Comparison of Fungicides for the Control of Powdery Mildew on Dogwood

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Heavy colonization of dogwood leaves by powdery mildew fungus.
Severe powdery mildew outbreak on the 'Pink Flame' flowering dogwood.
Heavy leaf colonization of dogwood leaf surfaces by powdery mildew fungus. Note the slight stretching and dwarfing of heavily colonized juvenile leaves.

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A. K. Hagan, J. W. Olive, J. Stephenson, and M. E. Rivas-Davila

INTRODUCTION

Flowering dogwood (*Cornus florida* L.) is one of the most widely cultivated small flowering trees found in residential and commercial plantings in the southeastern United States. Showy bracts, attractive fall color, red fruit clusters, and widespread adaptation across this region account for the popularity of flowering dogwood with consumers *(4).*

Since 1994, powdery mildew, caused by the fungus *Erysiphe pulchra*, is the most common disease seen on flowering dogwood in landscapes, as well as on field- and container-grown trees *(2,3,6).* Although disease-related damage on established flowering dogwood appears to be largely cosmetic, slowed shoot elongation, reduced caliper diameter, and death of year-old seedlings have recently been attributed to severe outbreaks of powdery mildew *(10).*

Cultivars and native 'seedling' flowering dogwoods differ considerably in their susceptibility to powdery mildew. Several cultivars of flowering dogwood, particularly Cherokee Brave™, Cherokee Chief™, 'Bay Beauty', and 'Weavers White', are resistant to powdery mildew and also to spot anthracnose caused by *Elsinoe cornii (6).* Recently, Mmbaga and Sauve *(11)* reported that 'Fragrant Cloud' and Cherokee Brave™ were moderately resistant to powdery mildew. However, the majority of trees in Alabama's landscapes are native 'seedling' trees or cultivars that are susceptible to powdery mildew. Since powdery mildew recently emerged as a widespread and damaging disease, considerable information is available concerning the efficacy of synthetic and biorational fungicides for control of this disease in production or landscape settings *(5,14).*

In a recent Tennessee trial, Banner MAXX®, Spectro™ 90, Eagle® 20EW, and Terraguard® 50W, controlled powdery mildew on field-grown 'Rubra' flowering

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dogwood *(15).* Windham *et al. (15)* noted that the percentage of symptomatic leaves on trees treated with the above fungicides ranged from 10 to 25 percent compared to nearly 100 percent on the untreated controls. In contrast, bimonthly applications of First Step™ failed to protect 'Rubra' flowering dogwood from powdery mildew *(15).* Mulrooney and Gregory *(13)* noted that Sunspray Ultrafine Oil™ and Eagle® were equally effective in controlling this disease. Over a three-year period, the soaps Ajax® and Equate®, as well as Armicarb® were nearly as effective in controlling powdery mildew and suppressing fruiting body (ascocarp) formation of the powdery mildew fungus as 3336™ 4.5F, Heritage® 50W, Phyton 27®, and Banner MAXX® on container- and field-grown flowering dogwood *(9).* Mmbaga and Sheng *(9).* also noted that more fruiting bodies (ascocarps) of the causal fungus developed when fungicide treatments were stopped in August than in October. Finally, stem caliper and tree height were significantly increased by synthetic fungicides such as Banner MAXX® and several biorational fungicides *(10).*

The fungicide trifloxystrobin, which is marketed for use on ornamentals and turf under the trade names Compass™ 50W and Compass O™, is classified as a strobilurin or QoI (Quinone outside inhibitor) fungicide. This fungicide is absorbed into the waxy leaf cuticle and has translaminar, or local, movement through the leaf but is not redistributed through the xylem like the systemic QoI fungicide Heritage™ 50W *(1).* Compass™ 50W is a broad spectrum fungicide that has activity against numerous diseases, including powdery mildew on a variety of annuals, perennials, and small flowering trees. Previously, Windham *et al. (15)* obtained a high level of control of powdery mildew on flowering dogwood with Compass™ 50W applied at the 2-ounce and 4-ounce- per-100-gallon rates on a two-week schedule. In a recent Delaware study *(12),* the 1-, 2-, and 4-ounce rates of Compass™ 50W when applied at two-, three-, and four-week intervals, respectively, restricted powdery mildew development to less than 2 percent of the leaves on 'seedling' flowering dogwood. In this same study, all rates of Compass™ 50W also proved as effective in controlling this disease as the registered fungicides Heritage® 50W and Eagle® *(12).*

