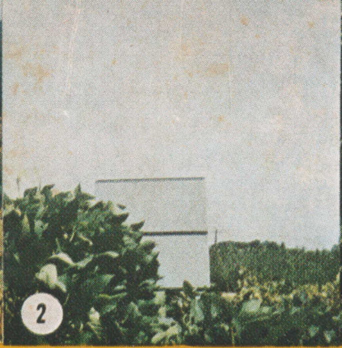

SOYBEAN PRODUCTION—
Recent Research Findings

BULLETIN 413 MAY 1971

AGRICULTURAL EXPERIMENT STATION/AUBURN UNIVERSITY

E. V. Smith, *Director* Auburn, Alabama

COVER PHOTOS

1. Good land use on Lipscomb Stone and Son farm in Jackson County. Soybeans on valley soils, Coastal bermudagrass pasture on more rolling lands, and forest on the steep slopes.

2. Response to lime on Norfolk sandy loam. Left, soil pH 6.0. Right, pH 5.0.

3. Response to potassium on Norfolk sandy loam.

4. Podworm at work. Soybean's number one insect enemy.

5. Moisture stress on soybeans caused by subsoil compaction on Lakeland sand. Left, compacted (300 psi); right, no compaction. Rainfall: August 15-September 15 was 0.44 inch. Photographed September 12.

6. Row spacing experiment. Close rows give early ground coverage and better weed control.

7. Good stand of soybeans obtained with no-tillage planter on small grain residue.

8. Postemergence control of sicklepod in soybeans.

ACKNOWLEDGMENTS

Credit is gladly given for assistance in obtaining much of the yield data reported in this bulletin to personnel on the Black Belt, Gulf Coast, Lower Coastal Plain, Sand Mountain, Tennessee Valley, and Wiregrass substations; Brewton, Monroeville and Prattville experiment fields; Plant Breeding Unit; and Foundation Seed Stocks Farm. Recognition is also given for cooperation of the Soil and Water Conservation Division of ARS, USDA in the soil compaction and irrigation studies.

CONCLUSIONS

Based on research results reported in this bulletin the following conclusions are drawn:

1. Soybeans in Alabama are much more competitive with other areas of the United States than is corn. Three times in the last 15 years Alabama's average yield per acre of soybeans has exceeded the national average.

2. In addition to some of the lands now in other row crops, a potential for considerable expansion of soybean acreage in this State exists primarily on imperfectly drained flood plains along the Tennessee River and its tributaries in northern Alabama, bottomlands and low terraces in central and southern parts of the State, and poorly-drained Coastal Plain soils of extreme southern Alabama.

3. Water is vital during podfilling of soybeans. Other production factors are important but the true yield barrier generally is lack of water during the 5-week period, August 15 to September 20, for central Alabama. Supplemental irrigation appears promising, especially where the same source of water and equipment can be used on cotton and soybeans. The critical time for soybean irrigation frequently is later in the season than for cotton.

4. Compacted subsoils severely restrict soybean root development on many Alabama soils and when this condition exists it is a major factor in reducing available soil moisture.

5. For maximum production over an extended harvest period select varieties by the following planting date and maturity group schedule:

Location	Planting date	Varieties and maturity groups
Northern Alabama	May 1-31	York, Dare (V); Lee, Hood, Davis (VI); Bragg (VII)
	June 1-15	Lee, Hood, Davis (VI)
Central Alabama	May 5-25	Lee, Hood, Davis (VI); Bragg (VII); Hampton 266A (VIII)
	May 26-June 15	Bragg (VII); Hampton 266A (VIII)
	June 16-July 5	Hampton 266A (VIII)
Southern Alabama	May 15-June 5	Davis (VI); Bragg (VII); Hampton 266A (VIII)
	June 6-15	Bragg (VII); Hampton 266A (VIII)

6. Plant soybeans in as narrow rows as weed and insect control practices will permit. Late planted beans, especially, will yield better if planted in rows not over 30 inches apart.

7. Burning small grain straw before planting soybeans did not reduce yields. However, suitable equipment is available for shredding large amounts of straw so that it can be handled satisfactorily in planting and cultivating a bean crop after small grain is harvested.

8. No-tillage planting of soybeans in small grain stubble and straw, using herbicides to control weeds, is in the experimental stage for Alabama conditions.

9. A subsoiler-planter has been used successfully after small grain harvest on sandy loam soils. Yields with this mulch planting system compared favorably with conventional plow-plant methods.

10. Yield increases from the use of the growth regulator TIBA have not been large enough to offset cost of the required rates of application.

11. Although response to lime has varied on different soils at a given pH, most soils below pH 5.8 need lime for soybeans. The amount of lime needed to correct a low soil pH can be determined in the laboratory by a lime requirement soil test.

12. Molybdenum is not needed for soybeans on soils limed at the recommended rate.

13. Although commercial nitrogen frequently produces greener foliage, and on new lands more vigorous early growth, it has not increased yields when soybeans are inoculated.

14. Phosphorus (P) and potassium (K) fertilizers added directly for soybeans should be broadcast. Soils testing "low" in P or K gave satisfactory increases for additions of these elements. In rotations, enough P and K should be applied to the other crop, or crops, in the sequence to maintain these elements in the soil at a level sufficient for beans and the other crops.

15. Annual grass weeds and most small-seeded broadleaf weeds can be satisfactorily controlled in soybeans with herbicides presently available. Large-seeded broadleaf weeds such as cocklebur, morningglory and sicklepod (coffeeweed) present the major weed problem in this crop. Other broadleaf weeds such as prickly sida (tea- or ironweed), Florida beggarweed and the pigweeds are

problems in soybeans in certain areas. Postemergence herbicide treatments offer the most promise for control of these species.

16. Soybean diseases can be expected to increase with increased acreages. Good sanitation practices and resistant varieties offer practical means of control.

17. Cutworms can be controlled with trichlorfon as a bait. The lesser cornstalk borer is not adequately controlled by any materials currently labeled for use on soybeans. Control of the corn earworm (podworm) should be started when one worm per foot of row is found. The stinkbug, another serious pod-damaging insect, can be controlled with insecticides currently labeled for use on soybeans.

18. Suitable crops to rotate with soybeans present a major problem to many Alabama growers. Double-cropping soybeans after small grains in rotation with corn yielded as well as full-season beans at four of five locations in short term experiments. However, full season beans generally will produce higher yields because they offer more flexibility in planting with good soil moisture and reducing the weed and insect problems.

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SOYBEAN PRODUCTION—RECENT RESEARCH FINDINGS

INTRODUCTION

HOWARD T. ROGERS[1]

"THE PLANT IS VALUABLE for man and stock and the results of experiments at Auburn show that it can be easily grown in Alabama . . . ", thus reported Mell *(17)* of the Alabama Agricultural Experiment Station in 1895, referring to the soybean. His was some of the first research conducted on soybeans in the United States, in which he compared varieties of "foreign seeds" in Alabama.

Although considered, until recent years, to be primarily a Corn Belt crop, the first U.S. grown beans were processed by The Elizabeth City Oil and Fertilzer Company in North Carolina. For years Baldwin County, Alabama, was reported to plant the highest percentage of its cropland in beans of any county in the United States. It was introduced as a "grain" crop in Jackson County in the late thirties.

PRESENT STATUS

The estimated harvested acreage in Alabama in 1970 was 609,000, exceeding both cotton and corn. As shown by Figure 1 this acreage is concentrated in the southwestern, Black Belt, and Tennessee Valley counties plus about 25,000 acres in the Coosa Valley in Talladega County. A significant increase in the last 2 years has taken place in several counties in southern Alabama bordering Florida.

With highly disappointing corn yields for at least 3 years in central and southern Alabama, and declining cotton and corn acreages for many years, farmers are looking for a replacement cash crop. Others need a substitute crop for corn and are using small grain double-cropped with soybeans.

Soybeans in Alabama are more competitive than corn with other areas of the United States as shown in Figure 2. In fact, three times in the last 15 years, Alabama's average per-acre soybean yield has exceeded the national average. This relative com-

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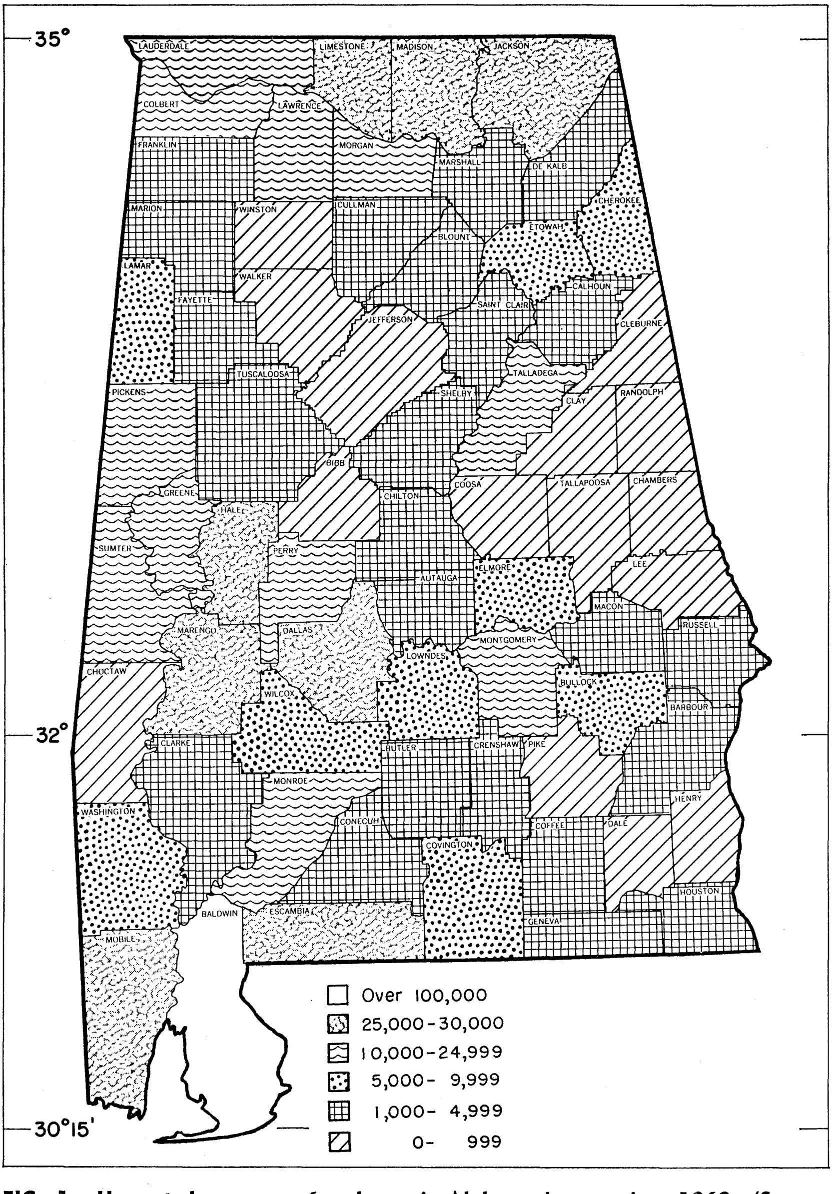

FIG. 1. Harvested acreages of soybeans in Alabama by counties. 1969. (Source: Preliminary estimates by Alabama-USDA Cooperative Crop and Livestock Reporting Service.)

