On-farm Lime and Fertilizer Experiments with Soybeans and Cotton in Northern Alabama, 1977-1980

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Information contained herein is available to all persons without regard to race, color, sex, or national origin.

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C. H. BURMESTER, A. WAGGONER, and FRED ADAMS[1]

INTRODUCTION

A COOPERATIVE RESEARCH program on lime and fertilizer for soybeans and other crops of the area in northern Alabama began with farmers in 1975. Results of this study over a four-year period (1977-80) are reported in this publication. Counties included in this program are: Cherokee, Colbert, Cullman, DeKalb, Jackson, Lauderdale, Lawrence, Limestone, Madison, Marshall, and Morgan. The purpose of this program is two-fold: (1) to establish up-to-date fertilizer and lime requirements for major crops in the area, particularly cotton and soybeans and (2) to improve Auburn University's soil testing program and service to farmers in the area. This program was initiated because the Alabama Agricultural Experiment Station's substations at Belle Mina and Crossville do not adequately represent the diversity of soils and conditions in this major agricultural area of the State.

In this program, small areas were located on farmers' fields that were representative of soil types for the region. These areas were divided into 8, 12, 16, 20, or 24 plots, depending upon the number of liming or fertilizer treatments. Each lime or fertilizer rate was repeated four times at each location. These experimental areas received no special attention other

[1]Research Associate, former Research Associate, and Professor, respectively, Department of Agronomy and Soils.

than the lime or fertilizer treatments, which were applied by the researcher. Each farmer followed his other normal practices of land preparation, planting, cultivation, and control of weeds, diseases, and insects. Cotton plots consisted of six 35-foot rows and soybean plots consisted of eight 100-foot rows. Cotton plots were harvested by hand while soybeans were machine combined.

The soil areas covered in this program include the fine-textured soils of the Tennessee Valley, the silty soils of the Highland Rim area north of the Tennessee River, the loamy soils on stream terraces, and the sandy soils of the Appalachian Plateau south of the River. The dark red soils of the Tennessee Valley, such as Decatur and Dewey, are used primarily to grow cotton and are often referred to as "red lands". The Highland Rim soils are locally called "gray land", and very little soil fertility research has been done on them prior to this program. The sandy soils of the Appalachian Plateau, with proper management, can be highly productive. Crops grown on these soils have responded to higher rates of fertilizer than crops on most other soils.

Besides the use of these experiments to gather soil testing information, these experiments help individual farmers make decisions about correct liming and fertilization of their fields. Many of these experiments were also visited by groups of farmers on county tours in which they served as an excellent educational tool.

LIME EXPERIMENTS WITH SOYBEANS

A total of 39 lime experiments with soybeans was harvested during the 4 years between 1977-80, table 1. Fifteen of these experiments were located on Highland Rim soils, 12 on Tennessee Valley soils and 12 on Appalachian Plateau soils. No yield response to liming was found on the Highland Rim or Tennessee Valley soils above pH 5.4. Yields were not increased by liming above pH 5.5 on the Appalachian Plateau soils. The Dickson soil on the Highland Rim and the Wynnville soil on the Appalachian Plateau were the soil series most often used. Both of these soils typically have a fragipan (or hardpan) within 2 feet of the surface.

The greatest yield response to liming in individual tests was 9 bushels per acre on Highland Rim soils, 22 bushels on Tennessee Valley soils, and 12 bushels on Appalachian Plateau soils.