Trials were initiated on container-grown flower dogwood in 1997 and continued through 2003 to identify efficacious fungicides for the control of powdery mildew. In addition, the efficacy of the strobilurin fungicide Compass™ 50W was evaluated over a range of application rates and treatment intervals for the control of powdery mildew on flowering dogwood.

MATERIALS AND METHODS

Plant culture. Bare-root flowering dogwoods were potted in number 3 containers filled with in pine bark:peat moss (3:1 by volume)) or 100 percent pine bark amended with 14 pounds of 17-7-12 Osmocote, 6 pounds of dolomitic limestone, 2 pounds of gypsum, and 1.5 pounds of Micromax per cubic yard of potting mixture. They were maintained on a clam shell-covered bed under a 47 percent shade cloth and were watered daily with overhead impact sprinklers. While 'seedling' flowering dogwoods were used in 1997, the cultivar 'First Lady' was used in 1999 and 'Cloud 9' in 2001, 2002, and 2003. A randomized complete block design with six or eight

replications of one plant per treatment was used. Blocks of plants were re-randomized following each fungicide application. All studies were conducted at the Ornamental Horticulture Research Center in Mobile, Alabama.

Fungicide evaluations. Fungicides were applied to run-off with a CO_2-pressurized backpack sprayer at the intervals specified below. In 1997, 2001, 2002, and 2003, recommended rates of commercial fungicides were evaluated for the control of powdery mildew on flowering dogwood. Fungicides evaluated in 1997 were Bayleton® WSP at 4 ounces per 100 gallons of spray volume, 3336™ 4.5F at 20 fluid ounces per 100 gallons, Banner MAXX® at 5 fluid ounces per 100 gallons, Phyton 27® at 40 fluid ounces per 100 gallons, and Eagle® 40W at 6 ounces per 100 gallons. In 2001, Heritage 50W™ at 4 ounces per 100 gallons and Sunspray Ultrafine Oil® at the rate of 1 percent v/v were added. The non-ionic surfactant Sil-Spread™ at 0.06 percent v/v was added to Eagle® 40W, Heritage™ 50W, and Bayleton® WSP tank mixtures. Fungicides were applied at two-week intervals from March 30 until August 16, 2000; May 2 to July 24, 2001; May 24 to August 14, 2002; and May 7 to July 29, 2003. Canopy height and width were also recorded on August 14, 2001 to calculate a growth index (GI) according to common horticultural practice *(7)*.

Application rate and timing comparisons for Compass™ 50W. In 1999, the efficacy of selected rates of Compass™ 50W was compared with Banner MAXX® at 5 fluid ounces per 100 gallons of water, Eagle® 40W at 6 ounces per 100 gallons, and Heritage™ 50W at 4 ounces per 100 gallons of water for the control of powdery mildew on 'First Lady' flowering dogwood. The 0.5 ounce rate of Compass™ 50W was applied on a one-week schedule and compared to a two-week schedule for the 1- and 2-ounce-per-100-gallon rates of the same fungicide. While the application interval for Eagle® 40W and Heritage™ 50W was two weeks, Banner MAXX® was applied on a three-week schedule. Fungicides were applied from April 12 through October 6, 1999.

In 2001, 2002, and 2003, the 1-, 2-, and 4-ounce rates of Compass™ 50W were applied at one-, two-, and four-week intervals, respectively, to 'Cloud 9' flowering dogwood. Eagle® 40W, which was applied at the 6-ounce-per-100-gallon rate every two weeks, was included as a commercial standard. The non-ionic surfactant Sil-Spread™ at 0.06 percent v/v of spray volume was added to Compass™ 50W and Eagle® 40W. Fungicides were applied to run-off from May 2 to July 24, 2001; May 24 to August 13, 2002; and May 27 to July 29, 2003.