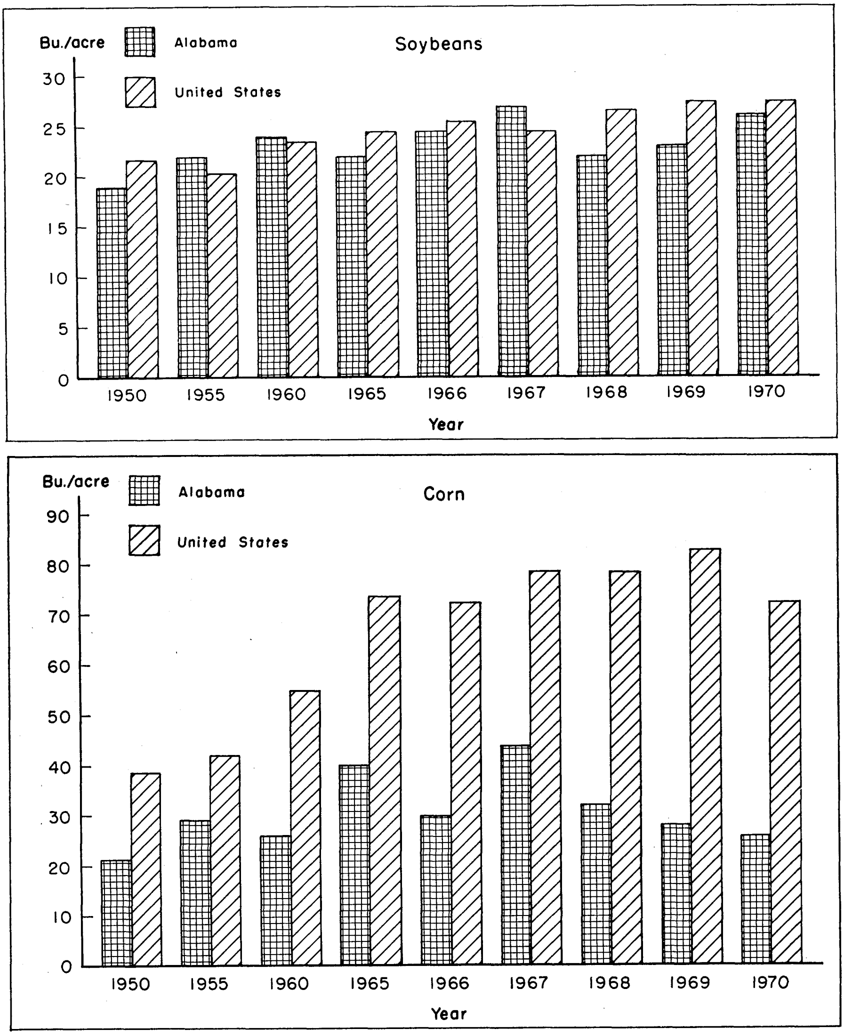

FIG. 2. Soybean and corn yields per acre in Alabama compared with U.S. (Source: Alabama-USDA Cooperative Crop and Livestock Reporting Service.)

petitive efficiency of production probably will be reflected in further increases in acreage unless the crop is put under acreage control. Increased production will depend on beans being planted on lands adapted to the crop and certain cultural problems being solved by research and practices accepted by growers.

The soybean is a versatile plant, being grown from southern Canada to Mexico. Estimated production in Mexico has ranged between 150,000 and 300,000 metric tons in recent years and the acreage there is expected to increase 25 to 35 per cent annually for the next 5 years. In spite of the wide range of soil and climate under which the crop is produced, it responds quite differently to management within the environment existing where beans are grown in the United States. For this reason generalized statements on production practices should be avoided.

This bulletin reports recent research findings in Alabama on soybean production practices. It will not cover the crop as broadly in scope as did Bulletin 373 *(3)* issued in 1967 by this Station, but will present more conclusive information on certain practices discussed in Circular 136 *(22)*, published in 1961.

SITE SELECTION AND IMPORTANCE OF WATER

HOWARD T. ROGERS

SITE SELECTION, rainfall distribution, irrigation, and subsoil compaction affect water availability during critical stages of the soybean plant development.

SITE SELECTION

It has been said that soil, which will produce good cotton or corn, will produce soybeans. This is misleading. Soybeans are not as drought tolerant as cotton, especially during the fruiting period. They also have a peak moisture requirement later than corn under Alabama conditions. The moisture demands of any crop obviously affect the selection of soils suitable for that crop.

The potential for considerable expansion of soybean acreage in this State exists primarily on the following lands: (1) imperfectly drained flood plains and overflow lands along the Tennessee

FIG. 3. Good land use as shown by soybeans on bottom land along the Tallapoosa River in central Alabama. Note drainage ditch on left.

FIG. 4. Poorly drained Lower Coastal Plain soils of the Craven-Dunbar-Bladen Association. Above, area in native vegetation of wiregrass and sparse stand of pines. Below, similar soils in soybeans. (Courtesy of Soil Conervation Service, USDA.)

River and its tributaries, (2) relatively level uplands with restricted internal drainage in northern Alabama, (3) bottomlands and low terraces along the rivers and smaller streams in central and southern Alabama, and, (4) nearly level, poorly-drained Coastal Plain soils of extreme southern Alabama. Much of this acreage is not well-adapted to corn and cotton. Cover Photo 1 and Figures 3 and 4 show representative landscapes of some of these land types.

Table 1 shows the comparative yields of soybeans on bottomlands and upland soils in central Alabama. In these maximum

TABLE 1. SOYBEAN YIELDS ON UPLAND AND BOTTOMLAND SOILS IN CENTRAL ALABAMA (MAXIMUM YIELD TESTS)

Location	Soil	Yields of soybeans per acre, bushels							
		1963	1964	1965	1966	1967[1]	1968	1969	7-Yr. av.
Auburn	Light-textured upland	21	34	17	44	45	23	32	31
Prattville	Medium-textured upland	14	27	27	24	48	42	22	29
Tallassee	Medium-textured bottomland	36	53	41	41	52	22	46	42

[1] Adequate rainfall at all locations in 1967.

yield tests all practices known to favor high yields, except supplemental irrigation, were followed. The bottomland soil at Tallassee produced 40 per cent more beans than upland soils at other locations as a 7-year average.

RAINFALL DISTRIBUTION

Published rainfall charts *(11)* show clearly one reason why soybean production in Alabama was concentrated in the extreme southwestern counties for many years. The average daily rainfall for this region during the last 20 days of August and first 20 days of September is approximately 0.2 inch, whereas upstate

TABLE 2. MAXIMUM AND AVERAGE YIELDS OF SOYBEANS AS RELATED TO RAINFALL, EIGHT LOCATIONS, 1963-69

Location and soil class[1]	High yield year		1963-69 Average	
	Yield	Rainfall[2]	Yield	Rainfall[2]
	Bu.	*In.*	*Bu.*	*In.*
Alexandria Field, cl.	48	7.8	30[3]	4.3[3]
Agronomy Farm, Auburn, sl.	45	10.5	31	4.1
Brewton Field, sl.	46	4.7	36	3.4
Monroeville Field, sl.	40	7.1	27	3.0
Prattville Field, sl.	48	6.7	29	3.3
Sand Mountain Substation, Crossville, fsl.	52	6.3	34	3.9
Plant Breeding Unit, Tallassee, fsl.	53	3.7	42	3.7
Wiregrass Substation, Headland, sl.	39	7.8	27[4]	3.5[4]
Average	46	6.8	32	3.7
Increase over average, pct.	44	84		

[1] Abbreviations: cl = clay loam; sl = sandy loam; fsl = fine sandy loam.
[2] Rainfall during the period August 20 to September 20.
[3] Average for 6 years only.
[4] Average for 5 years only.

the average for this period is between 0.1 and 0.15 inch. Anyone growing soybeans, or contemplating starting production of this crop should study these long-term rainfall distribution charts.

Water is vital during podfilling of soybeans. Alabama's all-time record yield of 27 bushesl per acre in 1967 was next to the highest state average ever made in the Southeast. The reason was adequate rainfall during the critical period of pod development and filling. Other production factors are important but the true yield barrier generally is lack of water at this critical time. In a maximum yield test at eight locations over the State, soybean yields averaged 44 per cent higher the year of highest rainfall during pod fill (84 per cent more rain) than the average for the 1963-69 period, Table 2. Rainfall distribution may be even more critical in double-cropping systems such as soybeans after wheat for grain. The close relationship between yield and rainfall during late August and early September was shown by a 10-year experiment at Auburn on upland loamy sand *(21)*. Soybeans produced a top yield of 58 bushels per acre in 1967 when 10.5 inches of rain fell between August 20 and September 20. Beans in this test were grown in a 3-year rotation with cotton, corn and wheat or oats for grain.

