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Pecan Disease Research in Alabama

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Pecan Disease Research in Alabama

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DISEASE IS A MAJOR limiting factor in the production of pecans, the most important horticultural crop in Alabama. Spraying pecan trees for disease and insect control has become standard practice, especially with owners of large orchards. Development of improved models of air-blast, mist-blower, and hydraulic sprayers and use of new, highly effective pesticides has resulted in increased yield and quality of nuts adequate to pay for equipment, labor, and chemicals and yield a profit. Increased yields are not due to pest control alone, but are also attributed to use of new knowledge from research on nutrition (fertilization), management, and mechanical harvesting. This publication summarizes results of research on major pecan diseases by Auburn University Agricultural Experiment Station.

SCAB

Pecan scab is one of the major diseases encountered in producing pecans in Alabama. The causal fungus, *Fusicladium effusum* Wint., attacks most seedling and improved varieties. In the past, Stuart pecans showed good resistance to scab *(5)* whereas Success and Schley exhibited little. Scab has become widespread on Stuart in recent years *(4,5)* and little difference in susceptibility between Stuart and Success has been evident during the last 5 years. Apparently, physiological races of the fungus capable of attacking Stuart and Desirable have developed.

Symptoms appear on new foliage as olive-brown lesions on the ventral (lower) leaf side and later on the dorsal (upper) sur-

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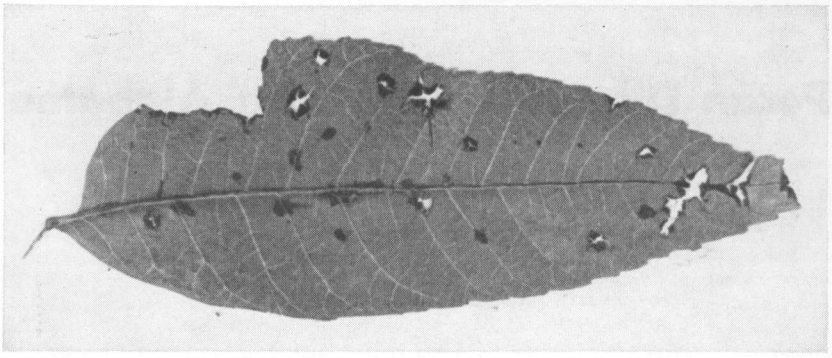


FIG. 1. Scab lesions (black spots) on pecan leaflets.

face, Figure 1. Initially lesions are pin-point in size, but soon enlarge to 3-5 mm. diameter and coalesce. Those on shucks are small, black, and circular, Figure 2, and appear sunken as the nut-shuck enlarges. Entire shuck surfaces of highly susceptible varieties may become blackened by coalesced scab lesions. Immature scabby nuts in such condition fall prematurely before harvest or fail to fill. Lesions may develop on current-season leaf petioles and contribute to leaf abscission. The primary source of overwintering inoculum is scabbed leaves, shucks, and twigs.

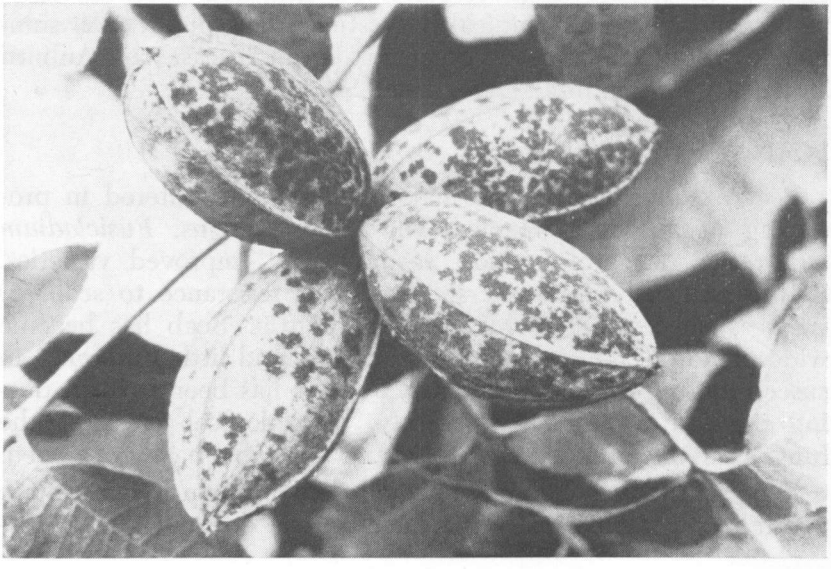


FIG. 2. Scab lesions (blackened areas) on pecan shucks.

Materials and Methods

Research on scab control with fungicides has been conducted in Alabama since 1961 *(4)*. Fungicides evaluated are listed in Table 1 by common and chemical names. Insecticides were applied throughout the season as recommended for insect control, usually in combination with a fungicide.

TABLE 1. FUNGICIDES USED IN PECAN DISEASE CONTROL INVESTIGATIONS

Trade or proprietary name	Common name	Chemical name
ACX-77 50 W	-------	not available
Benlate 50 W	benomyl	1-(butylcarbamyl)-2-benzimidazole-carbamate
Brestan 60 W	-------	triphenyltin acetate
Cyprex 65 W[1] and Cyprex 80 W	dodine	n-dodecylguanidine acetate
Daconil 2787 75 W	chlorothalonil	tetrachloroisophthalonitrile
Difolatan 80 W 4F	-------	N-[1,1,2,2-tetrachloroethyl)-sulfenyl] *cis*-4-cyclohexene-1,2-dicarboximide
Dithane M-45 80 W	-------	coordination product of zinc ion and maneb
Du-ter 50 W[1]	-------	triphenyltin hydroxide
Kocide 101 86 W	-------	cupric hydroxide
Polyram 80 W	-------	5.2 parts by weight ammoniates of [ethylene-bis(dithiocarbamate)]-zinc with 1 part by weight ethylenebis [dithiocarbamic acid] bimolecular and trimolecular cyclic anhydrosulfides and disulfides
TD-225 FS 75 W	-------	1-dodecyl-1,4,5,6-tetrahydro-2-methyl pyrimidine
Topsin-M 70 W	thiophanate-methyl	1,2-bis (3-methoxycarbonyl-2-thioureido) benzene
Zerlate 76 W	ziram	zinc dimethyldithiocarbamate
Zineb 75 W	zineb	zinc ethylenebis (dithiocarbamate)

[1] Registered for pecan disease control.