Disease assessment. Fungicides were applied to run-off with a CO_2-pressurized backpack sprayer at the previously specified intervals. Incidence of powdery mildew on the leaves was rated using the 1 to 12 Horsfall and Barratt rating scale where 1 = no disease, 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 the leaves colonized by the powdery mildew fungus. In the general screening trials, incidence of powdery mildew was recorded on October 1, 1997; July 10, 2001; September 9, 2002; and July 10, 2003. In the Compass™ 50W trials, powdery mildew ratings were logged on July 7, 1999; July 10, 2001; September 9, 2002; and August 6, 2003.

Canopy height and width were also recorded on September 29, 1999 and August 14, 2001 to calculate a growth index (GI) according to common horticultural practice *(7)*.

RESULTS AND DISCUSSION

Fungicide efficacy. Although all treatments significantly reduced the incidence of powdery mildew compared with the unsprayed control in 1997, significant differences in the level of disease control among the fungicides were observed (Table 1). Eagle® 40W and Phyton 27® were equally effective in controlling powdery mildew. On the trees receiving applications of the above fungicides, disease development was limited to a few unobtrusive fungal colonies on 3 to 4 percent of the leaves. In comparison, 3336™ 4.5F and Bayleton WSP gave less control of powdery mildew than Eagle® 40W and Phyton 27®. The percentage of disease leaves on the 3336™ 4.5F- and Bayleton WSP-treated dogwoods, which exceeded 12 percent and 25 percent, respectively, was well below the 87 percent rate of leaf colonization seen on the untreated controls.

In 2001, 2002, and 2003, Banner MAXX®, Eagle® 40W, and Heritage™ 50W consistently gave the best control of powdery mildew (Table 1). Only a few isolated colonies of the powdery mildew fungus were seen on a few, scattered leaves of the trees treated with Banner MAXX®, Eagle® 40W, or Heritage™ 50W. Incidence of fungal colonized leaves on the dogwood treated with SunSpray Ultrafine Oil® and Phyton 27® was in the range of 1 percent to less than 12 percent. Bayleton WSP® and 3336® 4.5F failed to protect dogwood from this disease, especially in 2001 and 2003 when powdery mildew pressure was high. Powdery mildew incidence on the untreated controls ranged from a low of approximately 35 percent of leaves colonized in 2002 to more than 80 percent in 2001 and 2003. In addition, extensive colonization of the entire surface of most leaves as well as noticeable leaf deformation was observed on the untreated controls in 2001 and 2003.

Compass™ 50W performance against powdery mildew. In 1999, all rates of Compass™ 50W, as well as Banner MAXX®, Eagle® 40W, and Heritage™ 50W, greatly reduced the incidence of powdery mildew compared to the untreated control (Table 2). As indicated by a disease rating of 12.0, all of the leaves on the untreated

TABLE 1. EFFICACY OF SELECTED FUNGICIDES APPLIED ON A TWO-WEEK SCHEDULE FOR THE CONTROL OF POWDERY MILDEW ON CONTAINER-GROWN FLOWERING DOGWOOD

Fungicide	Application rate (*g ai/liter*)	Incidence of powdery mildew 1997	2001	2002	2003
Bayleton WSP	4 fl oz	5.3	4.2	2.5	5.6
3336 4.5F	20 fl oz	4.1	3.8	2.2	6.3
Banner MAXX	5 fl oz	2.5	2.0	1.0	2.6
Phyton 27	40 fl oz	1.9	3.5	2.2	3.0
Eagle 40W	6 oz	1.6	3.2	1.2	2.2
Heritage 50W	4 oz	—[1]	2.3	1.2	1.6
SunSpray Ultrafine Oil	1% v/v	—	3.8	1.8	3.3
Untreated control	—	9.0	7.8	5.5	7.6