SUPPLEMENTAL IRRIGATION

Sprinkler and furrow irrigation experiments with soybeans show the importance of timely applications of water. It appears that cotton and soybeans might use the same source of water and equipment on a reasonable-size operation as the critical time for irrigating beans usually will come later in the season than for cotton. An experiment at Auburn, Table 3, showed that in 1968, when only 1.7 inches of rain fell between August 20 and September 20, adding 3 inches of water with sprinklers increased bean yields 14 bushels. This was a 47 per cent increase in soybeans grown after wheat in a 2-year rotation with cotton on a sandy

TABLE 3. RESPONSE OF SOYBEANS TO SPRINKLER IRRIGATION UNDER DIFFERENT RAINFALL SITUATIONS, AUBURN, 1967-69

Year	Moisture		Yields per acre		
	Rainfall, 8/20-9/23	Water applied	Not irrigated	Irrigated	Increase
	In.	*In.*	*Bu.*	*Bu.*	*Pct.*
1967	10.5	1.0	49	50	2
1968	1.7	3.0	30	44	47
1969	8.0	2.3	41	45	10

TABLE 4. RESPONSE OF BRAGG SOYBEANS TO FURROW IRRIGATION, LUCEDALE FINE SANDY LOAM, THORSBY, ALABAMA[1]

Year	Moisture, 8/1-9/30: Rainfall	Water applied[2]: Intermediate	Water applied[2]: High	Bean yields per acre: Not irrigated	Irrigation levels, Actual: Intermediate	Irrigation levels, Actual: High	Irrigation levels, Increases: Intermediate	Irrigation levels, Increases: High
	In.	*In.*	*In.*	*Bu.*	*Bu.*	*Bu.*	*Pct.*	*Pct.*
1968	6.2	3.3	4.9	26	37	38	42	46
1969	8.8	1.8	5.0	32	46	48	44	50

[1] This is a cooperative experiment with Soil and Water Conservation Division of ARS-USDA. The research involves water use, plant populations, variety and row width comparisons, and leaf area and other plant growth indices as affected by levels of irrigation. Detailed analysis of these factors, as well as yields, will be reported when the experiment is terminated.

[2] "Intermediate" and "high" levels of irrigation designate that water was applied when 70 and 30 per cent, respectively of available soil moisture was depleted.

loam. During 1967 and 1969 yields of 41 to 49 bushels per acre were obtained without supplemental water. Two years of the three additional water was not needed.

Increases for furrow irrigation in an experiment on a fine sandy loam at Thorsby ranged between 42 and 50 per cent, Table 4. These results did not indicate a significant response to the high level of irrigation over the intermediate. The low level of irrigation required only 1.8 to 3.3 inches of water to produce 11 and 14 bushels per acre increases in soybean yields. This represents a 43 per cent average increase for the 2 years from irrigation. Other factors, such as lodging, limited top production to 48 bushels per acre.

SUBSOIL COMPACTION

Another important factor affecting water supply for growing soybeans is the depth of rooting and available soil moisture. The effect of compacted subsoils on growth and development of the soybean was studied on both coarse- and medium-textured soils in 1968 and 1969 at Auburn.

In 1968 beans produced only 18 per cent as much on moderately compacted as they did on non-compacted soil. In 1969 the same amount of compaction cut yields approximately one-half. This moderate compaction (penetrometer resistance of 150 p.s.i.) is less than the density of the subsoil frequently encountered in the field in sandy soils. Hendricks and Dumas *(15)* reported a penetrometer resistance of 600 p.s.i. at 2.4-inch depth in the traf-

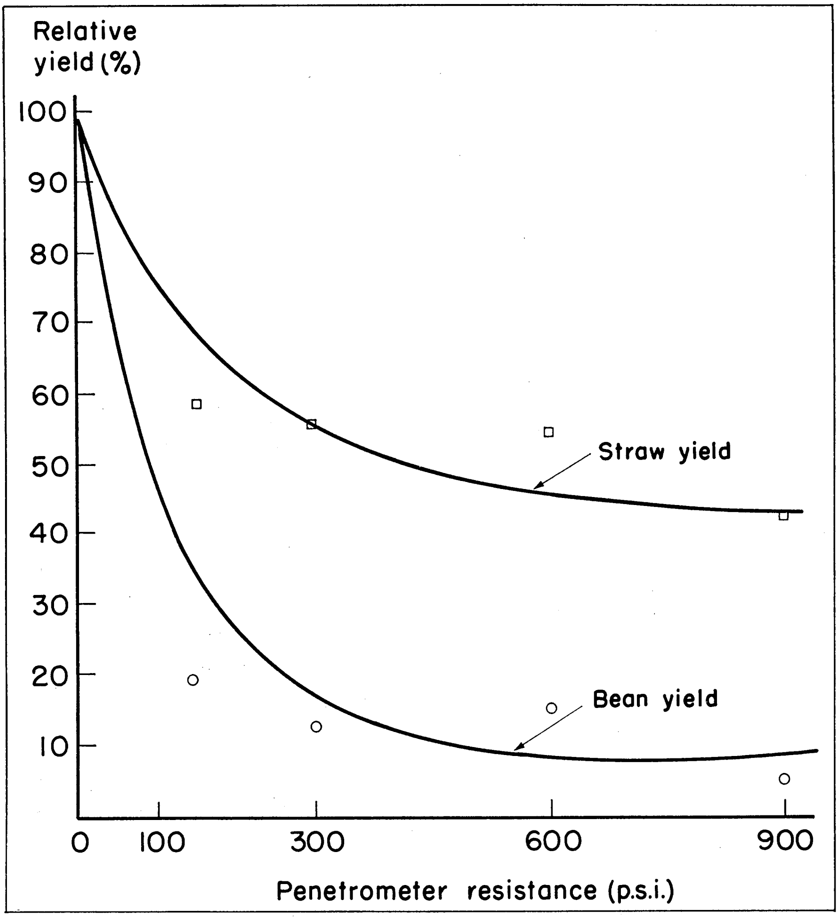

FIG. 5. Effect of subsoil compaction as shown by penetrometer resistance on bean and straw yields (average of 2 soils).

fic furrow between cotton rows on a sandy loam that was turned 12-14 inches deep each year. During the period of full bloom and pod fill rainfall measured 2.1 inches in 1968 and 2.9 inches in 1969. Figure 5 shows severe effects of only light subsoil compaction on bean yields. Also, see Cover Photo 5. Beans on coarse-textured soil (sand) with lower moisture holding capacity suffered much more stress than those on fine sandy loam. The inability of soybean roots to penetrate even moderately compacted soil layers is a more serious problem than is generally recognized, particularly on soils with low moisture holding capacity such as sands and sandy loams *(24)*.

VARIETIES AND DATES OF PLANTING

DONALD L. THURLOW[1]

SOYBEANS are highly photoperiodic and maturity date of a variety does not vary greatly from year to year at a given location. Soybeans grow vegetatively until days shorten to a length critical for each variety, then vegetative growth stops and fruiting begins. For each variety the day length required for flowering is specific. Because of this photoperiod difference, varieties have been divided into maturity groups 00 (early) through VIII (late). The groups V, VI, VII, and VIII are adapted for planting in Alabama. The average critical day length in Group VII is 14½ hours. Varieties in Group V and VI have a longer critical day length, thus flower in mid-summer, and are earlier maturing than Group VII; Group VIII varieties have a shorter critical day length and are later maturing than those of Group VII. When planted late, mid- and late-season varieties (Groups VII and VIII) grow longer and yield more than earlier maturing varieties.

The summer day lengths for southern, central, and northern Alabama are shown in Figure 6. The corresponding degrees latitude are shown on the map, Figure 1, which illustrates the approximate date at which Group VII varieties start flowering in different areas. The maturity of the varieties is shown by Tables 8, 9, and 11, and Figures 7 and 8 for central and northern Alabama. Group V matures by approximately mid-September in southern Alabama as compared to early October in northern Alabama. The maturity of Group VII varieties is October 10-15 and October 17-25 for southern and central Alabama, respectively, and similarly Group VIII varieties mature approximately October 19-28 and October 25 to November 5 in southern and central Alabama, respectively.

Because soybeans varietal performance changes with latitude, time of planting and soil type, it has been necessary to place variety trials at many locations in Alabama. Soybean variety trials are reported from six locations, Table 5. The trials consisted of two types: (1) State trials consisting of 12-14 released varieties comprising Groups V, VI, VII, and VIII, and (2) regional trials

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

TABLE 5. LOCATION, SOIL TYPE, DATES OF PLANTING, AND ROW WIDTHS OF VARIETY TRIALS

Station and location	Soil type[1]	Date of planting			Row width, in.	Type of test
		1st	2nd	3rd		
Tennessee Valley Substation Belle Mina	Dewey sil	May 2-30 May 18 av.			42	Reg. groups V and VI
Sand Mountain Substation Crossville	Hartsells fsl	May 1-3	May 20-25	June 10-15	36	State
Plant Breeding Unit, Tallassee	Cahaba lfs	May 11 to June 22 May 23 av.			40	Reg. groups VII and VIII
Black Belt Substation Marion Junction	Houston c 1967-68 Sumpter sic 1969	May 6-11	May 26 to June 5	June 24 to July 2	36	State
Gulf Coast Substation, Fairhope	Malbis fsl	June 1-10			38	State and Reg. groups VI, VII, VIII
Brewton Field, Brewton	Benndale sl	May 10-13	June 1-12		36	State

[1] Abbreviations: sil = silt loam; fsl = fine sandy loam; lfs = loamy fine sand; c = clay; sic = silty clay; sl = sandy loam.

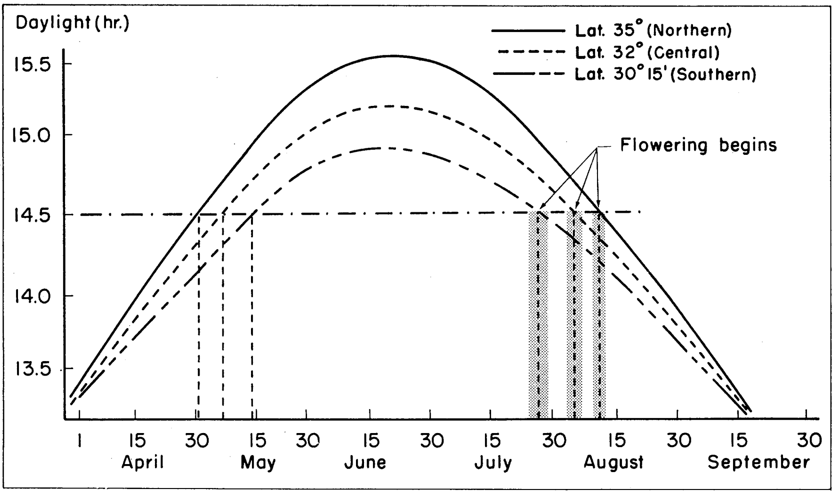

FIG. 6. Day length and date of flowering for Group VII varieties of soybeans in southern, central, and northern Alabama.

in cooperation with USDA consisting of evaluating breeding lines from Group V, VI, VII, and VIII.