TABLE 1. EFFECT OF LIME ON SOYBEAN YIELD, 1977-80

Farmer	County	Soil type	Soil group[1]	Unlimed soil pH	Per-acre yield Unlimed	Per-acre yield Limed
					Bu.	*Bu.*
		Highland Rim soils				
W. Darby	Lauderdale	Dickson silt loam	2	4.4	12.5	16.8[2]
K. Winter	Lauderdale	Dickson silt loam	2	4.5	7.3	11.3[2]
K. Winter	Lauderdale	Dickson silt loam	2	4.6	6.5	10.8[2]
J. Williams	Limestone	Dickson silt loam	2	4.9	26.9	29.7[2]
S. Usery	Limestone	Taft silt loam	2	4.9	11.2	16.0[2]
B. Rose	Limestone	Armour silt loam	2	4.9	19.0	24.1[2]
Tenn. Valley Substation	Limestone	Fullerton cherty silt loam	2	5.0	28.0	27.7
J. B. Williams	Limestone	Dickson silt loam	2	5.0	31.1	34.0
N. Collier	Lauderdale	Mountview cherty silt loam	2	5.2	25.8	26.7
H. Liles	Lawrence	Dickson silt loam	2	5.3	42.3	46.1[2]
S. Menefee	Limestone	Dickson silt loam	2	5.4	15.1	15.8
J. Paulk	Limestone	Bewleyville silt loam	2	5.4	21.0	28.1
A. D. Peters	Lauderdale	Bewleyville silt loam	2	5.4	17.7	26.3[2]
E. Jones	Limestone	Dickson silt loam	2	5.5	32.0	33.4
G. Thacker	Lauderdale	Dickson silt loam	2	5.6	44.5	46.1
		Tenn. Valley soils				
J. Eckl	Lauderdale	Etowah silt loam	2	4.7	14.5	18.1[2]
L. Smith	Lawrence	Tupelo silty clay loam	5	5.0	10.4	32.9[2]
R. Tumlin	DeKalb	Etowah loam	2	5.1	65.8	68.5
B. James	Colbert	Etowah-Emory	2	5.2	35.8	52.2[2]
J. Kennamer	Marshall	Allen loam	2	5.2	30.5	42.8[2]
J. White	Morgan	Emory silt loam	2	5.2	13.4	18.6[2]
C. Newton	Lauderdale	Pruitton silt loam	2	5.2	9.6	12.1[2]
Tenn. Valley Substation	Limestone	Pruitton silt loam	2	5.3	38.8	40.6
J. D. Johnson	Colbert	Remlap silt loam	5	5.4	39.0	44.1[2]
D. Wall	Madison	Dewey silt loam	2	5.7	46.8	47.6
B. Douglas	Madison	Emory silt loam	2	5.8	22.8	24.6
C. Turney	Morgan	Nauvoo silt loam	2	5.8	42.4	44.6
		Appalachian Plateau soils				
T. Connor	Marshall	Wynnville sandy loam	2	4.7	30.6	42.6[2]
T. Grantland	Morgan	Wynnville sandy loam	2	4.7	15.3	19.1[2]
T. Grantland	Morgan	Wynnville sandy loam	2	4.7	35.5	42.1[2]
J. Groves	Marshall	Wynnville sandy loam	2	4.8	24.2	27.7[2]
L. Miller	Marshall	Wynnville sandy loam	2	5.1	29.0	40.7[2]
D. Miller	Morgan	Wynnville sandy loam	2	5.3	32.0	39.8[2]
R. O'Tinger	DeKalb	Wynnville sandy loam	2	5.4	35.9	54.3[2]
R. Tumlin	DeKalb	Wynnville sandy loam	2	5.5	62.2	65.3[2]
L. Hill	Morgan	Wynnville sandy loam	2	5.7	35.1	36.5
C. Herefurth	Cullman	Hartsell sandy loam	2	5.8	29.8	28.3
J. Precise	Jackson	Hartsell sandy loam	2	5.8	25.6	26.3
J. Graves	Marshall	Wynnville sandy loam	2	6.2	29.8	29.7

[1]Based on soil texture and cation-exchange capacity as classified by Auburn's Soil Testing Laboratory.
[2]Yield is statistically greater on limed plots.

In a previous report, Mitchell et al. (1) reported the results of lime experiments on soybeans for the first 2 years of the project, 1975-76. Those results are combined with the 1977-80 results and graphed in figure 1 to show the relationship between soil pH and the yield response to liming.