[1] — = Fungicides were not evaluated in 1997

controls were colonized by the causal fungus. Although the percentage of leaves on all of the fungicide-treated trees was low, differences in the level of disease control were noted between fungicide treatments. Disease incidence was higher on the trees treated bimonthly with the 1- and 2-ounce-per-100-gallon rates of Compass™ 50W compared with weekly applications of the 0.5 ounce-per-100-gallon rate of the same fungicide. Also, fewer colonized leaves were observed on the flowering dogwood treated with Eagle® 40W and Heritage™ 50W than on those trees with the two higher rates of Compass™ 50W at the same treatment interval. The highest rate of Compass™ 50W and Banner MAXX® gave the same level of control of powdery mildew.

In 2001, Compass™ 50W greatly reduced the incidence of powdery mildew on 'Cloud 9' flowering dogwood when applied over a range of labeled rates and treatment intervals, as compared with the untreated control (Table 3). Nearly 50 percent of the leaves of the untreated controls were heavily colonized by the powdery mildew fungus. At the 1- and 2-ounce-per-100-gallon rates, Compass™ 50W gave better disease control when applied on a one- and two-week schedule than when applied at

TABLE 2. COMPARISON OF COMPASS 50W WITH SELECTED FUNGICIDES FOR THE CONTROL OF POWDERY MILDEW AND TREE DIMENSION OF CONTAINER-GROWN 'FIRST LADY' FLOWERING DOGWOOD, 1999

Fungicide	——Application—— Rate *g ai/liter*	Interval *wk.*	Powdery mildew incidence	Growth index[1]	Tree caliper *(cm)*
Compass 50W	0.5	1	1.8	141.1	19.0
Compass 50W	1.0	2	4.3	157.9	19.8
Compass 50W	2.0	2	3.0	162.0	21.2
Banner MAXX	5 fl oz	3	2.1	149.0	20.1
Eagle 40W	6.0 oz	2	1.6	156.0	21.4
Heritage 50W	8.0 oz	2	1.4	153.0	19.2
Untreated control	----	----	12.0	133.1	14.8

[1]Growth index = (height + width1 + width 2)/3

TABLE 3. INFLUENCE OF APPLICATION RATE AND INTERVAL ON THE EFFICACY OF COMPASS 50W FOR THE CONTROL OF POWDERY MILDEW AND THE GROWTH OF CONTAINER-GROWN 'CLOUD 9' FLOWERING DOGWOOD

Fungicide	—Application— Rate *oz.*	Interval *wk*	Powdery mildew ——incidence—— 2001	2002	2003	Growth index 2001
Compass 50W	1.0	1	2.2	1.0	1.7	105
Compass 50W	1.0	2	2.5	1.2	2.7	97
Compass 50W	1.0	4	4.8	1.0	3.7	104
Compass 50W	2.0	1	1.7	1.0	2.0	104
Compass 50W	2.0	2	2.0	1.0	2.0	95
Compass 50W	2.0	4	4.2	1.0	3.3	103
Compass 50W	4.0	1	1.5	1.0	1.7	100
Compass 50W	4.0	2	2.5	1.0	2.0	108
Compass 50W	4.0	4	2.8	1.2	2.5	96
Eagle 40W	6.0	2	1.8	1.4	2.5	92
Unsprayed control	—	—	6.7	5.6	6.7	106

monthly intervals. Disease incidence on the trees treated with the two lower rates of Compass™ 50W at one- and two-week intervals was similar. Incidence of powdery mildew on flowering dogwood treated with the highest rate of Compass™ 50W at one-, two-, and four-week intervals did not greatly differ. With the exception of the 1- and 2-ounce-per-100-gallon rates applied monthly, Compass™ 50W proved equally effective in controlling powdery mildew on flowering dogwood as the fungicide standard Eagle® 40W.