Research was conducted in Autauga, Baldwin, Dallas, Macon, Mobile, and Montgomery counties on the Lewis, Mahan, Moore, Schley, Stuart, and Success varieties. Much of the research involved the Success pecan, however, since it scabs severely each year in Baldwin and Mobile counties where extensive plantings of large trees were available with cooperating growers. John Bean and Myers air-blast, Hurricane mist-blowers, and John Bean hydraulic sprayers were used in pesticide applications *(4,5, 6,15,16.)*

Data were taken from three to eight replicated single-tree plots per treatment each year between August 15 and September 4. Data were collected using 50 green nuts from each tree before shuck-split and recorded as: **clean**—no scab on shuck, or

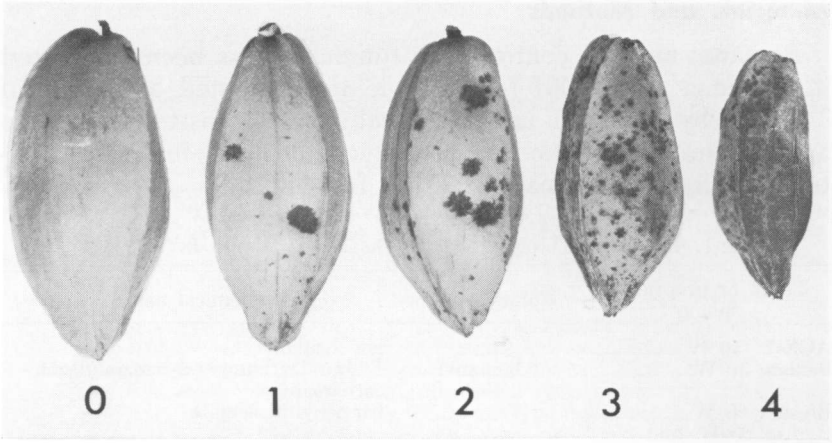


FIG. 3. Nearly full-grown nuts of the Schley variety classed according to degree of scab infection: 0—clean, no scab on shuck: 1—trace to 10 per cent scab; 2—11 to 25 per cent scab; 3—26 to 50 per cent scab; and 4—51 to 100 per cent scab (USDA photo).

scabbed shuck—class 1, trace to 10 per cent; class 2, 11 to 25 per cent; class 3, 26 to 50 per cent; class 4, 51 to 100 per cent. Scab indices were calculated by multiplying number of nuts in a class by the class number; classes were summed and the total divided by the product of replications times 100. Percentage figures under light scab incidence represent a summary of classes 1 and 2. Heavy incidence, Figure 3, represents a summary of classes 3 and 4.

Data on nut quality of Success pecans were collected by the following procedures: Trees were shaken and a random sample of 100 nuts collected by picking 12 nuts at eight different places under the tree. Nuts were cracked and data recorded for total weights of No. 1 meats as percentage, weight of ambers as percentage, and the price offered for the combined meats by a commercial sheller *(4)*. Data were summarized as means for 10 replications of each treatment.

Results and Discussion

Environmental conditions in Alabama have been consistently favorable for disease development the last 11 years. Disease control data from research in Baldwin and Mobile counties are summarized in tables 2 and 3. A scab index less than 1.0 indicates that approximately 90 per cent of green nuts had less than 10 per cent of the shuck surface covered with scab; this constitutes

TABLE 2. SUMMARY OF SCAB CONTROL ON SUCCESS PECAN WITH FUNGICIDE APPLICATIONS AT 3-WEEK INTERVALS IN BALDWIN AND MOBILE COUNTIES, 1963-1969, 1971

Treatment and rate, pounds/100 gallons	Years tested	Scab index[1]	Scab incidence on shucks		
			Clean	Light	Heavy
	No.		*Pct.*	*Pct.*	*Pct.*
ACX-77 50 W, 0.3	1	0.11	91.5	8.5	----
Benlate 50 W, .2	2	.10	92.8	7.2	----
Benlate 50 W, .3	2	.06	94.0	6.0	----
Benlate 50 W, .4	2	.02	98.7	1.3	----
Brestan 60 W, .2	2	.11	92.8	6.1	1.1
Brestan 60 W, .3	2	.03	97.0	3.0	----
Brestan 60 W, .4	1	.02	98.0	2.0	----
Cyprex 65 W, .75	2	.41	78.0	16.4	5.6
Cyprex 65 W, 1.0	8	.11	91.4	8.2	.4
Cyprex 80 W, .8	4	.08	93.0	7.0	----
Daconil 2787 75 W, 1.0	1	1.42	17.3	64.7	18.1
Daconil 2787 75 W, 1.5	1	.90	38.3	56.7	5.0
Daconil 2787 75 W, 2.0	1	1.70	8.0	71.3	20.7
Difolatan 80 W, 1.0	1	.12	89.2	10.8	----
Difolatan 4F, 1.0	1	.17	90.0	10.0	----
Difolatan 4F, 1.5	1	.19	89.0	11.0	----
Dithane M-45 80 W, 2.0	1	.10	92.0	7.0	1.0
Du-ter 20 W, 1.5	2	.06	96.8	3.2	----
Du-ter 50 W, .2	5	.09	92.6	7.1	.3
Du-ter 50 W, .3	5	.03	97.1	2.9	----
Du-ter 50 W, .4	3	.05	95.3	4.5	.2
Du-ter 50 W, .6	1	.07	94.0	6.0	----
Kocide 101, 2.0	1	.60	62.6	29.7	7.7
Zineb 75W, 2.0	2	.58	63.6	28.0	8.4
Polyram 80 W, 2.0	2	1.59	19.4	59.0	21.6
TD 225 FS, 1.2	1	1.47	14.8	72.8	12.4
Topsin-M 70 W, 1.0	1	.05	97.4	2.6	----
Check (unsprayed)	8	2.91	.7	30.5	68.8

[1] Rated on scale of 0-4.

a high degree of control. Nuts in classes 3 and 4 were unmarketable and grouped under "scab incidence heavy," tables 2 and 3.