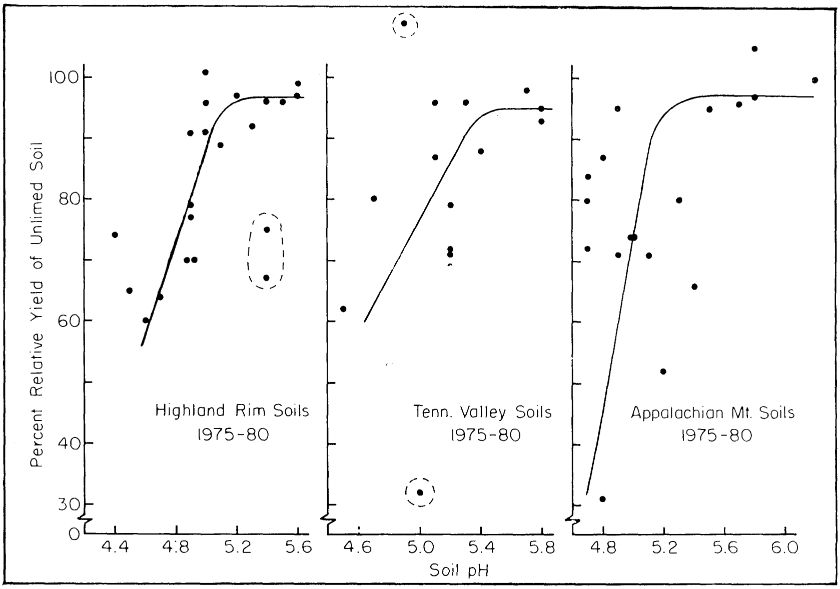

FIG. 1. Effect of soil pH on response of soybeans to liming soils on farmers' fields in northern Alabama, 1975-1980.

The soil pH below which a yield response to liming is expected is called the "critical" pH. The critical pH for liming Highland Rim soils for soybeans appears to be about 5.2. There were two exceptions; both were on Bewleyville silt loam at pH 5.4, where liming increased yield about 50 percent (the data points are circled on the graph).

The critical pH for liming Tennessee Valley soils for soybeans appears to be about 5.4. There were two major exceptions (both are circled on the graph); one was at pH 4.9 where liming failed to increase yield (Dewey silt loam); the other was at pH 5.0 where liming increased yield three-fold (Tupelo silty clay loam).

The critical pH for liming Appalachian Plateau soils for soybeans is about 5.4. However, there is considerable variation in the data, just as there is with data from the other soil areas. One reason for much of the variation on Appalachian Plateau soils is probably due to differences in depth to the fragipan of the Wynnville soil.

An interesting finding in these lime experiments was that soybeans in many of the unlimed plots appeared to be suffering from a nitrogen deficiency. In several tests, soybean leaves were noticeably yellow in plots that received no lime. Apparently, low pH was affecting the plant's ability to "fix" nitrogen. At this time, it is speculated that the nitrogen deficiency was actually caused by molybdenum deficiency as a result of low soil pH. The availability of soil molybdenum is increased by liming. Since molybdenum is an essential element for the nitrogen-fixing bacteria, it is possible that not enough is available at low pH values. However, further research will be done to verify the causative agent for this apparent nitrogen deficiency.

FERTILIZER EXPERIMENTS WITH SOYBEANS

Eight experiments were harvested in which phosphorus (P) fertilizer was applied broadcast prior to planting soybeans, table 2. Two experiments also had plots with and without potassium (K) fertilizer (the Carpenter and Ellis farms). Two experiments were located on Highland Rim soils, two on Appalachian Plateau soils, and four on Tennessee Valley soils. Three of the experiments showed a yield response to phosphorus fertilizer. None showed a response to potassium fertilizer; all soils were *medium* or *high* in soil K.

A Wynnville sandy loam (D. Ellis farm), with a soil fertility P index of only 20 VL, showed a 13-bushel yield increase to P fertilizer, while a Locust loam (C. Turney farm), with a similar P index but a greater drought stress, showed only a 6-bushel increase. A test on L. Ritter's farm in Lauderdale County, which had a soil fertility P index of 60L, produced a 3.5-bushel increase. A test on T. Buckelew's farm in Marshall County did not respond to phosphorus fertilizer even though the soil fertility P index was only 40 VL. Drought during pod-filling may have been the reason for this "no" response.

LIME EXPERIMENTS WITH COTTON

Twenty-five lime experiments with cotton were harvested between 1977-80, table 3. Eighteen of these experiments were harvested on Limestone Valleys and upland soils, four on upland stream, and three on terrace soils. No response to liming was found on the Decatur or Dewey series (Tennessee Valley soils) above a pH of 5.1. Liming a Colbert silt loam with a pH of 5.2 (the Lamon farm) produced a 160-pound-per-acre increase in seed-cotton. Liming also increased yields on two Highland Rim soils. One was a Dickson loam with a pH of 4.7 (the Isbell farm) and the other was a Bewleyville silt loam with a pH of 5.3 (the Hays farm).