As indicated by a disease rating of 5.6 where 15 to 20 percent of the leaves on the unsprayed control were colonized, powdery pressure was relatively low in 2002 (Table 3). The level of powdery mildew colonization on all the Compass™ 50W-treated flowering dogwood was similar. For most rates of Compass™ 50W at all three treatment intervals, very little if any leaf colonization by the causal fungus was seen. Also, all rates of Compass™ 50W were equally effective in controlling this disease.

For 2003, the level of leaf colonization by the powdery mildew fungus was higher for the unsprayed control compared with for all of the Compass™ 50W treatments (Table 3). At all rates of Compass™ 50W application, powdery mildew incidence increased as the treatment interval was lengthened from one to four weeks. At each treatment interval, disease incidence on the trees treated with all three rates of Compass™ 50W was similar. When applied at one-, two-, and four-week intervals, no appreciable differences in powdery mildew control were noted between any rates of Compass™ 50W and the Eagle® 40W standard. The percentage of diseased leaves for any of the Compass™ 50W treatments was below 12 percent.

Tree growth. The impact of powdery mildew on tree growth appeared to be related to disease severity in a particular year. In the 1999 trial, severe powdery mildew development on the unsprayed ‘First Lady’ flowering dogwood had an adverse affect on tree growth. The growth index (GI) and trunk caliper logged for the untreated trees were considerably lower than those for nearly all of the fungicide-treated trees (Table 2). Although the lowest rate of Compass™ 50W gave excellent disease control, the GI for these trees did not differ significantly from that recorded for the unsprayed controls. In contrast, the GI for flowering dogwoods treated with the 1- and 2-ounce-per-100-gallon rates of Compass™ 50W was higher than those for the lowest rate of this same fungicide, as well as the untreated control. Trunk caliper for the flowering dogwood sprayed with the highest rate of Compass™ 50W was much larger than that for trees treated receiving the lowest rate of the same fungicide. Trees treated with the 1-ounce-per-100-gallon rate of Compass™ 50W had a similar trunk caliper as did the flowering dogwood treated with the 0.5-ounce-per-100-gallon rate of the same fungicide. Generally, the GI and trunk caliper for trees treated with Banner MAXX®, Eagle® 40W, and Heritage™ 50W were similar to the results recorded for the two highest rates of Compass™ 50W. In 2001, the GI of untreated dogwoods was not appreciably different from those recorded for the flowering dogwood treated with Banner MAXX®, Eagle® 40W, 3336® 4.5F, Phyton 27®, and SunSpray Ultrafine Oil®.

Due to low disease pressure in 2001, application rate and treatment interval for Compass™ 50W had no impact on tree growth (Table 3). The height for the Eagle® 40W-treated trees was similar to that recorded for the dogwoods receiving all rates of Compass™ 50W.

While Bayleton® WSP, 3336® 4.5F, Banner MAXX®, Phyton 27®, Eagle® 40W, Heritage™ 50W, and SunSpray Ultrafine Oil® are registered for the control of powdery mildew on a wide range of annual, perennial, and woody ornamentals, sizable differences in the level of powdery mildew control given by the above fungicides were noted in all four years. Banner MAXX®, Eagle® 40W, and Heritage™ 50W gave the most consistent and effective control of powdery mildew on flowering dogwood. Typically, the few leaves colonized by the powdery mildew fungus on flowering dogwood treated with the above fungicides had no detrimental impact on tree aesthetics. The superior activity of Banner MAXX® and Eagle® 40W for the control of powdery mildew on flowering dogwood has been reported in previous studies in Tennessee *(9,15).* Mmbaga and Sheng *(9)* also noted a sizable reduction in fruiting body (ascocarp) formation on the Banner MAXX®-treated flowering dogwood, which could also result early season suppression of this disease the following year.