Cyprex was the first fungicide to successfully control scab for periods up to 3 weeks between applications. This organic fungicide at a rate of 1 pound per 100 gallons has given excellent control during 8 years of use. It has been the standard for comparison of other fungicides in the evaluation program. Du-ter, which was developed a few years after Cyprex, also has shown excellent protective qualities for scab control. Applications of Du-ter at 0.3 and 0.4 pound per 100 gallons for 5 and 3 years, respectively, have been highly effective, Table 2. Du-ter treatments at 0.2 pound averaged 92.6 per cent scab-free shucks during 5 years of tests. However, this least effective rate of application may not result in commercially acceptable control when used by many applicators. Both Cyprex and Du-ter are registered with the

TABLE 3. CONTROL OF SCAB ON SUCCESS PECAN WITH FUNGICIDE APPLICATIONS AT 4-WEEK INTERVALS IN BALDWIN AND MOBILE COUNTIES, 1966, 1967, 1970

Treatment and rate, pounds/100 gallons	Years tested	Scab index[1]	Scab infection on shuck		
			Clean	Light	Heavy
			Pct.	*Pct.*	*Pct.*
Benlate 50 W, 0.4	'70	0.04	92.0	8.0	----
Brestan 60 W, .2	'67	.41	69.5	29.3	1.2
Brestan 60 W, .3	'67	.06	94.2	5.8	----
Brestan 60 W, .4	'66	.44	73.7	23.3	3.0
Cyprex 65 W, 1.0	'66,'70	.16	86.8	11.2	2.0
Cyprex 80 W, 1.0	'70	.05	91.0	9.0	----
Difolatan 4F, 1.0	'70	.13	81.0	19.0	----
Du-ter 50 W, .2	'66,'67,'70	.37	74.6	21.8	3.6
Du-ter 50 W, .3	'67	.18	86.2	13.4	.4
Du-ter 50 W, .4	'66,'67,'70	.08	90.8	9.2	----
Kocide 101 86 W, 2.0	'66	1.55	35.0	37.5	27.5
Check (unsprayed)	'66,'67,'70	3.34	.0	15.3	84.7

[1] Rated on scale of 0-4.

Environmental Protection Agency (EPA) for pecan scab control[1]. Benlate (4 years) and Brestan (3 years) both performed well throughout these tests. Difolatan provided good control of scab (1 year's data) and ranked between Du-ter and Zineb in effectiveness. Daconil 2787, Kocide 101, Zineb, Polyram, and TD-225FS have given poor scab control in the 3-week schedule. Daconil 2787 was first tested in 1964 at 2.0-pound rate; ineffectiveness was attributed by the manufacturer to partial loss of fungicidal activity during storage. Subsequently, the fungicide was retested at 1.0- and 1.5-pound rates with similar results in 1968, Table 2. Unsprayed pecans showed 69-85 per cent heavy scab infection, and most of these were unmarketable.

ACX-77 and Topsin-M were effective in first-year evaluations (1971) and warrant further investigation to determine optimum rates of application. These two fungicides are not registered for use on pecans.

A comparison of data in tables 2 and 3 shows that a 3-week spray interval resulted in consistently high percentages of clean shucks. When the spray interval was extended to 4 weeks, Table 3, disease control decreased *(6)*. Extending the spray interval to 4 weeks may prove disastrous under environmental conditions favoring high disease incidence, since the fungicide

[1] Refer to Table 1 for information about registration of fungicides used in these investigations, and for common and chemical names.

on pecan shucks or foliage may be weakened to a concentration ineffective to prevent fungal infection and scab development. Rainy weather, spray machinery breakdown, sprayer operator health conditions, or other extenuating circumstances may on occasion extend the spraying date several days beyond the desired 21st day. During such situations the rate of 0.3 or 0.4 pound Du-ter or 1.0 pound Cyprex still has been effective. However, the marginal rate of 0.2 pound Du-ter was only partially effective in 1966, with 47.5 per cent of the shucks remaining uninfected (data not presented.) The overall 3-year average was 74.6 per cent scab-free shucks from the 0.2-pound rate as compared with 86-90 per cent for 0.3- and 0.4-pound rates.

A 4-week schedule was followed in 1970 to maintain vigorous, disease-free foliage and promote maximum crop potential for 1971, since the trees had sustained severe damage from Hurricane Camille in 1969. Plant tissues associated with floral initiation and development were damaged by strong winds of the hurricane. In 1970, poor nut set was followed by prolific new vegetative growth; subsequently, many nuts that set fell prematurely and left few nuts to provide test results.

Data in Table 4 show that disease control prevented losses in quality and price of pecans, as well as yield losses, from premature drop. With a more susceptible variety, such as Mahan or Schley, the return from effective scab control in both yield and quality might be far greater, since unsprayed orchards of these two varieties averaged 75 to 90 per cent losses. This investiga-

TABLE 4. RELATION OF PECAN SCAB CONTROL WITH FUNGICIDES TO NUT QUALITY AND PRICE OF SUCCESS VARIETY IN BALDWIN COUNTY, ALABAMA, 1961

Treatment and rate, pounds/ 100 gal.	Green nuts			Grade at harvest						Premature drop, est. yield loss
	Nuts/ lb.	Disease index[1]	Shucks scabbed 0-10%	Nuts/ lb.	Pops	Total wt. meats	Wt. of No. 1 meats	Wt. of ambers	Offered price	
	No.		*Pct.*	*No.*	*No.*	*Pct.*	*Pct.*	*Pct.*	*Cents*	*Pct.*
Dodine, 1	17.2	0.70	89.4	50.7	4.3	49.3	39.0	10.3	19.4	----
Dodine, ½ and 1[2]	16.4	.67	88.0	50.0	5.0	44.7	34.5	10.8	17.0	----
Zineb, 2	16.8	1.46	58.8	54.2	6.1	47.5	35.5	11.9	17.9	2
Ziram, 2	18.0	2.78	6.2	53.6	4.5	46.4	35.5	10.8	17.9	10
Check[3]	21.2	3.57	4.8	56.7	7.2	44.5	29.2	15.2	15.1	30
LSD, 1%	1.5	.5		4.5	4.4	3.7	6.3	5.4	2.6	

[1] Rated on scale of 0-4.
[2] First four sprays at ½-pound, last four at 1-pound rate.
[3] Insecticide only.

tion demonstrated the value of pecan scab control with fungicidal sprays in increasing return, both in quality and total production *(4)*.

An added benefit from annual spraying for control of diseases and insects has been observed in reduced alternate bearing. A fairly good crop of pecans occurred each year in the test orchards. These results contrasted with unsprayed, poorly managed orchards where a heavy crop might occur only every other year. It is recognized that fertilization and proper management also enter into the overall problem of alternate bearing.