First planting dates varied from May 1 to June 5. Subsequent plantings were made at approximately 3-week intervals.

Yields were determined by cutting entire mature plant by hand and threshing. Most losses that commonly occur during combine harvesting were avoided by using this method.

Maturity was recorded as the estimated date when practically all pods were dry and most leaves had dropped.

VARIETIES BY MATURITY GROUPS

Very Early Varieties—Maturity Group V

Varieties of this maturity are recommended for production only in the northern area of Alabama. Yields of this group in other areas of the State are usually below those of later maturing varieties; however, varieties in Group V may yield more than the later maturing ones in years with a late summer drought. Highest yields were obtained from the earliest optimum planting date and yields dropped markedly when planting of these varieties was delayed. Hill, the earliest variety in this group, matures in mid-September in southern and central Alabama and late September to early October in northern Alabama. Relative maturity and other characteristics for varieties tested are presented in Table 6.

TABLE 6. MATURITY AND OTHER CHARACTERISTICS OF SOYBEAN VARIETIES TESTED

Group	Variety	Approximate maturity[1]	Plant characteristics				Reaction to individual diseases[4]					Nematode resistance		Registration No. and year[2]	
			Pubescence	Flower color	Pod color	Hila color	Bacteria pustule	Wildfire	Target spot	Phytophthora rot	Purple seed stain	Cysts	Root-knot		
V	Hill (earliest)	9-29	Tawny	White	Lt. Tan	Brown	R	R	MR	MR	S	S	R	29	1960
	Dare	+8	Grey	White	Tan	Buff	R	R	R	MR	R	S	MR	50	1966
	York	+7	Grey	Purple	Lt. Tan	Buff	R	R	R	MS	R	S	S	70	1968
	Dyer	+6	Brown	Purple	Tan	Black	R	R	R	VS	S	R	S	69	1968
VI	Hood (earliest)	10-7	Grey	Purple	Lt. Tan	Buff	R	R	R	S	MR	S	S	30	1960
	Davis	+5	Grey	White	Lt. Tan	Buff	R	R	R	R	MR	S	S	56	1966
	Lee	+7	Tawny	Purple	Lt. Tan	Black	R	R	MR	S	R	S	S	23	1958
	Lee 68	+8	Tawny	Purple	Lt. Tan	Black	R	R	R	VR	R	S	S	72	1968
	Pickett	+10	Grey	Purple	Tan	Black	R	R	MR	S	R	R	S	52	1966
VII	Semmes (earliest)	10-15	Grey	Purple	Tan	Black	R	R	R	VR	S	S	S	53	1966
	Bragg	+3	Brown	White	Brown	Black	R	R	R	R	S	S	R	43	1964
	Coker 208	+7	Grey	Purple	Tan	Buff	R	R	MR	S	S	S	S	[3]	--------
	McNair 800	+1	--------	--------	--------	Black	R	R	R	S	S	S	S	----	--------
VIII	Hampton 266A (earliest)	10-30	Grey	Purple	Lt. Tan	Buff	R	R	MR	VS	S	S	S	47	1964
	Hardee	+5	Grey	White	Tan	Buff	R	R	R	S	VR	S	MR	44	1964
	Coker 318	+3	Grey	White	Tan	Tan	R	R	R	S	S	S	S	[3]	--------

[1] Maturity given as the number of days later than the earliest variety within the same group.
[2] Registration of varieties are in *Agronomy Journal* from 1958-1963 and *Crop Science* 1964-1970.
[3] Sublines of Hampton.
[4] These are relative order of resistance: VR—very resistant; R—resistant; MR—moderately resistant; S—susceptible; VS—very susceptible.

Early Varieties—Maturity Group VI

Varieties in this maturity group are adapted to all production areas of Alabama except the sandy soil of the southeastern section. Maximum yields usually can be expected from adapted varieties in this group if they are planted at recommended dates of planting in northern Alabama and during the earliest optimum planting date in other areas of the State. Hood, the earliest variety in this group, matures approximately October 2 and 15 in southern and northern Alabama, respectively, when planted as a full-season crop. Relative maturity and other characteristics of varieties tested are presented in Table 6.

Mid-season Varieties—Maturity Group VII

Varieties of this maturity are adapted for planting in central and southern Alabama. Production in the northern part of the State is hazardous because the maturity date of this group is so near the date of first frost. Yields of varieties of Group VII are not much different from Group VI when planted at the recommended date. However, mid-season varieties are better adapted for late planting than are early maturing ones. Bragg, the standard maturing variety in this group, matures approximately October 15 and 22 in southern and central Alabama, respectively. Relative maturity and other characteristics for varieties tested are presented in Table 6.

Late Varieties—Maturity Group VIII

Varieties of this maturity are adapted for planting in central and southern Alabama. These late varieties, like the mid-season varieties, make more vegetative growth before flowering than the earlier types; therefore, they have a higher yield potential when planted late or planted on the sandy soils in the southeastern section of the State. Yields of the late varieties are not reduced as drastically by late planting as are yields of the earlier varieties. Hampton 266A, the earliest maturing variety in this group, matures approximately October 23 and 29 in southern and central Alabama, respectively. Relative maturity and other characteristics for varieties tested are presented in Table 6.

RESULTS AND DISCUSSION

Northern Alabama

Yields of soybean varieties when grown in northern Alabama at the Sand Mountain Substation are shown in Table 7. Yields of varieties in Groups V, VI, and VII were similar when planted the first week of May.

Yields of all varieties decreased with later planting. The largest decrease was for Group V varieties, approximately 2 bushels for each week delayed after May 1. Group VI varieties decreased in yield almost 1 bushel per week planting delay after May 1. The best varieties for early planting appear to be Dare, Davis, and Bragg, all with 3-year averages of 41 bushels per acre. For late plantings, Davis and Lee appear to be the best varieties as their 3-year average for late planting was 33 and 32 bushels per acre, respectively. Group VIII varieties are too late for this location as they were killed by frost before maturity 2 of 3 years. Some Group VII varieties are often killed by frost since their date of maturity is near the average frost date. Therefore, they should be used only for early plantings.

TABLE 7. YIELD OF SOYBEAN VARIETIES BY PLANTING DATES AT SAND MOUNTAIN SUBSTATION, CROSSVILLE

Variety	Per acre yield by planting date								
	May 1-3			May 20-25			June 10-15		
	67-69	68-69	69	67-69	68-69	69	67-69	68-69	69
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Group V (very early)									
Hill	36.3	32.9	35.1	34.3	30.7	30.3	27.3	25.3	16.5
Dare	41.4	38.6	39.0	35.9	32.9	30.5	30.5	29.7	18.5
York	----	38.1	36.3	----	34.4	33.7	----	30.5	20.6
Group VI (early)									
Hood	38.2	40.2	39.7	36.5	35.1	30.1	29.4	29.6	19.2
Davis	40.9	39.3	37.3	38.1	36.3	32.9	33.4	30.2	19.4
Lee	38.6	37.6	33.6	37.0	35.2	29.7	31.7	38.7	17.9
Group VII (midseason)									
Semmes	38.0	36.3	32.9	35.9	33.9	29.7	28.4	24.0	15.2
Bragg	41.0	38.1	33.0	39.4	39.7	33.9	31.0	27.9	15.2
Coker 208	----	41.3	37.8	----	39.8	36.0	----	32.2	26.9
McNair 800	----	----	36.2	----	----	31.0	----	----	20.0
Group VIII (late)									
Hampton 266A	39.5	38.9	39.5	37.7	37.2	35.5	30.6	28.4	17.4
Harlee 11	39.4	38.8	38.5	35.8	34.7	31.6	28.9	26.4	14.1
Coker 318	----	34.0	35.0	----	34.1	33.7	----	23.6	14.9
Harlee 12	----	38.1	35.4	----	33.7	29.3	----	25.8	13.6

TABLE 8. AVERAGE MATURITY DATES OF SOYBEAN VARIETIES BY PLANTING DATES AT CROSSVILLE, 1967-69

Variety	Maturity by planting date		
	May 1-3	May 20-25	June 10-15
Group V (very early)			
Hill	9/20	9/24	10/17
Dare	9/27	10/4	10/20
York	9/24	9/26	10/14
Group VI (early)			
Hood	10/13	10/14	10/18
Davis	10/25	10/22	10/25
Lee	10/20	10/24	10/23
Group VII (midseason)			
Semmes	10/24[1,2]	10/29[1,2]	11/2[1,3]
Bragg	10/23[1,2]	10/26[1,2]	10/30[1,3]
Coker 208	10/22[1,2]	10/28[1,2]	10/21[1,3]
McNair 800	10/17	10/27	---- [3]
Group VIII (late)			
Hampton 266A	10/28[1,3]	11/4[1,3]	10/28[1,3]
Harlee 11	11/4[1,3]	11/4[1,3]	11/7[1,3]
Coker 318	---- [3]	---- [3]	---- [3]
Harlee 12	---- [3]	---- [3]	---- [3]

[1] Average maturity for years not killed by frost.
[2] Frost killed beans before maturity 10-25-68.
[3] Frost killed beans before maturity 10-25-68 and 11-1-69.

The average maturity of varieties in Group V was 3½ weeks earlier than varieties of Group VI when planted early at Sand Mountain Substation, Table 8. However, when planted at the later planting dates, they were only a week earlier in maturity than varieties in Group VI. Maturity of Group VII varieties was similar to Group VI in that a delayed planting of 3 weeks only delays the maturity 7 days. The maturity of Group VII of the second 3 weeks delay plantings was similar to the first in the year not killed by frost.

The yield of varieties in Groups V and VI are very similar when grown at Belle Mina in the regional soybean nursery, Table 9. Dare and York in Group V and Hood and Davis have very similar yields. These data also show that Lee 68 is very similar to Lee in yield. Lee 68 is a Lee line that has had phytophtora rot resistance incorporated into it.

It can be seen from Table 9 that the maturity of Group VI is 2 weeks later in northern Alabama even though they were planted 2 weeks earlier than in southern Alabama.