In at least one year, Phyton 27® and SunSpray Ultrafine Oil® were slightly less efficacious in controlling powdery mildew than were Banner MAXX®, Heritage™ 50W, or Eagle® 40W. However, both of these fungicides, as well as Banner MAXX®, Eagle® 40W, and Heritage™ 50W were more effective against this disease than 3336 4.5F and Bayleton® WSP. While SunSpray Ultrafine Oil® appears as a biorational or organic alternative to the above synthetic fungicides, an objectionable mottling and marginal leaf burn was noted in 2003 and 2004 on field-grown ‘Rubra’ flowering dogwood in full sun that were treated at one- or two-week intervals in the spring and summer with this product *(5).*

As previously noted by Windham *et al. (15),* Compass™ 50W demonstrated excellent activity against powdery mildew on flowering dogwood. When applied monthly, the 2- and 4-ounce-per-100-gallon rates of Compass™ 50W often gave effective control of powdery mildew. The 1-ounce-per-100-gallon rate was more effective when applied at one- and two-week intervals than on a monthly schedule. Windham *et al. (15)* got excellent control of powdery mildew on field grown ‘Rubra’ flowering dogwood with the 4- and 8-ounce-per-100-gallon rates of Compass™ 50W applied on a two-week schedule but not with monthly treatments of the 8-ounce-per-100-gallon rate of the same fungicide. Under the heavy disease pressure seen in the 1999 study, treatment intervals may have to be reduced to two weeks or less in order to maintain effective disease control.

While the application rate and treatment interval for Compass™ 50W evaluated here match the information on the product label, repeated applications of this or other strobilurin fungicides such as Heritage™ 50W over an extended period of time on vegetable, fruit, turf, and cereal crops can result in control failures due to the selection of strobilurin-resistant fungal plant pathogens, especially powdery mildew fungi *(1).* According to FRAC (Fungicide Resistance Action Committee, www.frac.info/) guidelines, the risk of control failures due to resistance can be greatly reduced by insuring that a strobilurin fungicide makes up no more than one-third of the total fungicide applications and that no more than two consecutive applications of a strobilurin fungicide are made. Either tank-mixing or alternating fungicides with different modes of action is also an effective strategy for reducing the risk of a control failure. When a

strobilurin fungicide is applied alone or tank-mixed with another type of fungicide, no more than 50 percent of the total fungicide application made in that growing season should include any strobilurin fungicide.

Figure, top right: Difference in top growth on 'Cloud 9' flowering dogwood obtained with Compass 50W at the 2-ounce-per-100-gallon rate (left) compared with untreated control (right). Note differences in tree height, leaf size, and canopy density between the fungicide-treated and untreated trees.

Figure, bottom right: Differences in top growth on 'Cloud 9' flowering dogwood obtained with Heritage 50W at the 4-ounce-per-100-gallon rate (left) compared with the untreated control (right).

SUMMARY

Historically, the impact of powdery mildew diseases on woody plants has been considered largely cosmetic *(4,8).* Few published reports have noted a relationship between slowed shoot growth with severe outbreaks of powdery mildew. In the 1999 Compass™ 50W study, the GI of the untreated controls was well below the GI for all fungicide treatments except for the lowest rate of Compass™ 50W. Similar powdery mildew-related reductions in the growth of untreated 'seedling' and Cherokee Brave™ flowering dogwood have recently been observed in Tennessee *(10).* Increased shoot growth and larger stem caliper on flowering dogwood were obtained with Banner MAXX® alone or when alternated with Armicarb® as well as with Equate® soap and Heritage™ 50W *(10).* When powdery mildew pressure was relatively low, differences in tree dimensions or GI were not observed between the untreated and the fungicide-treated flowering dogwood in this and an earlier Georgia study *(2).*

In summary, Banner MAXX®, Heritage® 50W, and Eagle® 40W were shown to be highly effective in controlling powdery mildew on flowering dogwood. Systemic Fungicide™ (ferti-lome®) contains the same active ingredient (propiconazole) as Banner Maxx® and is available at garden centers and other retail outlets as is Immunox™ (Spectracide®), which contains the same active ingredient as Eagle 40W. Phyton 27® also proved to be a possible control option. Due to the high risk of damage to the leaves of flowering dogwood growing in full sun, Sunspray Ultrafine Oil® may not be an acceptable biorational or organic substitute for the other fungicides screened, particularly on flowering dogwood not shaded by other trees. The new strobilurin fungicide Compass™ 50W, which gave effective control of powdery mildew over a range of rates and treatment intervals, is targeted for use by the commercial greenhouse and nursery industry. Bayleton® WSP and 3336™ 4.5F (Halt™ Systemic) gave inconsistent control and are not the fungicides of choice for managing powdery mildew on flowering dogwood.