Fungicide protective activity was correlated with the thoroughness of fungicide application. A pecan branch or limb "missed" by the spray was readily detected by the amount of scab and foliage diseases at harvest. A fungicide will serve its purpose only when the pecan tree is thoroughly sprayed with an adequate dosage at the prescribed time interval.

Experience gained from research in cooperating growers' orchards has shown that vigorous unsprayed trees with high disease (scab) incidence and defoliation may be sprayed the following year with Cyprex or Du-ter and scab controlled 94 per cent or better *(16)*. When pecan foliage and nut shucks were adequately covered with a fungicide, scab was controlled 90 per cent or better throughout these investigations. Control was achieved despite the area's prevailing high humidity, which is highly favorable for scab development.

DOWNY SPOT

Downy spot, caused by the fungus *Mycosphaerella caryigena* Demaree and Cole, attacks most pecan varieties, Moneymaker

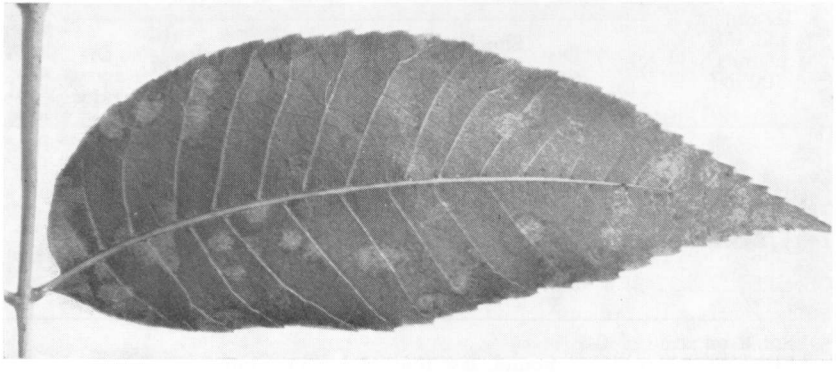


FIG. 4. Downy spot lesions (frosty, white spots) on underside of pecan leaflets.

and Stuart being the most susceptible *(17)*. Downy spot lesions interfere with photosynthesis during summer, resulting in lower nutrient availability for the current season nut development and subsequent crop initiation *(3)*.

Lesions first appear in early summer as white tufts or "frosty" spots approximately 1/8 inch in diameter on the lower sides of leaflets, Figure 4, caused by sporulation of *M. caryigena*. Later in the summer the spots become greenish-yellow on both leaf surfaces, then change to brown in the fall. As the season advances, diseased areas die and some premature defoliation occurs. Leaflet abscission from the leaf rachis may begin in early September. The fungus overwinters in the diseased leaves where its life cycle is completed. During rainy periods in spring, new leaves are infected by fungal spores disseminated from fruiting bodies of the pathogen in old leaves *(3)*.

Materials and Methods

The efficacy of fungicides Benlate, Cyprex, Difolatan, Du-ter, and Zineb for control of downy spot in Alabama was determined. Each fungicide was applied with a Myers air-blast sprayer to five Stuart pecan trees. In 1968, evaluations were made on blocks of trees sprayed on a 2- or 3-week schedule starting with a pre-pollination application when leaves showed 1/2 to 3/4 inch growth (April 11). Evaluation of a third block of trees was initiated post-pollination (May 2). In 1969 and 1971, experiments were designed to evaluate disease control when spraying was begun pre-pollination (April 20) or post-pollination (May 22, 1969, and May 10, 1971). Since applications in 1970 did not begin until April 28, pre-pollination protection sprays were omitted.

Leaf disease severity was determined on 12 compound leaves that were collected from each single-tree plot at a height 6 to 12 feet from the ground. Three leaves were collected from each of four equidistant stations per tree. The fourth leaf from terminal bud was collected during September of each year. Leafspot data were analyzed statistically *(11,12)*.

Results and Discussion

Infections by the fungus continued to increase throughout the 1968 season. Leaves sprayed with Difolatan exhibited a "bloom" of infections that were too numerous to count as definite leafspots on September 18; only definite leafspots that occurred early in the season could be counted. Fungicides applied on a 2- or

TABLE 5. CONTROL OF DOWNY LEAFSPOT ON STUART PECAN WITH FUNGICIDES IN MACON COUNTY, ALABAMA, 1968

Treatment and rate, pounds/100 gallons	Spots per compound leaf[1]	
	July	September
	No.	*No.*
2-week interval		
Cyprex, 1.0	4.8 a	6.1 a
Difolatan, 1.0	33.5 bc	35.6 abc
Du-ter, .4	11.6 ab	11.8 a
Zineb, 2.0	16.3 ab	28.0 abc
3-week interval		
Cyprex, 1.0	13.2 ab	18.1 ab
Difolatan, 1.0	46.2 c	50.6 bc
Du-ter, .4	18.4 ab	22.9 ab
Zineb, 2.0	50.1 c	58.4 c
Zineb (PPSO)[2], 2.0	87.1 d	101.1 d
Unsprayed	163.2 e	206.2 e

[1] Means followed by the same letter are not significantly different at the 1 per cent level according to Duncan's Multiple Range Test.
[2] PPSO = pre-pollination spray omitted, Zineb applied post-pollination only.

3-week schedule were effective in controlling leafspot, Table 5. However, Cyprex was significantly better than Difolatan at 2-week intervals and both Cyprex and Du-ter were better than Difolatan at 3-week intervals. Effectiveness of Zineb was equal to Du-ter at 2-weeks, but leafspotting at 3 weeks was nearly three times greater.

Statistically significant differences that occurred between pre- and post-pollination applications illustrate the benefit of pre-pollination applications for preventing early leaf infection by *M. caryigena.* Some variability in disease control among Benlate, Cyprex, and Du-ter treatments was observed each year in pre-pollination applications. Leafspot incidence per compound leaf was so small, however, that differences may have been unimportant to overall photosynthetic activity of the foliage, Table 6. When post-pollination applications in 1969 were delayed until May 22, pronounced differences between Cyprex, Benlate, and Du-ter were recorded. These results emphasize the importance of making three pre-pollination applications on a 2-week schedule beginning as leaves first emerge, followed by the 3-week spray schedule until September. This prevents scab and foliage diseases through the growing season.