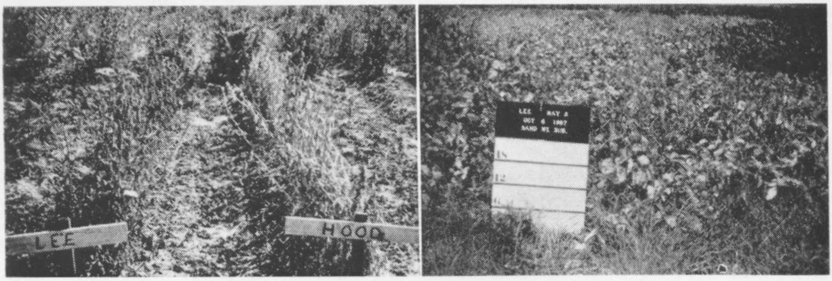

FIG. 7. Maturity of Lee and Hood, October 10, 1967, at Fairhope, left, when planted June 7; and Lee, October 6, 1967, at Crossville, right, when planted May 3.

TABLE 9. YIELD OF SOYBEAN VARIETIES BY LOCATION

Variety	Per acre yield and maturity							
	Belle Mina[1]			Tallassee[2]		Fairhope[3]		
	Maturity	Yield 65-69	Yield 66-69	Maturity	Yield 65-68	Maturity	Yield 65-69	Yield 66-69
		Bu.	*Bu.*		*Bu.*		*Bu.*	*Bu.*
Group V (very early)								
Hill	10/3	33.2	31.2	----	----	----	----	----
Dare	10/13	37.2	36.6	----	----	----	----	----
York	10/11	37.1	35.8	----	----	----	----	----
Group VI (early)								
Hood	10/18	37.3	35.7	----	----	9/30	40.3	38.8
Lee	10/20	33.1	32.7	----	----	10/8	41.8	41.6
Davis	10/22	35.5	35.5	----	----	10/6	41.6	40.5
Lee 68	10/22	----	33.4	----	----	10/8	----	39.7
Group VII (midseason)								
Bragg	----	----	----	10/22	34.0	10/14	40.6	40.8
Semmes	----	----	----	10/26	29.0	10/12	37.5	35.2
Group VIII (late)								
Hampton 266A	----	----	----	11/2	38.8	10/22	44.7	45.3
Hardee	----	----	----	11/5	33.8	10/28	41.8	43.4

[1] Average planting date for Belle Mina was May 19.
[2] Average planting date for Tallassee was May 8.
[3] Average planting date for Fairhope was June 6.

FIG. 8. Maturity of Davis, October 6, 1967, at Crossville (left) when planted May 3; and Davis and Hill, October 10, 1967, at Fairhope (right) when planted June 7.

TABLE 10. YIELD OF SOYBEAN VARIETIES BY PLANTING DATES AT BLACK BELT SUBSTATION, MARION JUNCTION

Varieties	Per acre yield by planting date								
	May 6-11			May 26-June 5			June 24-July 2		
	67-69	68-69	69	67-69	68-69	69	67-69	68-69	69
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Group V (very early)									
Hill	28.9	20.8	20.3	18.4	15.9	15.2	10.4	9.0	15.3
Dare	31.5	28.5	29.6	22.7	21.0	21.7	*	*	20.4
York	----	21.9	23.0	----	21.2	22.9	----	*	9.3
Group VI (early)									
Hood	32.0	26.8	24.7	21.6	17.3	17.6	*	*	16.7
Davis	35.4	28.4	25.3	29.3	23.4	21.8	*	*	25.7
Lee	34.7	29.6	27.2	27.1	24.5	26.3	*	13.7	17.1
Group VII (midseason)									
Semmes	31.8	28.1	25.0	25.7	21.0	23.9	13.6	14.2	18.7
Bragg	35.9	29.3	27.6	29.8	23.0	28.7	14.8	15.1	25.1
Coker 208	----	26.4	27.5	----	----	19.7	----	12.8	16.9
McNair 800	----	----	27.6	----	----	26.0	----	----	21.0
Group VIII (late)									
Hampton 266A	32.9	26.7	28.0	29.3	23.6	23.7	16.3	13.0	15.7
Harlee 11	32.5	25.5	27.0	27.2	22.3	22.3	19.1	18.6	21.7
Coker 318	----	25.3	26.7	----	22.5	25.7	----	16.7	20.1
Harlee 12	----	23.5	24.0	----	22.4	23.5	----	21.6	21.5

* Beans planted but sufficient stands were not obtained to harvest.

Central Alabama

Yields of soybean varieties grown in central Alabama on the Black Belt Substation are shown in Table 10. Yields of varieties in Groups VI and VII are similar when planted at the earliest planting date. However, the average yield decrease of Group VI varieties with delayed planting was greater than Group VII. This was 2.6 and 1.9 bushels per acre decrease per week delayed in planting, respectively. The best yielding varieties in Group VI were Lee and Davis, and in Group VII was Bragg. The 3-year average for Dare in Group V was 32 bushels per acre when planted early which was approximately 3 bushels per acre less than Lee and Davis in Group VI, but it decreased very rapidly with delayed planting. The yield and maturity of standard varieties in Groups VII and VIII in the regional tests are shown in Tables 11 and 12.

The average maturity dates for planting dates at Black Belt Substation are shown in Table 11. From these maturity dates and the yields in Table 10, selection can be made to obtain high yields

TABLE 11. AVERAGE MATURITY DATES OF SOYBEAN VARIETIES BY PLANTING DATES AND LOCATION FOR 1967-69

Variety	Maturity by location and planting date					
	Marion Junction			Brewton		Fairhope
	May 6-10	May 26 to June 5	June 24 to July 2	May 10-13	June 1-12	June 1-10
Group V (very early)						
Hill	9/19	9/24	10/20	9/18	9/28	9/16
Dare	9/27	9/29	10/23	9/21	10/1	9/22
York	9/23	9/28	10/25	9/18	10/4	10/1
Group VI (early)						
Hood	9/29	10/3	10/21[1 3]	9/22	10/5	9/27
Davis	10/5	10/7	10/30	10/1	10/12	10/5
Lee	10/9	10/13	10/24[1 3]	10/5	10/14	10/9
Group VII (midseason)						
Semmes	10/16	10/18	10/29	10/11	10/15	10/10
Bragg	10/17	10/18	10/30	10/12	10/17	10/13
Coker	10/18	10/25	---- [2]	10/28	10/25	10/15
McNair 800	----	10/16	10/27	----	----	10/10
Group VIII (late)						
Hampton 266A	10/25	10/28	11/4[2 1]	10/24	10/24	10/19
Harlee 11	10/25	10/30	11/6[1 2]	10/25	10/24	10/21
Coker 318	10/24	10/27	---- [2]	10/28	10/25	10/22
Harlee 12	10/26	10/27	---- [2]	10/28	10/25	10/24

[1] Average maturity for years not killed by frost.
[2] Frost killed beans October 26, 1968 and November 5, 1969.
[3] Frost killed beans November 5, 1969.

and also spread the harvest over a period of 4 to 6 weeks. For example, using the best variety of Groups V, VI, VII, and VIII such as Dare, Davis or Lee, Bragg, and Hampton 266A, respectively; and by planting these varieties in this sequence, harvest would start in late September and end in late October to early November.

Southern Alabama

The yields of soybean varieties when grown in southern Alabama at Brewton Field and Gulf Coast Substation are shown in Tables 9 and 12. Varieties in Groups VII and VIII yielded best in southern Alabama, but Davis of Group VI and Dare of Group V looked good at Brewton Field in 1967 and 1968. This was because of the high rainfall in late June, July, and August which did not continue into September so the yield of later varieties such as Groups VII and VIII was cut short.

TABLE 12. YIELD OF SOYBEAN VARIETIES BY PLANTING DATES AT BREWTON EXPERIMENT FIELD AND GULF COAST SUBSTATION

Variety	Per acre yield by location, average							
	Brewton					Fairhope		
	Planted May 10-13	Planted June 1-12				Planted June 1-10		
	67-68	67-69	67-68	68-69	69	67-69	68-69	69
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Group V (very early)								
Hill	31.9	27.2	31.2	24.7	19.3	32.2	29.7	25.1
Dare	38.0	30.3	33.6	28.0	23.7	37.0	34.5	33.6
York	----	----	----	23.6	18.0	----	32.5	31.4
Group VI (early)								
Hood	32.6	27.1	29.5	28.9	22.2	37.5	36.6	36.9
Davis	44.5	38.3	43.5	33.7	28.0	36.5	33.2	33.2
Lee	33.0	29.5	31.9	30.4	24.6	37.5	34.6	35.4
Group VII (midseason)								
Semmes	33.5	30.1	33.2	26.9	23.8	39.3	31.6	31.7
Bragg	38.5	34.1	37.3	33.0	27.8	40.1	36.4	39.0
Coker 208	----	----	----	34.0	34.6	----	34.0	33.7
McNair 800	----	----	----	----	25.6	----	----	37.9
Group VIII (late)								
Hampton 266A	39.7	37.8	40.1	35.1	33.1	38.2	33.8	32.8
Harlee 11	35.1	34.8	36.6	32.0	31.2	34.1	34.6	35.1
Coker 318	----	----	----	32.2	33.7	----	32.5	34.8
Harlee 12	----	----	----	28.1	29.5	----	33.6	36.1

ROW SPACING

D. L. THURLOW

MOST SOYBEANS IN ALABAMA have been planted in 38-42-inch rows with the same equipment used for cotton and corn. A survey conducted by the National Soybean Crop Improvement Council in 1969 indicated that 20 per cent of the Southeastern soybean growers contacted had planted their 1968 soybean crop in rows closer than 33 inches with intentions to plant 27 per cent of their 1969 crop in rows closer than 33 inches, and 8 per cent indicated that they would plant in rows less than 26 inches.

Previous research *(9,14)* in the Southeast did not indicate any advantage from close rows; however, with changing varieties and increased double cropping causing delayed planting, closer rows have resulted in increased yields *(16)*.