TABLE 2. EFFECT OF PHOSPHORUS AND POTASSIUM FERTILIZER ON SOYBEAN YIELD, 1977-1980

					Soil-test values								
					P		K		Fert. rate		Per-acre yield		
Farmer	County	Soil type	Soil group[1]	pH	Lb./A.	Rating	Lb./A.	Rating	P_2O_5	K_2O	No. P	No K	Fert.
									Lb./A.	*Lb./A.*	*Bu.*	*Bu.*	*Bu.*
		Highland Rim soils											
L. Ritter	Lauderdale	Dickson silt loam	2	4.9	17	60 L	93	80 M	80	0	29.5	—	33.0[2]
B. S. Tomlinson	Lauderdale	Mountview silt loam	5	5.7	14	70 L	140	80 M	40	0	33.1	—	33.6
		Tennessee Valley soils											
D. Carpenter	Colbert	Etowah silt loam	2	5.6	34	80 M	217	120 H	120	60	14.5	14.5	14.5
Tenn. Valley Substation	Limestone	Pruitton silt loam	2	5.3	24	70 L	223	120 H	80	0	40.8	—	40.0
S. Spruell	Lawrence	Decatur silt loam	5	6.9	13	60 L	159	100 H	40	0	33.3	—	36.5
C. Turney	Morgan	Locust loam	2	5.5	4	20 VL	96	80 M	120	80	13.5	—	18.8[2]
		Appalachian Plateau soils											
D. Ellis	Marshall	Wynnville sandy loam	2	5.8	4	20 VL	71	70 M	120	120	26.2	26.2	39.0[2]
T. Buckelew	Marshall	Wynnville sandy loam	2	5.1	10	40 VL	113	80 M	60	0	19.0	—	19.0

[1]All fertilizer broadcast prior to planting.
[2]Yield is statistically greater on fertilized plots.

TABLE 3. EFFECT OF LIME ON YIELD OF SEED-COTTON, 1977-80

Farmer	County	Soil type	Soil group[1]	Un-limed soil pH	Per-acre yield	
					Un-limed	Limed
					Lb.	*Lb.*
		Tennessee Valley soils				
A. Bragg	Madison	Dewey-Dickson	2	4.7	2,480	2,990[2]
M.W. Haney	Limestone	Decatur silty clay loam	5	4.8	670	1,160[2]
B. Stewart	Limestone	Decatur silt loam	5	4.9	1,530	1,820[2]
B. Minor	Colbert	Decatur silt loam	5	5.0	1,190	1,460[2]
E. Sears	Lawrence	Decatur silt loam	2	5.0	980	1,190[2]
B. Stewart	Madison	Decatur silt loam	5	5.0	2,500	2,500
S. Jones	Lawrence	Decatur silt loam	2	5.1	1,830	1,770
M. Tate	Madison	Dewey silt loam	2	5.1	2,730	3,100[2]
D.C. Thornton	Lauderdale	Decatur silt loam	2	5.1	1,880	2,380[2]
J. Minor	Lauderdale	Etowah silt loam	5	5.2	1,170	1,440
R.&D. Lamon	Lawrence	Colbert silt loam	2	5.2	750	910[2]
J.D. Underwood	Colbert	Decatur silt loam	5	5.3	920	860
H. Aday	Colbert	Etowah silt loam	5	5.3	810	710
M. Davis	Madison	Decatur silt loam	5	5.4	720	700
W. Johnson	Madison	Decatur silt loam	5	5.5	1,840	1,880
J. Patterson	Madison	Decatur silt loam	5	5.5	1,760	1,850
D. Entrekin	Colbert	Dewey silt loam	5	5.7	1,940	1,920
O. Johnson	Limestone	Decatur silt loam	5	6.1	1,700	1,910
		Highland Rim soils				
H. Isbell	Colbert	Dickson loam	2	4.7	930	1,250[2]
F. Hays	Limestone	Bewleyville silt loam	2	5.3	1,800	2,130[2]
D. Martin	Madison	Mountview silt loam	2	5.9	1,320	1,250
D. Newbern	Lauderdale	Bewleyville silt loam	2	5.9	2,110	1,920
		Stream Terrace soils				
C.R. Hotchkiss	Lawrence	Locust sandy loam	2	5.4	1,680	1,920
H. Chandler	Cherokee	Holston sandy loam	2	6.1	2,680	2,560
C.R. Hotchkiss	Lawrence	Locust sandy loam	2	6.5	2,080	2,090