The high incidence of downy spot lesions on unsprayed trees in September, tables 5 and 6, does not show all leafspots that developed during the season, since many leaflets had already abscissed. Whole compound leaves were difficult to find at this

TABLE 6. DOWNY LEAFSPOT INCIDENCE ON STUART PECANS SPRAYED WITH FUNGICIDES IN MACON COUNTY, ALABAMA, 1969-71

Treatments and rate, pounds/100 gallons	Spots per compound leaf		
	1969[1]	1970[1]	1971[2]
	No.	*No.*	*No.*
Pre-pollination[3]			
Benlate 50 W, 0.4	1.1 a	----	6.3 b
Cyprex 65 W, 1.0	3.9 a	----	1.8 a
Du-ter 50 W, .3	5.9 a	----	7.1 b
Unsprayed	81.8 b	----	----
Post-pollination[3]			
Benlate 50 W, .4	23.6 a	7.2 a	8.4 bc
Cyprex 65 W, 1.0	126.6 b	8.0 a	11.3 cd
Du-ter 50 W, .3	30.4 a	15.7 a	11.9 d
Unsprayed	153.0 c	205.1 b	203.0 ----

[1] Means of 60 compound leaves; number followed by same letter not significantly different at 1 per cent level according to Duncan's Multiple Range Test.
[2] Means of 60 compound leaves; number followed by same letter not significantly different at 5 per cent level according to Duncan's Multiple Range Test.
[3] Significant differences between pollination times at 1 per cent, according to "F" test for significance.

late date on some heavily infected trees. High disease incidence caused some leaflets to fall from the rachis when the leaf was picked or jarred loose. Some leaves with high lesion counts may remain on the tree, but become of little value in supporting nut production.

From a grower's viewpoint it would be practical if the fungicide selected for scab disease control also controlled foliage diseases. Commercial control of downy spot was obtained with Benlate, Cyprex, and Du-ter on a 3-week schedule in these experiments. In the past, Stuart pecan possessed some resistance to scab; thus growers delayed spraying until scab was evident. Such practices permitted high scab development on shucks and extensive downy leafspot incidence, resulting in loss of nutrients required by the tree for nut production.

BROWN LEAFSPOT

Brown leafspot is caused by the fungus *Cercospora fusca* Rand. Leafspots first appear in June or July on mature leaves of Stuart and other varieties. Symptoms on leaflets appear as circular concentrations of reddish-brown angular flecks on the leaf surface. These flecks may coalesce into a consolidated necrotic region with an irregular margin 10 to 20 mm. in diameter, Figure 5. If uncontrolled, the disease causes early defoliation and complete

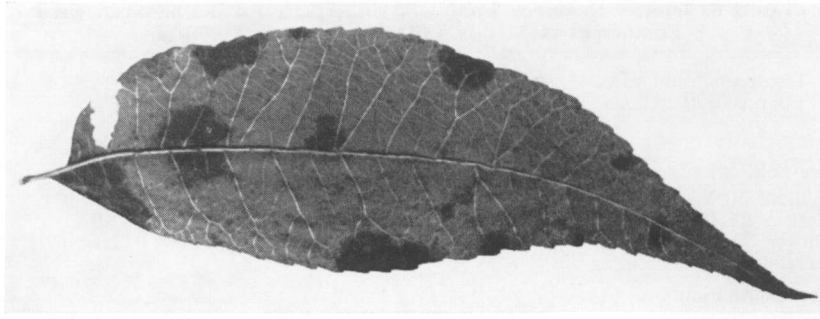


FIG. 5. Brown leafspot lesions (diffuse and concentrated necrotic areas) on underside of pecan leaflet.

loss of leaves by October. The brown leafspot fungus overwinters in necrotic tissue of old leaves.

Materials and Methods

In Montgomery County, Cyprex, Du-ter, and Zineb were applied to Lewis pecan trees with a mist blower on a monthly schedule from June to September 1965. Data for brown leafspot severity were calculated from the percentage of leaves infected on 10 to 20 terminals and averaged for five single-tree replications *(5)*.

Fungicides were applied with a Myers air-blast sprayer to Stuart pecans in Macon County beginning April 20 and continuing on a 3-week schedule through August 1969. During 1971, spraying was initiated on April 20 with additional applications made May 10, June 9, June 23, August 3, and September 1. Data for brown leafspot were recorded as for downy leafspot, i.e., from 12 compound leaves per tree and five replications per treatment *(11,12)*.

Results and Discussion

In Montgomery County, Du-ter gave the best control of brown leafspot, whereas Zineb did not control the disease *(5)*. Control probably would have been better if spraying had been initiated earlier than June.

Applications of Benlate, Cyprex, and Du-ter prevented development of brown leafspot in the Macon County research plots, and in Baldwin and other counties where spraying was begun as early as April 20. In each experiment, extensive symptom expression and defoliation of trees was observed in adjoining unsprayed orchards, Table 7.

TABLE 7. CONTROL OF BROWN LEAFSPOT WITH FUNGICIDES APPLIED TO LEWIS PECAN TREES (MONTGOMERY COUNTY 1965) AND STUART PECAN TREES (MACON COUNTY 1969, 1971)

Treatments and rate, pounds/100 gallons	Infected leaves, Lewis[1] variety, 1965	Spots/compound leaf, Stuart[2] variety	
		1969	1971
	Pct.	*No.*	*No.*
Benlate 50 W, 0.4	---	0	0
Cyprex 65 W, 1.0	8.6	0	0
Du-ter 50 W, .6	1.2	---	---
Du-ter 50 W, .3	---	0	0
Zineb 75 W, 2.0	29.4	---	---
Unsprayed check	85.4	124	74.2

[1] Ten to 20 terminals averaged for five replications (trees).
[2] Spots counted per leaflet from 12 compound leaves for five replications.

In Alabama, brown leafspot has caused the most widespread defoliation of any fungal disease. Other diseases, such as zonate leafspot, are more sporadic and cause highly localized defoliation. Although brown leafspot incidence and effects may be severe, it has been the easiest foliage disease to control.

LIVER SPOT

Liver spot disease, caused by the fungus *Gnomonia caryae* var. *pecanae* Cole, has been found in orchards in central Alabama. Highest incidence was observed on seedling pecans in Macon County. The disease has not been observed in Baldwin or Butler counties *(10)*. Two trees were found infected near Grand Bay, Mobile County. According to Cole *(1)*, liver spot does not occur in regions of high humidity, such as along the Gulf Coast.