Field tests were conducted at four Alabama locations: Fairhope, Auburn, Marion Junction, and Belle Mina, from 1967 to

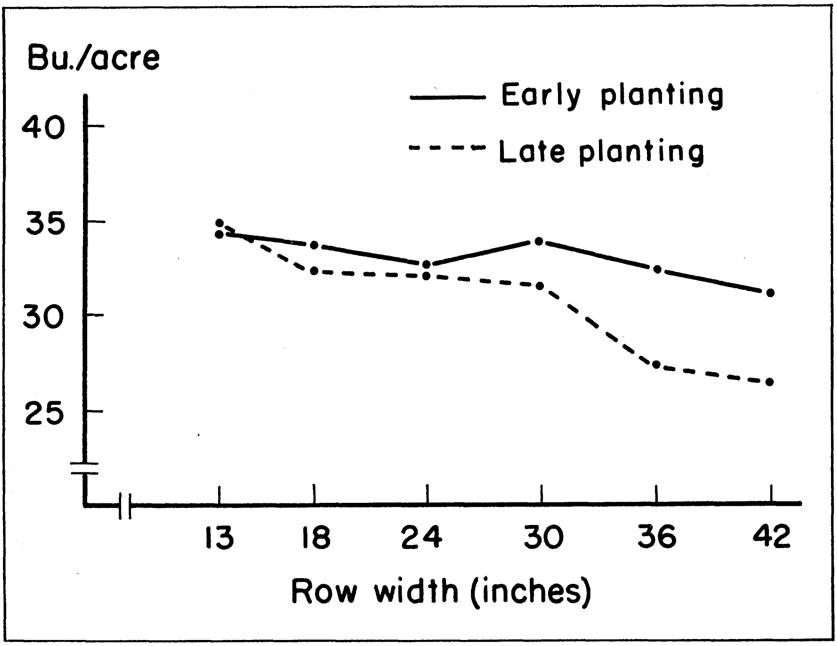

FIG. 9. Effect of row spacing on soybean yield in early and late planting tests from 1967 through 1969.

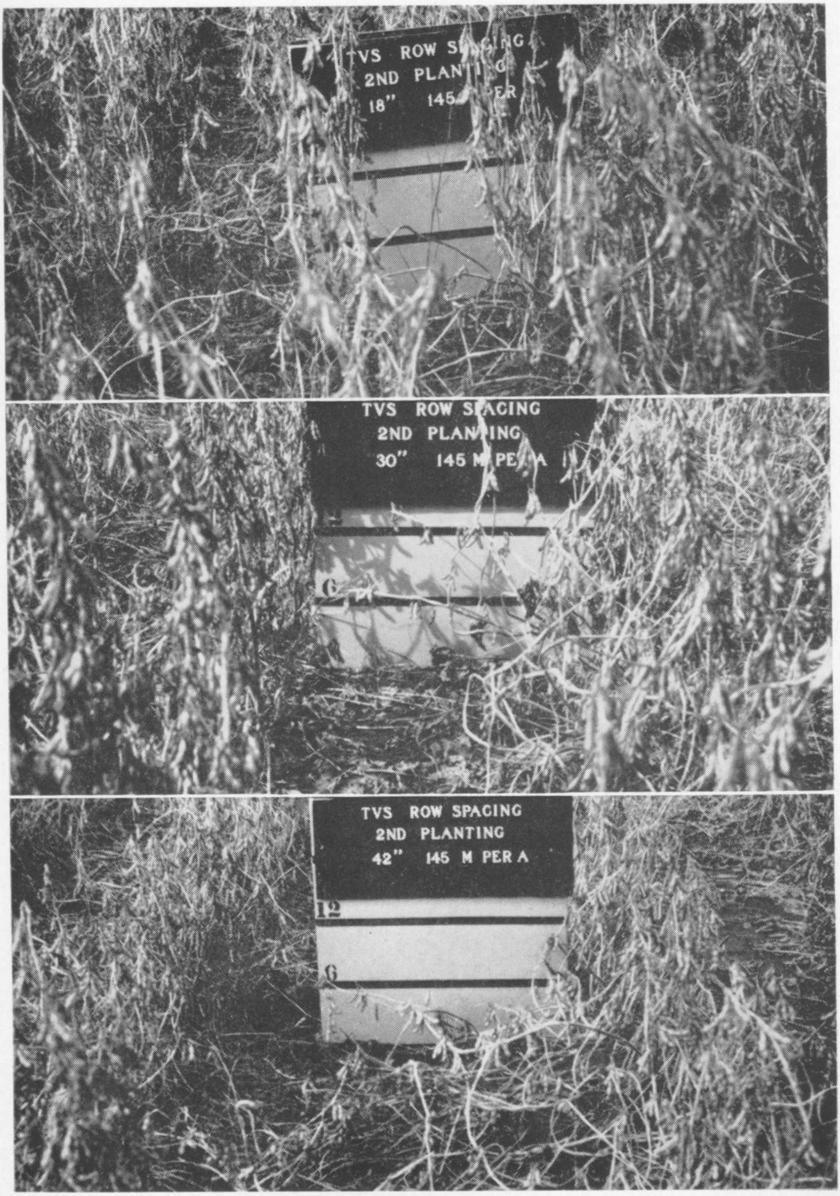

FIG. 10. Lodging of Lee soybeans at Belle Mina when planted in 42-, 30-, and 18-inch rows shown at bottom, middle, and top, respectively.

1969. These tests included row widths 7 to 42 inches in 1967 and 13 to 42 inches in 1968 and 1969 with six different spacings at each location. All row widths at each location were planted at the same seeding rate of 1 bushel per acre which was approximately 10 plants per foot of row in 36-inch row spacing. Yield data in Figure 9 were obtained by averaging 10 early planting experiments and 7 late planting experiments. The early planting dates were May 28 to June 6 in southern Alabama, May 12-23 in central Alabama, and May 2-21 in northern Alabama. The late planting dates were June 23 to 26, June 17-21, and May 26 to June 8 in southern, central, and northern Alabama, respectively.

Responses were obtained at only 3 of the 10 early planted tests to row width closer than 40-42 inches; also, at all three locations where there was a yield increase to narrow rows, the closest row spacing of 13 inches had the highest yield. There was a response to the closer row spacing at six of the seven late planting tests with maximum yields at 13-, 18-, and 24-inch spacing at three, one, and two locations, respectively. The average of seven late plantings indicates that the greatest yield increase came from reducing row width from 36 to 30 inches, Figure 9. These data indicate that some of the yield loss by late planting can be compensated for by closer row spacing.

Lodging, as indicated by Figure 10, was also reduced as the row width was narrowed; and, also, the height of the first pod on the stalk was higher as rows were narrowed.

These results indicate that soybeans should be produced in narrow row spacings providing other cultural practices such as weed and insect control are not hindered.

CROPPING SYSTEMS AND OTHER CULTURAL PRACTICES

HOWARD T. ROGERS, D. L. THURLOW, AND GALE A. BUCHANAN[1]

WHAT ROTATION or cropping system to use is one of the most difficult decisions for Alabama soybean growers. Research and farmer experiences with soybeans show several advantages of crop rotation over continuous cropping. The control of weeds almost dictates some form of crop rotation for successful soybean production over a period of years. In Alabama's Black Belt this has become an acute problem threatening further expansion of soybeans in this area. Some large landowners, who are cattlemen, are using soybeans successfully in renovating old pasture sods. This practice has its limitations as weeds frequently become a major problem after 1 or 2 years in soybeans.

Cotton can be rotated with soybeans but limited acreage allotments, and other factors, rule out this crop in many situations. Corn yields generally are not competitive with the Corn Belt, as indicated earlier, although this crop is a logical choice where reasonably satisfactory yields can be obtained. Using improved varieties of grain sorghum, researchers and farmers are taking another look at this crop.

DOUBLE-CROPPING

There is much interest in double-cropping soybeans with small grains. Whether this practice can be followed, using the same crops year after year on the same land, without weed, insect, and disease buildup is doubtful. Short term results, however, look promising when double-cropping is used in a 2-year rotation, as shown in Table 13. In these experiments corn, wheat, and soybeans were compared with corn and soybeans as full-season crops in a 2-year rotation. In tests over the State, as an average for 2 years, soybeans as a double crop after wheat yielded as well as full-season beans at four of five locations. The Tennessee Valley experiment was an exception, where wheat averaged 53 bushels per acre and double-cropped soybeans produced 6 bushels less

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

TABLE 13. SOYBEAN YIELDS AS A FULL-SEASON CROP AND DOUBLE-CROPPED WITH WHEAT IN 2-YEAR ROTATION WITH CORN, 1968-69

Location	Yield per acre		
	Wheat	Soybeans	Difference in soybeans for full season
	Bu.	*Bu.*	*Bu.*
Brewton	----	28.1	+1.6
	20.4	26.5	----
Monroeville	----	25.6	—3.5
	28.1	29.1	----
Prattville	----	34.9	+1.6
	39.9	33.3	----
Sand Mountain	----	34.8	—1.8
	29.2	36.6	----
Tennessee Valley	----	30.1	+6.3
	53.0	23.8	----
Av.—5 locations	----	30.7	+0.9
	34.1	29.8	----

than full-season beans. On the other hand, the best bean yield at any location was produced when double-cropped after wheat on the Sand Mountain Substation.

Early planted full-season beans on Houston clay at the Black Belt Substation outyielded soybeans double-cropped with wheat 5 to 10 bushels per acre as a 3-year average, Table 14. Wheat yields averaged 36 bushels, which might offset the reduction in bean yields from double-cropping depending on the prices of wheat and beans. Also, wheat may be used for winter grazing without much reduction in grain yield.

Some high bean yields have been made when the crop was planted after small grain and rainfall was adequate. For example, Rogers and Thurlow *(21)* reported a 58-bushel per acre yield of

TABLE 14. YIELDS OF SOYBEANS (FULL-SEASON) AND SOYBEANS AFTER WHEAT (DOUBLE-CROPPED), BLACK BELT SUBSTATION, HOUSTON CLAY, 1967-69

Cropping systems	Yield per acre							
	1967		1968		1969		3-year average	
	Wheat	Soy-beans	Wheat	Soy-beans	Wheat	Soy-beans	Wheat	Soy-beans
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Soybeans only	----	47.6	----	29.0	----	18.3[3]	----	31.6
Wheat-soybeans[1]	38.4	42.2	36.8	16.1	37.8	22.4	37.7	26.9
Wheat-soybeans[2]	36.3	39.7	32.8	8.6	31.2	16.2	33.4	21.5

[1] Wheat straw baled, land turned and disced before planting soybeans.
[2] Wheat straw chopped, land disced without turning before planting soybeans.
[3] Soybeans planted May 13 but failed to get stand; replanted May 30.

soybeans grown after wheat on a loamy sand at Auburn in 1967. In spite of these promising results from double-cropping, the fact remains that over a long period of years full-season beans will produce higher yields in most situations because of the flexibility the grower has in planting with good soil moisture and in reducing the weed problem. The large grower will spread out planting dates and use both early and late maturing varieties. In many cases, it will not be practical for him to plant all of his acreage as a double-crop after small grain. According to Henderson[2] between one-fourth and one-third of the soybean crop grown in Alabama in 1970 was planted in double-cropping systems. This practice probably will increase as more small grain is planted.

