H. Yeager, and D. Kent. 2000. Fertilizer rate and type impacts magnolia and oak growth in a sandy landscape soil. J. Arboriculture. 26:177-182.

8. Hagan, A. K., J. R. Akridge, and R. Dawkins. 2006. Comparison of flowering and hybrid dogwood to diseases at two locations in Alabama. Proc. Southern Nursery Res. Conf. 51:187-190.

9. Hagan, A. K., J. R. Akridge, and M. E. Rivas-Davila. 2004. Control of powdery mildew, spot anthracnose, and Cercospora leaf spot on field-grown flowering dogwood trees. Proc. Southern Nursery Res. Conf. 49:254-258.

10. Hagan, A. K., J. W. Olive, J. Stephenson, and M. Rivas-Davila. 2005. Comparison of fungicides for the control of powdery mildew on dogwood. J. Environmental Horticulture. 23:179-184.

11. Hagan, A. K., B. Harden, C. H. Gilliam, J. D. Williams, and G. Creech. 1998. Susceptibility of cultivars of several dogwood taxa to powdery mildew and spot anthracnose. J. Environmental Horticulture 16(3):147-151.

12. Hagan, A. K., M. E. Rivas-Davila, J. R. Akridge, and J. W. Olive. 2005. Resistance of shrub and groundcover roses to black spot and Cercospora leaf spot, and impact of fungicide inputs on the severity of both diseases. J. Environmental Horticulture 23:77-85.

13. Hoitink, H. A., M. E. Watson, and W. R. Farber. 1986. Effect of nitrogen concentration in juvenile foliage of rhododendron to Phytophthora dieback severity. Plant Disease 70:292-294.

14. Ingram, D. L., B. Roach, and M. Klahr. 1998. Effects of controlled-release fertilizers on growth and nutrient content of field-grown nursery crops. Proc. Southern Nursery Res. Conf. 43:124-127.

15. Mizell, R. F. and A. K. Hagan. 2000. Biological problems and their management in urban soils: IPM of arthropods and diseases. p. 119-155. *In* Managing Soils in the Urban Environment, Agronomy Monograph 39. R. B. Brown, J. H. Huddleston, and J. L. Anderson, eds. Society of Agronomy. Madison, WI.

16. Mmbaga, M. T. and R. J. Sauve. 2004. Management of powdery mildew in flowering in the field with biorational and synthetic fungicides. Canadian J. Plant Science 84:837-844.

17. Mmbaga, M. T. and R. J. Sauve. 2004. Multiple disease resistance in dogwoods (*Cornus* spp.) to foliar pathogens. J. Arboriculture 30:101-107.

18. Neely, D. 1981. Application of nitrogen fertilizer to control anthracnose on black walnut. Plant Disease 65:580-581.

19. Neely, D. 1986. Total leaf nitrogen correlated with walnut anthracnose resistance. J. Arboriculture 12:312-315.

20. Oerke, E. C., and F. Schonbeck. 1990. Effect of nitrogen and powdery mildew on the yield formation of two winter barley cultivars. Journal of Phytopathology 130(2):89-104.

21. Olesen, J. E., L. N. Jorgensen, J. Petersen, and J. V. Mortensen. 2003. Effect of rates and timing of nitrogen fertilizer on disease control by fungicides in winter wheat. 2. Crop growth and disease development. Journal of Agricultural Science 140(1):15-29.

22. Smiley, E. T., S. J. Lily, and P. Kelsey. 2002. Best Management Practices: Trees and Shrub Fertilization. International Society of Arboriculture, Champaign, IL.

23. Smith, E. M. and C. H. Gilliam. 1979. Fertilizing landscape and field grown nursery crops. OSU Coop. Ext. Ser. Bull. 650.

24. Stuve, D. K. 2002. A review of shade tree nitrogen fertilization research in the United States. J. Arboriculture 28:252-263.

25. Tattar, T. A. 1989. Diseases of shade trees. Acad. Press, San Diego, CA.

26. Van der Werken, H. 1981. Fertilization and other factors enhancing the growth rate of young shade trees. J. Arboriculture 7:33-37.

27. Witte, W. T, M. T. Windham, A. S. Windham, F. A. Hale, D. C. Fare, and W. K. Clatterbuck. 2000. Dogwoods for American Gardens. University of Tennessee Ag. Ext. Serv. PB1670.

28. Wright, R. D. 1992. Influence of nitrogen nutrition on flower bud initiation of rhododendron. American Rhododendron Society Journal 46:99-100.

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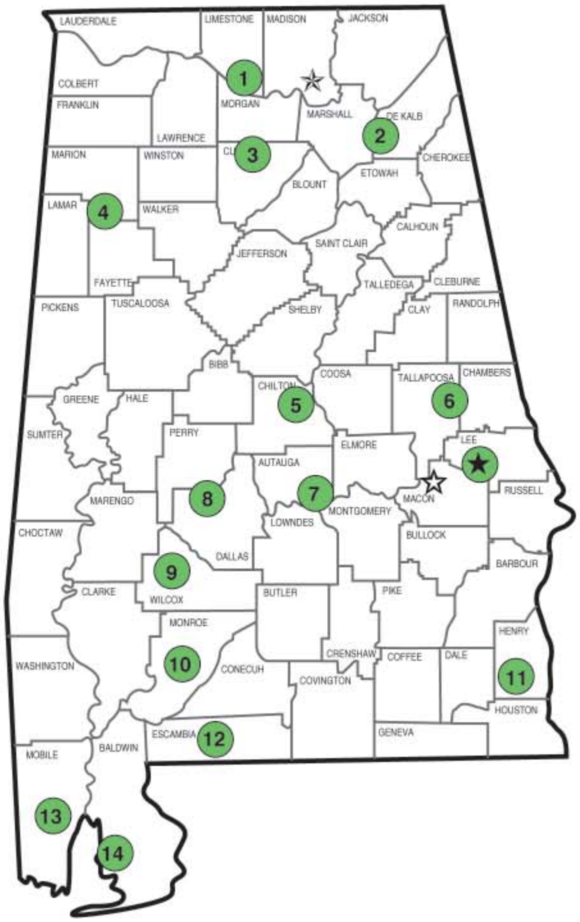

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