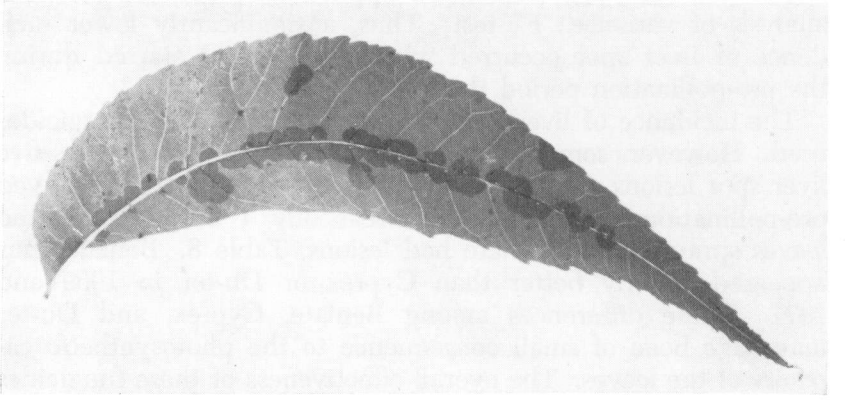


FIG. 6. Liver spot lesions on a pecan leaflet (USDA photo).

Leafspots appear in June as dark brown circular areas, 5 to 12 mm. diameter, on the lower surface of leaflets. As the summer progresses, lesions may be observed on both lower and upper surfaces with leafspots exhibiting the liver color during late summer, Figure 6. Acervuli (fungal fruiting structures) appear as minute blisters on the lower leaf surface. Conidia (spores) from these structures are further spread by air currents in the orchard. It overwinters and completes its life cycle in fallen leaves where more spores are produced to infect succulent young leaves the following spring.

Materials and Methods

Tests were conducted in Macon County to determine the value of Benlate, Cyprex, and Du-ter for liver spot control. Each fungicide was applied to five Stuart pecan trees with a Myers airblast sprayer. Spraying was begun in 1969 and 1971 on April 20, with subsequent applications made every 3 weeks until September. During 1970, pre-pollination applications were omitted since spraying could not start until April 28.

Twelve compound leaves were collected from each single-tree plot for leafspot counts. Three leaves were collected from each of four stations around the tree. The fourth leaf from terminal bud was collected in September of 1969 and 1971 and in July of 1970. Leafspot data were analyzed statistically for differences among treatments and times of applications.

Results and Discussion

Significant differences were observed in 1969 and 1971 between pre- and post-pollination applications, according to the analysis of variance "F" test. Thus, a significantly lower incidence of liver spot occurred when applications started during the pre-pollination period than later, Table 8.

The incidence of liver spot was low with all of the fungicides used. However, some distinct differences were noted, e.g., five liver spot lesions were counted on each compound leaf sprayed pre-pollination with Du-ter, whereas ony 7 of 10 compound leaves sprayed with Benlate had lesions, Table 8. Benlate thus appeared slightly better than Cyprex or Du-ter in 1969 and 1971. These differences among Benlate, Cyprex, and Du-ter may have been of small consequence to the photosynthetic capacity of the leaves. The overall effectiveness of these fungicides was especially apparent when compared with unsprayed checks

TABLE 8. INCIDENCE OF LIVER SPOT ON STUART PECAN SPRAYED WITH FUNGICIDES, MACON COUNTY, 1969-71

Treatments and rate, pounds/100 gallons	Spots per compound leaf		
	1969[1]	1970	1971[1]
	No.	*No.*	*No.*
Pre-pollination[2]			
Benlate 50 W, 0.4	0.17 a	----	0.70 a
Cyprex 65 W, 1.0	.20 a	----	1.50 a
Du-ter 50 W, .4	.68 a	----	5.22 a
Post-pollination[2]			
Benlate 50 W, .4	.55 a	1.27[3]	.93 a
Cyprex 65 W, 1.0	.58 a	1.28	4.57 a
Du-ter 50 W, .4	1.03 a	.17	2.97 a
Unsprayed (check)	59.23 b	4.78	45.58 b

[1] Means followed by same letter are not significantly different at 1 per cent level according to Duncan's Multiple Range Test.
[2] Significant differences occurred between pre- and post-pollination sprays according to "F" test for significance at 1 per cent level of probability.
[3] No significant differences among treatments and check.

in which 59 lesions (1969) and 45 lesions (1971) occurred per compound leaf. Disease incidence of such proportions caused abscission of leaflets from the compound leaf rachis and premature defoliation.

ZONATE LEAFSPOT

Zonate leafspot, caused by *Cristulariella pyramidalis* Waterman and Marshall, was reported first in Alabama and Georgia in 1967 *(8,14)*. Symptoms on pecan were similar to those described on maple and other hosts *(2)*. The appearance of leafspots on the dorsal side of pecan leaves was grayish brown with concentric ring formation less distinct than from the ventral view. Leafspots viewed from the ventral side appeared light brown to tan in the center, becoming darker brown toward the periphery. Small lesions were characteristically circular with the pronounced concentric rings formed in the leafspot of the larger irregular-shaped necrotic tissue, Figure 7. A few cone-shaped, tan, fruiting bodies (conidiophores) of *C. pyramidalis* were observed on the lower leafspot surface with the aid of a hand lens. Conidiophores were not observed on small lesions (7-10 mm.); however, on large lesions (15-20 mm.) the conidiophores were erect and occurred somewhat randomly over the leafspot. Leaves with extensive lesion development became desiccated, curled upward from the margins, and fell from the trees. De-

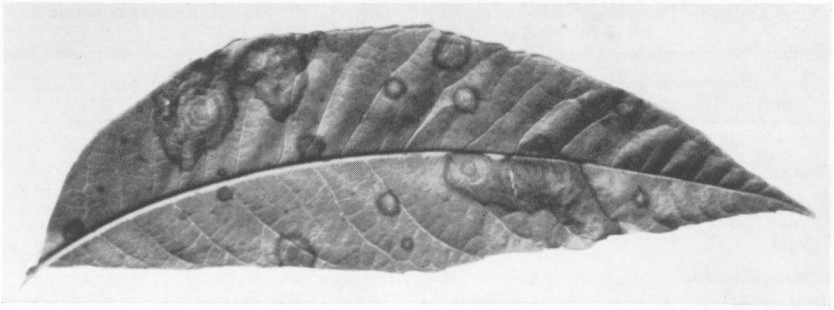


FIG. 7. Zonate leafspot (circular lesions and concentric rings in lesions) on pecan leaflet.

foliation occurred in early August 1971 following extensive leaf infection *(13)*. Disease incidence was closely related to weather conditions. According to Davis *(2)*, zonate leafspot on maple occurred sporadically and typically followed an unusually moist and cool period during late summer. The incidence of zonate leafspot in Alabama appears to follow this pattern.