BURNING SMALL GRAIN STRAW

In 3-year tests on Houston clay at the Black Belt Substation and on sandy loam soils on the Plant Breeding Unit near Tallas-

TABLE 15. EFFECT OF BURNING SMALL GRAIN STRAW ON SOYBEAN YIELDS

Location of test and soil	Method of handling straw	Seedbed preparation and planting	Bushels per acre 3-year av. (1967-69)
Black Belt Substation, Marion Junction, Houston clay[1]	Burned	Disced and planted with corn-bean planter	21.6
	Shredded straw and left on field	Double disced straw and used corn-bean planter	21.5
Plant Breeding Unit, Tallassee, alluvial sandy and fine sandy loams[2]	Burned	Varitiller planter[3]	39.5
	Straw shredded or spread and left on field[4]	Varitiller planter[3]	37.8
	Straw shredded and left on field[4]	Plowed under straw, disced and used corn-bean planter	34.8
	Disced straw	Plowed under straw, disced and used corn-bean planter	36.2

[1] Treatments repeated on same plots for 3 years in wheat-soybean double-cropping system.
[2] Test planted on different area each year in 2-year rotation of corn or cotton followed by wheat or rye for grain and soybeans.
[3] Used Bush Hog "Varitiller" subsoiler-planter.
[4] Straw shredded with Gehl "Shredall."

[2] Personal communication from Dr. John B. Henderson, Extension Soybean Specialist, Alabama Cooperative Extension Service.

see, burning small grain straw before planting soybeans did not affect yields, Table 15. Similar experiments on coarse-textured soils by Musen[3] in South Carolina over a 5-year period likewise showed no reduction in yield from burning small grain straw. Equipment is available for shredding large amounts of straw so that it can be left on the surface or turned under satisfactorily.

NO-TILLAGE AND MULCH PLANTING

Variations of "stubble-mulch" farming have been used in experiments and by some innovative farmers for several years with differing degrees of success. Nature of the weed problem, type of soil, rainfall, available herbicides, types of planting equipment, insects and diseases, and cropping sequence will determine the feasibility of these minimum tillage schemes. There is widespread interest in these practices and many growers are planting sizeable acreages of soybeans in small grain stubble and after other crops without traditional land breaking, discing and cultivation *(26)*. No-tillage land-use systems reduce wind and water erosion and minimum tillage practices will receive increased attention from researchers and farmers.

No-Tillage

No-tillage planting in which the crop is planted in a sod or in stubble and straw after small grain harvest is the latest type of stubble-mulch farming to receive widespread attention. In this practice, a sod crop or small grain grown for grazing, mulching or grain is treated with a combination of contact and residual pre-emerge herbicides. A planter similar to the one shown in Figure 11 is used to place the seed in a slot or trench of sufficient width and depth to give suitable seed-soil contact and coverage. No other soil manipulation is involved. Table 16 gives results of tests conducted in 1969 at Prattville and Tallassee comparing no-tillage planting with conventional plow-planting of soybeans.

In the Prattville test, wheat was planted on an area that had been summer fallowed and was mowed to simulate winter and spring grazing. The regrowth residue and early weeds were killed with Paraquat and left on the surface. Linuron (Lorox) or alachlor (Lasso) was applied with the Paraquat as a residual her-

[3] Personal communication from Dr. H. L. Musen, Edisto Experiment Station, Blackville, S.C.

TABLE 16. NO-TILLAGE PLANTING COMPARED WITH CONVENTIONAL PLOW-PLANTING OF SOYBEANS AFTER SMALL GRAIN, 1969

Treatment No.	Seedbed preparation	Method of planting	Weed control		Yield bu./acre
			Herbicide	Mechanical	
		Prattville Experiment Field, sandy loam[1]			
1	Turned with moldboard plow 10 days before planting, disced	A. C. "No-Til" planter	Preplant nitralin, 0.75 lb./acre (Planavin)	Cultivated twice	29.2
2	None	Same as No. 1	Preemerge Paraquat, 0.25 lb./acre	None	30.2
3	None	Same as No. 1	Preemerge Paraquat, 0.25 lb./acre plus linuron, 2.0 lb./acre (Lorox)	None	31.8
4	None	Same as No. 1	Preemerge Paraquat, 0.25 lb./acre plus alachlor, 2.5 lb./acre (Lasso)	None	35.8
		Tallassee, Plant Breeding Unit, fine sandy loam[2]			
1	Disced straw, turned with mold-board plow, and disced before and after preplant herbicide	Planet, Jr. corn-bean planter	Preplant trifluralin, 0.5 lb./acre (Treflan)	Cultivated twice	40.1
2	None	A. C. "No-Til" planter	Preemerge Paraquat, 0.5 lb./acre	None	13.7
3	None	Same as No. 2	Preemerge Paraquat, 0.5 lb./acre plus linuron, 2.0 lb./acre (Lorox)	None	16.4
4	None	Same as No. 2	Preemerge Paraquat, 0.5 lb./acre plus alachlor, 2.5 lb./acre (Lasso)	None	13.1

[1] Beans planted in Prattville test after wheat for grazing with regrowth residue left on surface. Minor weed problem as area was summer fallowed previous year.

[2] Beans planted in Tallassee test after harvesting 30 bushels per acre rye seed, with 2.5 tons straw left on surface. Severe injury to soybeans from Lorox and subsequent weed problem as 4.1 in. rain fell soon after bean plants emerged.

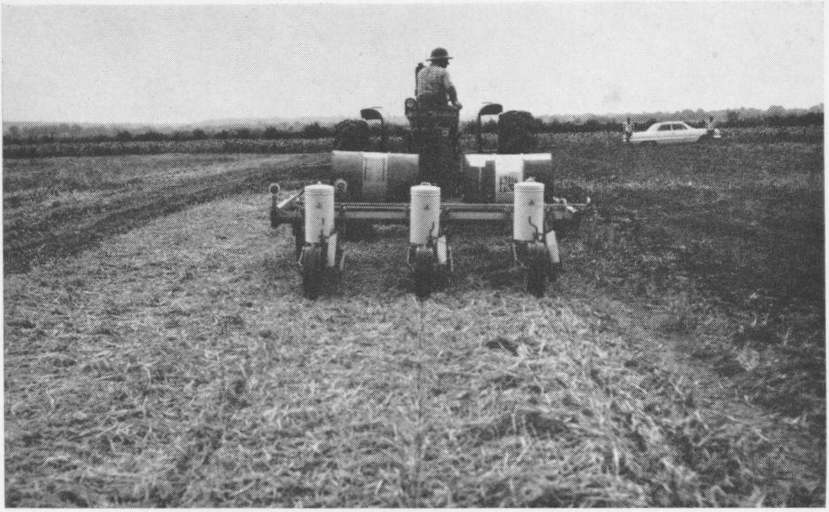

FIG. 11. Planting soybeans on heavy rye straw residue with Allis Chalmers "No-Til" planter. Cahaba fine sandy loam, Plant Breeding Unit, Tallassee. Photographed June 19, 1969.

bicide to hold back summer weeds until soybeans could shade out later weed growth. The no-tillage beans produced as well as conventional plow-planting with preplant herbicide and cultivation. Weeds were a minor problem on this area in 1969 due largely to summer fallow in 1968. This test was repeated on the same area in 1970 but a much more severe weed problem developed and the same herbicides were not effective in controlling broadleaf weeds. Rank weed growth on some no-tillage treatments prevented taking soybean yield data on these plots in 1970.

In the Tallassee experiment, beans were planted on a fine sandy loam after rye harvested for seed. A 2.5 ton-per-acre straw residue was left as a mulch on the no-tillage areas. The conventional treatment involved discing ahead of turning with moldboard plow, discing again to level the area before applying trifluralin (Treflan), discing in the herbicide, planting, and cultivating twice. The no-tillage treatments consisted of planting with the "No-Til" planter and preemerge applications of combinations of Paraquat and Lorox or Paraquat and Lasso. Linuron at 2.0 pounds per acre on this fine sandy loam severely injured the soybeans and was apparently leached out of the soil by a 4.1-inch rain soon after the beans emerged. Poor grass control was obtained with either Lorox or Lasso as residual herbicides. The conventional plow-plant method yielded 40 bushels per acre of soybeans as compared with 13 to 16 bushels from the no-tillage treatments.

It is concluded that under the limited conditions observed no-tillage planting of soybeans is in the experimental stage. However, good stands of beans were obtained in heavy straw mulches with currently available equipment, Figure 11 and Cover Photo 7. Rates and kinds of herbicides, soil properties, rainfall distribution during the growing season and interaction of these factors with varying weed problems have not been evaluated adequately for Alabama conditions.

The Subsoiler-Planter

The subsoiler-planter shown in Figure 12 has been used successfully in experiments on sandy loams at Auburn and Tallassee, Table 17, and in field scale plantings on the Foundation Seed Stocks Farm at Thorsby. This "Varitiller" machine plants beans after small grain harvests with the straw left on the surface intact or shredded, Figure 12. Seed are planted in a furrow in the lower part of the plow layer or upper subsoil with the top soil thrown to the middles covering the straw. Cultivation of the crop in which the top soil is worked back to the row later is made easier by chopping the straw with a flail-type shredder. The conventional rotary mower is not as satisfactory for this straw chopping as the shredder, especially on small grain which has lodged severely. This planter was used less successfully on fine-textured soils at Prattville and on the Black Belt Substation. The Lucedale

TABLE 17. MULCH PLANTING COMPARED WITH CONVENTIONAL PLOW-PLANTING OF SOYBEANS AFTER SMALL GRAIN ON SANDY LOAM, PLANT BREEDING UNIT, TALLASSEE

Treatment	Method of handling straw[1], planting and controlling weeds	Yields per acre of soybeans			
		1967	1968	1969	Average
No.		*Bu.*	*Bu.*	*Bu.*	*Bu.*
1	Disc straw, plow, disc before and after preplant herbicide (Treflan), plant with corn-bean planter, cultivate	45.8	22.7	40.1	36.2
2	Same as No. 1 except shred straw before plowing under[2]	45.6	18.1	41.4	35.0
3	Shred straw[2], plant with subsoiler-planter[3], cultivate	48.4	21.5	44.0	38.0
4	Same as No. 3 except burn straw	51.4	24.2	42.8	39.5

[1] Amount of small grain straw ranged from 2 to 2.5 tons per acre.
[2] Used Gehl "Shredall" shredder or rotary mower.
[3] Used Bush Hog "Varitiller" planter.