[1]Based on soil texture and cation-exchange capacity as classified by Auburn's Soil Testing Laboratory.

[2]Yield is statistically greater on limed plots.

These experiments showed that cotton was fairly tolerant to low pH on these soils. Yields were not reduced unless the pH was near 5.2 or less; however, yields were often drastically reduced if soil pH was less than 5.0.

In a previous report, Mitchell et al. (1) reported the results of five liming experiments with cotton on Tennessee Valley soils and one each on Highland Rim and stream terrace soils. Results from those five Tennessee Valley soils are combined with the 18 in this report and graphed in figure 2. There is quite a bit of variation in the response of cotton to liming from site to site even when they have about equal pH levels. Nevertheless, it appears that soil pH will be less than 5.3 before a yield response to liming can be expected.

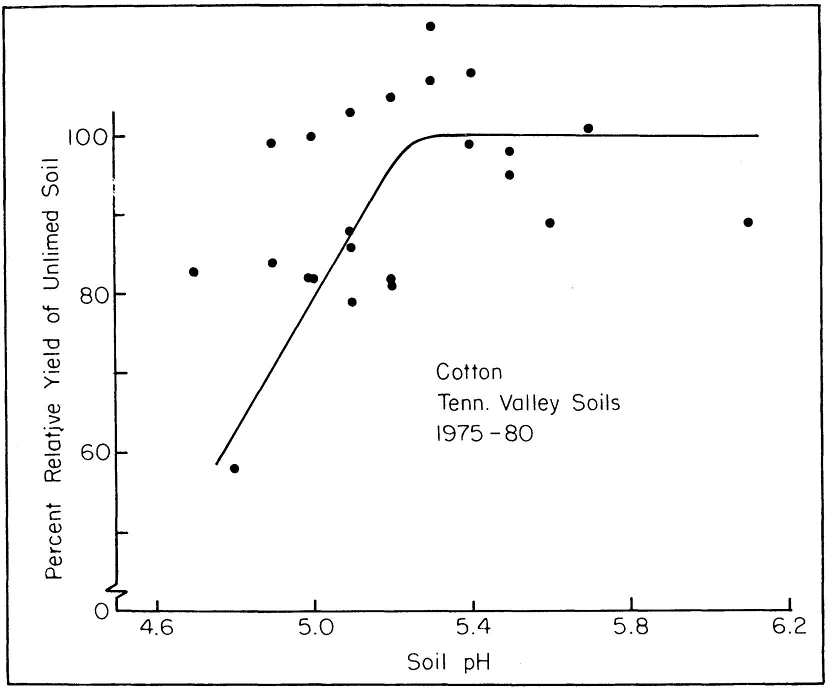

FIG. 2. Effect of soil pH on response of cotton to liming soils on farmers' fields in the Tennessee Valley, 1975-1980.

NITROGEN RATE EXPERIMENTS WITH COTTON

Nine experiments were harvested to determine the optimum nitrogen rate needed for cotton, table 4. All nitrogen rates were broadcast before planting as ammonium nitrate. The surprising thing about these studies was the lack of response to nitrogen fertilizer. No yield increase was seen in any experiment from more than 30 pounds per acre of nitrogen. In one test (R. G. Preuit's farm), more than 30 pounds per acre of nitrogen actually decreased yields. Four experiments were conducted in which a "O" rate treatment was used. In three of these experiments, the "O" treatment produced as much cotton as any of the nitrogen rates.

This lack of response to nitrogen fertilizer is apparently the result of a buildup of available soil nitrogen, probably caused by cotton being grown year after year on the same land with high rates of nitrogen fertilizer.