Pure culture isolations made from leafspots and from conidiophores of *C. pyramidalis* developed white mycelia and brownish-black sclerotia 1-5 mm. diameter on V-8 juice agar. The fungus has been cultured on agar plates amended with a variety of carbohydrates, vitamins, and natural media, but conidiophores did not form in these cultures. Sclerotia formed within 3 days on Czapek's medium supplemented with yeast extract or V-8 juice and within 4 days on potato dextrose agar. None formed on cornmeal, bean pod, or nutrient agar *(9)*.

Materials and Methods

Mycelial discs 3 mm. in diameter were placed on pecan leaves. The leaves were wounded by punching a root canal file through the mycelial disc and leaf five times. Infection was evidenced by the development of a light caramel brown lesion within 12 hours incubation in a mist chamber. Conidiophores were transferred to a pecan leaf and incubated in a humidity chamber also.

Fungicide tests were established in replicated plots in 1968 in the orchard where zonate leafspot occurred during 1967. Brestan, Cyprex, and Du-ter were evaluated.

Results and Discussion

Pecan seedling leaves inoculated with mycelial discs of *C. pyramidalis* grown on nutrient agar developed typical zonate

leafspot symptoms in glasshouse tests. Development of zonation in the leafspots was more pronounced under the fluctuating temperature of the glasshouse than in laboratory tests where temperatures were relatively constant *(8)*. Conidiophores formed readily on leaves incubated in a humid environment. Conclusive evidence for development of a secondary cycle of infection with conidiophores was demonstrated by using these fruiting bodies as a source of inoculum *(8)*.

The effectiveness of specific fungicides for control of zonate leafspot is unknown. Fungicide evaluations were negative during 1968, since zonate leafspot did not recur in the orchard where it was first discovered. Low incidence of zonate leafspot was observed during 1969 in the orchard where first observed in 1967. During 1970 and 1971, zonate leafspot was severe in Dallas and Perry counties; nearly total defoliation occurred on several trees in Perry County. Incidence of zonate leafspot is apparently increasing.

OTHER DISEASES

Powdery mildew, caused by the fungus *Microsphaera alni* Wint., appears as a white powder on leaves and nut-shucks in midsummer. The powdery appearance is caused by the white superficial fungal growth. Nut-shucks that are infected early in the season split prematurely, resulting in shriveled kernels. Sulfur 90 per cent W at 2 pounds per 100 gallons water was shown to prevent this disease. Pabst pecans are especially susceptible to it.

Sooty mold is caused by an unidentified species of *Capnodium,* a fungus that grows in aphid secretions on the pecan leaf surface. The fungal growth is entirely superficial, but often so abundant that it may injure the plants by significantly reducing the photosynthetic area. Du-ter at 0.6 pound per 100 gallons and Cyprex at 1 pound per 100 gallons prevented sooty mold, but Zineb treatment made no difference in sooty mold incidence as compared with unsprayed pecans *(5)*. The best procedure for control of sooty mold has been through elimination of aphids with applications of Dimethoate, ¾ pint per 100 gallons.

Zinc deficiency in pecan trees is characterized by a rosette appearance of foliage. Leaves become mottled and yellowish, and leaflets are narrow and crinkled in advanced stages of the disease. New shoot growth is checked, internodes are short, and the foliage appears bunched or rosetted. In the final stage, shoots

die back from the tips; this die-back is usually confined to the current year's growth. Affected trees bear poorly filled nuts or no nuts, depending on severity of the disease. Pecan trees with zinc deficiency symptoms may be treated with 150 pounds zinc sulfate per acre applied to the soil. Foliage sprays of 4 pounds Nu Zinc per 100 gallons should also be applied during the first three sprays in the first 2 years, and in subsequent years as symptoms persist.

Mouse ear (little leaf) is a nutritional disease. Symptoms were observed on several seedling trees and occasionally on branches of Schley in a large orchard of improved varieties near Hurtsboro in Macon County. Primary symptoms are blunt rounded leaflet tips where tissue has failed to develop, Figure 8. Leaf tissues are pale-green to yellow with some necrosis at the leaflet tip. Affected leaves may be considerably reduced in size, and the tip of the mid-vein often protrudes beyond the leaf margin. The disease may be found only on certain branches of some trees. Growth of nuts on severely affected trees is greatly retarded or prevented. The mouse ear condition is caused by a deficiency of manganese. Spraying trees with 1 or 2 per cent manganese sulfate or applying 2 to 4 pounds manganese sulfate to the soil under mature trees has been reported to promote a 50 per cent recovery of affected trees in 2 years *(7)*.

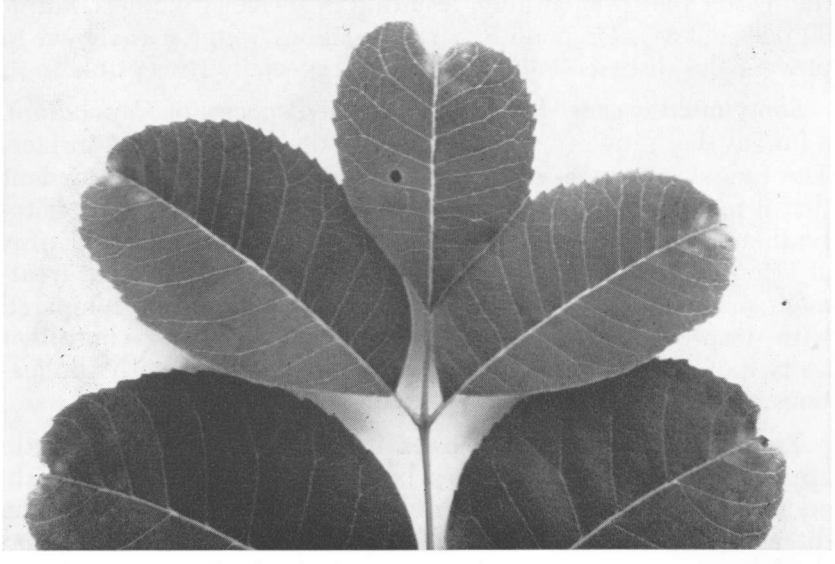


FIG. 8. Mouse ear disease symptoms (rounded leaf-tips) on pecan leaflet.