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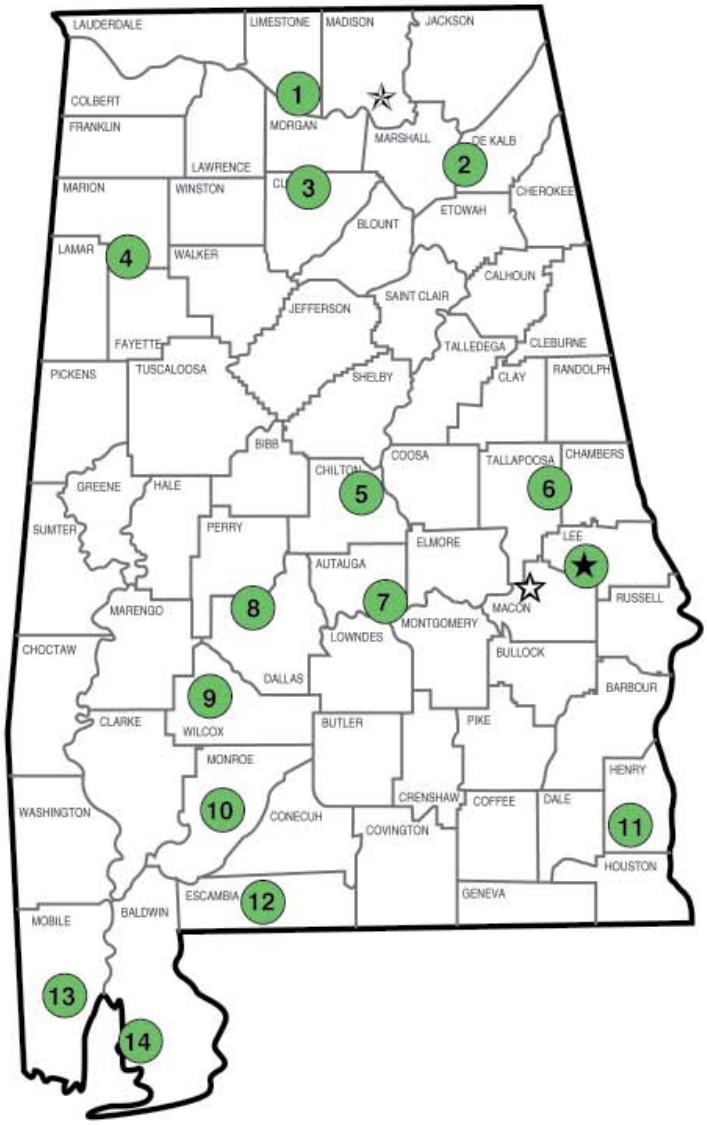

Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.
✯ Alabama A&M University.
☆ E. V. Smith Research Center, Shorter.

1. Tennessee Valley Research and Extension Center, Belle Mina.
2. Sand Mountain Research and Extension Center, Crossville.
3. North Alabama Horticulture Research Center, Cullman.
4. Upper Coastal Plain Agricultural Research Center, Winfield.
5. Chilton Research and Extension Center, Clanton.
6. Piedmont Substation, Camp Hill.
7. Prattville Agricultural Research Unit, Prattville.
8. Black Belt Research and Extension Center, Marion Junction.
9. Lower Coastal Plain Substation, Camden.
10. Monroeville Agricultural Research Unit, Monroeville.
11. Wiregrass Research and Extension Center, Headland.
12. Brewton Agricultural Research Unit, Brewton.
13. Ornamental Horticulture Research Center, Spring Hill.
14. Gulf Coast Research and Extension Center, Fairhope.