In a previous report, Mitchell et al. (1) reported on the yield response of cotton to nitrogen rates in four experiments. Those

TABLE 4. EFFECT OF NITROGEN RATE ON SEED-COTTON YIELD IN THE TENNESSEE VALLEY, 1977-80

Farmer	County	Soil type	Soil group	Per-acre yield at different N rates (Lb./A.)* 0	30	60	90	120
				Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
J. Syler	Colbert	Ellisville silt loam	5	—	2,270 a	2,240 a	2,040 a	2,040 a
G.E. Barringer	Lauderdale	Etowah silt loam	5	—	1,720 a	1,870 a	1,780 a	1,610 a
R.G. Preuit	Colbert	Decatur silt loam	2	—	1,290 a	890 b	1,000 b	1,000 b
S. Martin	Lawrence	Decatur silt loam	2	—	2,060 a	2,090 a	2,250 a	2,240 a
D. Newbern	Lauderdale	Bewleyville silt loam	2	—	2,320 a	2,370 a	2,090 a	2,250 a
S. Martin**	Lawrence	Decatur silt loam	2	1,550 d	1,980 cd	2,070 bcd	2,080 bc	2,220 a
D. Newbern**	Lauderdale	Bewleyville silt loam	2	1,800 a	1,800 a	1,840 a	1,850 a	1,840 a
S. Harris	Madison	Decatur silt loam	2	2,220 a	2,370 a	2,310 a	2,500 a	—
H. Isbell	Colbert	Decatur silt loam	5	2,130 a	1,950 a	1,990 a	—	—

* Any yield in the same row with a letter in common is not significantly different at the 10% level of probability.
** These tests were located on the same site as the previous year.

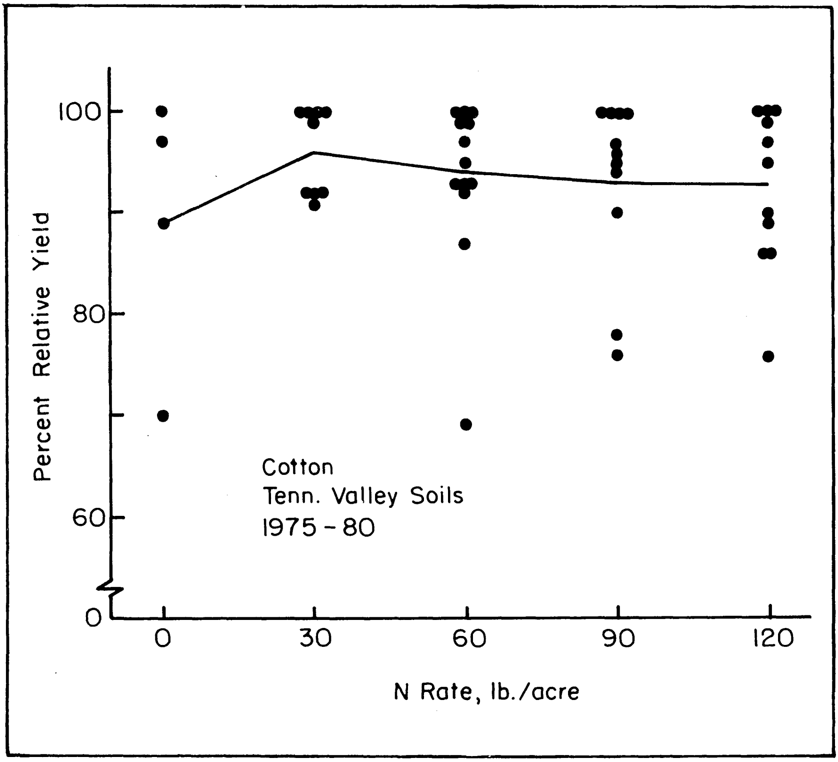

FIG. 3. Effect of nitrogen (N) rate on yield of seed cotton in experiments on farmers' fields in the Tennessee Valley, 1975-1980.

results are combined with those in table 4 and graphed in figure 3. In each experiment, the highest yielding N rate was assigned a relative yield of 100 percent. The yield of each N rate was then divided by the highest yield and multiplied by 100 to give the relative yield at each N rate. The data clearly show that most soils were well supplied with available nitrogen and very little fertilizer nitrogen was needed for maximum yields to be realized.