Shuck disease, also known as "tulip disease" or "pops," is manifest in some years by poor filling of nuts from the embryo. No parasitic organism has been implicated in this disease and the true cause is unknown. Shucks open prematurely and, in silhouette, the opening shucks and nut present the appearance of a tulip flower, Figure 9. Adjacent nuts in the same cluster may be properly filled when mature and open normally. When affected nuts are cracked, only a shriveled, dry embryo is found; such nuts are known as "pops." Occurrence of the problem has been associated primarily with Success pecan, but the disease also has been observed on occasion with the Mahan and Schley varieties. Success pecans growing in heavy soils exhibit this problem to an appreciable extent. Water relations may have some effect on proper nut filling.

FIG. 9. Shuck disease symptoms; note "tulip" configuration of opened shucks and adjacent green unopened shucks.

LITERATURE CITED

(1) COLE, J. R. 1933. Liver Spot Disease of Pecan Foliage Caused by *Gnomonia caryae pecanae* nov. var. J. Agr. Res. 47:869-881.

(2) DAVIS, T. C. 1963. Zonate Leafspots on Various Hosts Caused by *Cristulariella pyramidalis*. Plant Dis. Reptr. 47:983-985.

(3) DEMAREE, J. B. AND J. R. COLE. 1932. The Downy Spot Disease of Pecans. J. Agr. Res. 44:139-146.

(4) DIENER, U. L. 1962. Control of Pecan Scab in Alabama in 1961 and Its Relation to Nut Quality. Plant Dis. Reptr. 46:232-235.

(5) ---------- AND F. E. GARRETT. 1967. Control of Scab and Other Diseases of Pecan in Alabama. Plant Dis. Reptr. 51:185-188.

(6) ----------, A. J. LATHAM, AND F. E. GARRETT. 1968. New Fungicides for Control of Pecan Scab in Alabama. Highlights of Agr. Res. Auburn Univ. (Ala.) Agr. Exp. Sta. 15(1):9.

(7) GAMMON, N., JR., AND R. H. SHARPE. 1956. Mouse Ear a Manganese Deficiency of Pecans. Amer. Soc. Hort. Sci. 68:195-200.

(8) LATHAM, A. J. 1969. Zonate Leafspot of Pecan Caused by *Cristulariella pyramidalis*. Phytopathology 59:103-107.

(9) ----------. 1969. Zonate Leafspot of Pecan in Alabama and Georgia. Proc. Southeastern Pecan Growers Assoc. 62:86-87.

(10) ----------. 1970. Liver Spot Disease of Pecan in Alabama. Plant Dis. Reptr. 54:408.

(11) ----------. 1970. Efficacy of Selected Fungicides for Control of Downy Spot on Pecans in Alabama. Plant Dis. Reptr. 54:725-727.

(12) ----------. 1971. Fungicidal Control of Pecan Downy Leafspot. Highlights of Agr. Res. Auburn Univ. (Ala.) Agr. Exp. Sta. 18(1):6.

(13) ----------. 1972. Some hosts of *Cristulariella pyramidalis* in Pecan Orchard Hedgerows. Plant Dis. Reptr. 56:176-177.

(14) ---------- AND H. J. AMLING. 1968. A New Leafspot Disease of Pecan Incited by *Cristulariella pyramidalis* in Alabama and Georgia. Plant Dis. Reptr. 52:747.

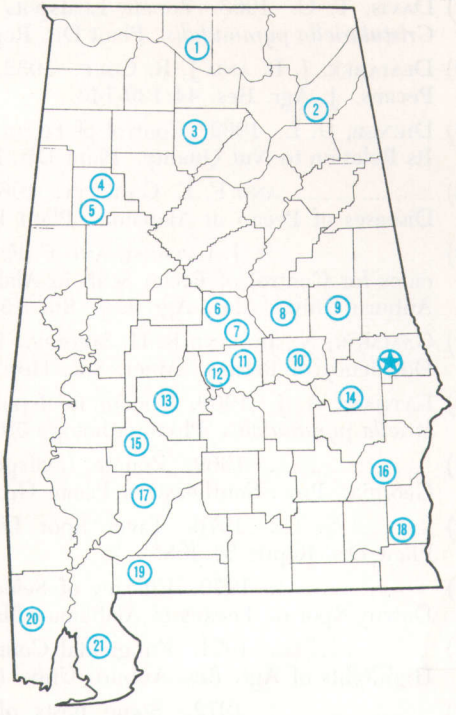
(15) ---------- AND F. E. GARRETT. 1969. Control of Pecan Scab in Alabama during 1968. Proc. Southeastern Pecan Growers Assoc. 62:90-95.

(16) ----------. 1970. Control of Pecan Scab in Alabama during 1969. Proc. Southeastern Pecan Growers Assoc. 63:40-43.

(17) OSBURN, M. R., W. C. PIERCE, A. M. PHILLIPS, J. R. COLE, AND G. E. KENKNIGHT. 1966. Controlling Insect and Diseases of the Pecan. USDA Agr. Handbook No. 240.

AGRICULTURAL EXPERIMENT STATION SYSTEM OF ALABAMA'S LAND-GRANT UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

★ Main Agricultural Experiment Station, Auburn.

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Thorsby Foundation Seed Stocks Farm, Thorsby.
7. Chilton Area Horticulture Substation, Clanton.
8. Forestry Unit, Coosa County.
9. Piedmont Substation, Camp Hill.
10. Plant Breeding Unit, Tallassee.
11. Forestry Unit, Autauga County.
12. Prattville Experiment Field, Prattville.
13. Black Belt Substation, Marion Junction.
14. Tuskegee Experiment Field, Tuskegee.
15. Lower Coastal Plain Substation, Camden.
16. Forestry Unit, Barbour County.
17. Monroeville Experiment Field, Monroeville.
18. Wiregrass Substation, Headland.
19. Brewton Experiment Field, Brewton.
20. Ornamental Horticulture Field Station, Spring Hill.
21. Gulf Coast Substation, Fairhope.