During 1978-80 cotton petioles were sampled in these test plots to determine if petiole sampling was a feasible way to monitor the nitrogen being supplied to the cotton plant. (This practice has been tested in other states in an effort to monitor the nitrogen requirement of cotton grown under irrigation.) Under the dry-land cotton growing conditions of Alabama, it was found to be too erratic and unpredictable to be of any value. Fluctuation of the nitrogen content in the cotton petioles during droughts and after heavy rains was too great. Because of this fluctuation, no critical levels could be set.

A new method of soil-nitrogen analysis was begun in 1980. All plots in each test were soil sampled to a depth of 2 feet before fertilizing. The object of these tests will be to try to calibrate yield to these soil-nitrogen values. However, several more years of research will be needed before any conclusions can be reached.

PHOSPHORUS AND POTASSIUM EXPERIMENTS WITH COTTON

Four experiments were conducted with P, K, or P and K fertilizer on cotton, table 5. All soils tested *high* in P, and three tested *high* in K. None showed a yield response to P or K fertilizer.

TABLE 5. EFFECT OF PHOSPHORUS AND POTASSIUM FERTILIZER ON SEED-COTTON YIELD, 1979-1980

			Soil-test values										
					P		K		Fert. rate		Per-acre yield[2]		
Farmer	County	Soil type[1]	Soil group	pH	Lb./A.	Rating	Lb./A.	Rating	P_2O_5	K_2O	No P	No K	Fert
									Lb./A.	*Lb./A.*	*Lb.*	*Lb.*	*Lb.*
W.J. Lee, III	Lawrence	Dewey silt loam	5	6.1	31	110 H	144	80 M	0	60	—	2,020	2,090
Burgreen Bro.	Madison	Dewey silt loam	5	5.5	54	180 H	261	110 H	100	0	2,460	—	2,680
H. Summerville	Pickens	Orangeburg sandy loam	2	6.3	67	140 H	211	120H	60	60	840	730	790
H. Summerville	Pickens	Orangeburg loamy sand	1	5.8	90	180 H	145	120 H	60	60	2,800	2,780	2,850

[1]Dewey is a Tennessee Valley soil. Orangeburg is a Coastal Plain soil.
[2]Yield was not affected by fertilizer in any experiment.

LITERATURE CITED

(1) Mitchell, C. C., S. M. Eich, and F. Adams. 1977. On-farm lime and fertilizer experiments with soybeans and cotton in northern Alabama, 1975-1976. Alabama Agr. Exp. Sta. Prog. Rpt. 110.

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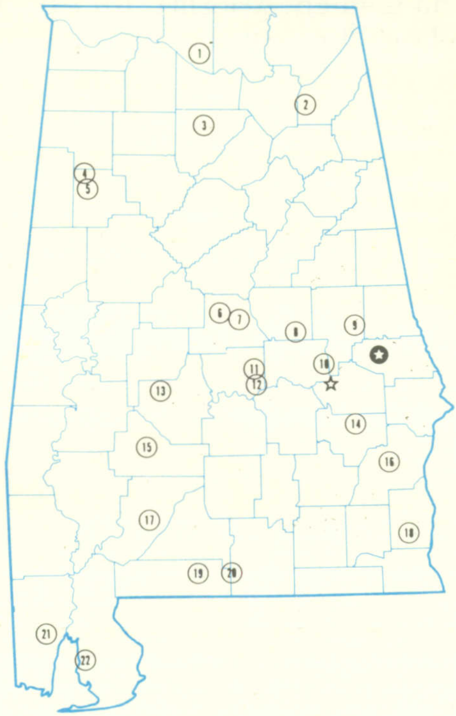
With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the State has a stake in this research program, since any advantage from new and more economical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



Research Unit Identification

⊛ Main Agricultural Experiment Station, Auburn.
☆ E. V. Smith Research Center, Shorter.

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. 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. The Turnipseed-Ikenberry Place, Union Springs.
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. Solon Dixon Forestry Education Center, Covington and Escambia counties.
21. Ornamental Horticulture Field Station, Spring Hill.
22. Gulf Coast Substation, Fairhope.