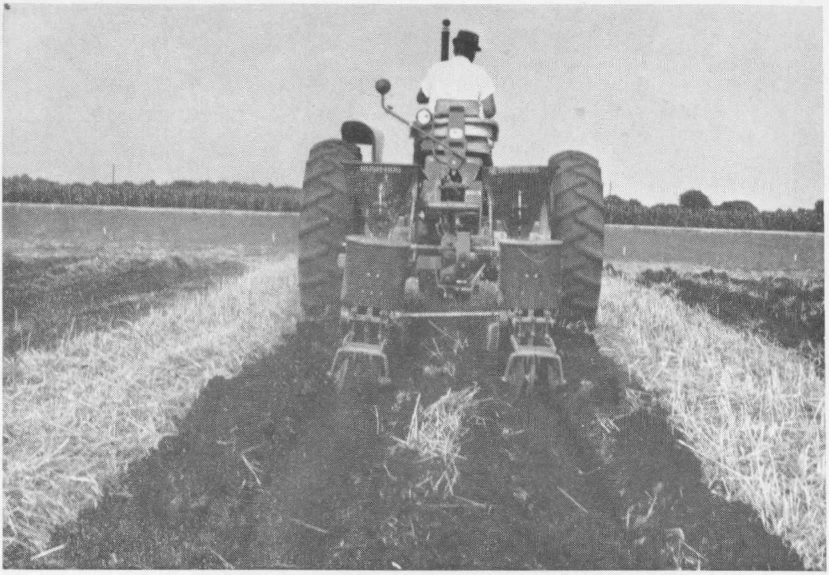

FIG. 12. Planting soybeans in wheat straw and stubble with Bush Hog "Vari-tiller" subsoiler-planter. Lucedale sandy loam, Prattville Experiment Field. Photographed June 25, 1969.

soil on the Prattville Experiment Field has a dense subsoil below the surface 6 or 7 inches. This clay loam subsoil becomes a hardpan on drying. The Black Belt soil is a clay, which also has a narrow critical range of moisture for satisfactory manipulation with a subsoiler-planter.

Growth Regulators

Much interest has been generated in recent years among soybean growers in the Midwest in growth-regulating chemicals. At least one chemical, 2,3,5-triiodobenzoic acid (TIBA), has been available commercially. Researchers have used some of these chemicals to study their effects on the growth and behavior of the soybean plant, including lodging and bean yields. Alabama work, over a 3-year period, included effects of three rates of TIBA applied at four different stages of growth. Early applications of the chemical reduced markedly height of the bean plants. Yield increases, however, have not been large enough to offset the cost of required rates of application. Five additional chemicals are being studied but the results are not adequate on which to draw conclusions.

FERTILITY REQUIREMENTS

HOWARD T. ROGERS,[1] D. L. THURLOW,[2] FRED ADAMS,[1]
C. E. EVANS,[2] AND JOHN I. WEAR[1]

LIME

THE EFFECT OF pH on soybean yields on a soil on the Brewton Experiment Field which is responsive to lime is shown clearly in Figure 13.

Response of soybeans to lime varies greatly on different soils at relatively low pH values. This may have led to the impression that the crop is not sensitive to soil acidity. The data in Table 18 show increases in yields ranging from 4 to 22 bushels per acre on various soils with approximately the same pH value. Although not a perfect indicator of the degree of response to be expected

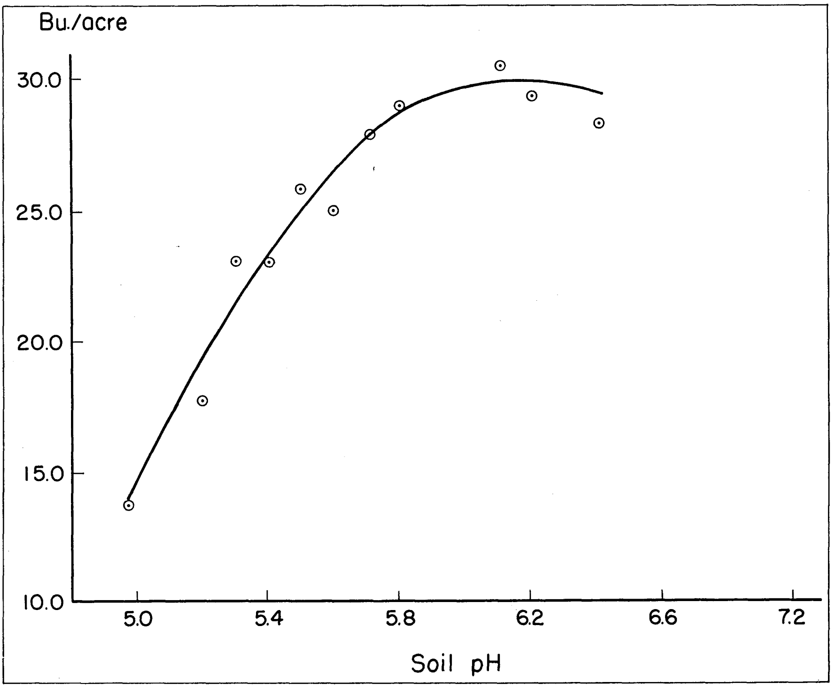

FIG. 13. Effect of soil pH on soybean yields. Benndale sandy loam, Brewton Experiment Field. 1969.

[1] Professors, Department of Agronomy and Soils.
[2] Associate Professors, Department of Agronomy and Soils.

TABLE 18. YIELD RESPONSE OF SOYBEANS TO LIME ON DIFFERENT SOILS

Location	Soil	Years	pH of unlimed soil	Yields, per acre		
				No lime	Lime	Increase
				Bu.	*Bu.*	*Bu.*
Brewton Experiment Field[1]	Benndale sandy loam	1968-69	5.0	10.2	27.0	16.8
Monroeville Experiment Field[1]	Lucedale, very fine sandy loam	1968-69	4.9	18.1	29.8	11.7
Prattville Experiment Field[1]	Lucedale sandy loam	1968-69	4.8	28.8	36.1	7.3
Sand Mountain Substation, Crossville[1]	Hartsells fine sandy loam	1968-69	5.1	16.7	38.6	21.9
Tenn. Valley Substation, Belle Mina[1]	Decatur clay loam	1968-69	5.5	14.8	22.2	7.4
Wiregrass Substation, Headland[1]	Dothan sandy loam	1969	4.9	22.4	27.9	5.5
Lower Coastal Plain Substation, Camden[2]	McLaurin sandy loam	1967-69	5.7	19.5	24.3	4.8
Gulf Coast Substation, Fairhope[2]	Malbis fine sandy loam	1967-69	5.1	27.2	30.9	3.7
Agronomy Farm, Auburn	Norfolk sandy loam	1969	4.8	25.0	39.0	14.0

[1] Two-year rotation of corn and wheat-soybeans.
[2] Continuous soybeans.

from liming, pH is still the best soil test of the need for lime. It is well known that different soils at a given pH value vary greatly in certain chemical properties some of which affect markedly plant response to lime *(1)*. Vegetative response was exceptionally good in the Auburn experiment. See Cover Photo 2.

MOLYBDENUM

Field experiments have been conducted over a period of years at eight locations in Alabama to measure response of soybeans to molybdenum (Mo). The soils ranged in texture from loamy sand to clay, Table 19. The pH of the unlimed soils ranged from 4.9 to 5.9. The only response to Mo was obtained on a very strongly acid Eutaw clay, pH 4.9, at the Black Belt Substation. In this test, adding sodium molybdate to the seed at the rate of one ounce per bushel increased the yield 8 bushels on unlimed soil. Response to Mo was not obtained when the soil was limed.

These tests show that Mo is not needed for soybeans on soils in Alabama when limed at the recommended rate. However, if lime is recommended and for some reason it is not used, or if lime is applied too late to react with the soil before planting beans,

TABLE 19. RESPONSE OF SOYBEANS TO MOLYBDENUM (MO) WITH AND WITHOUT LIMING MEDIUM TO VERY STRONGLY ACID SOILS, 1964-69

Location	Soil type	pH of unlimed soil	Yield per acre			
			No lime		Lime	
			Without Mo	Difference for Mo	Without Mo	Difference for Mo
			Bu.	*Bu.*	*Bu.*	*Bu.*
Alexandria Experiment Field	Decatur clay loam	5.3	18.6	−0.9	19.1	−1.0
Auburn, Agronomy Farm	Chesterfield sandy loam	5.9	32.1	+2.4	34.8	−0.2
Black Belt Substation, Marion Junction	Eutaw clay	4.9	37.1	+8.1	47.0	+0.1
Brewton Experiment Field	Benndale sandy loam	5.1	34.3	−1.5	38.2	−3.8
Gulf Coast Substation, Fairhope	Malbis sandy loam	5.0	38.2	−0.3	38.7	+0.7
Monroeville Experiment Field	Lucedale sandy loam	5.6	21.2	−1.3	21.1	−1.9
Prattville Experiment Field	Lucedale sandy loam	5.4	25.5	+1.1	26.7	−0.4
Wiregrass Substation, Headland	Dothan sandy loam	5.5	41.5	+1.1	46.6	+0.6

Mo may increase yields. An experiment on new lands on the Gulf Coast Substation where soybeans had never been grown established that a molybdenum salt in water solution could be added to soybean seed before mixing with dry inoculum without impairing inoculation.[3]

NITROGEN

Experiments in Alabama have failed to show yield increases from fertilizer nitrogen when soybeans are inoculated. It has been observed that commercial nitrogen will produce greener foliage, and on new lands more vigorous early growth of the plant, without increasing yields (25). This vegetative effect is probably the reason many farmers apply small amounts of N to the crop.

It has been speculated that soybeans might respond to fertilizer nitrogen on lands not previously planted to the crop, low pH soils, sandy soils low in organic matter, poorly drained soils, or soils in which large amounts of small grain straw had been incorporated. The data in Table 20 do not substantiate any of these assumptions. There is no evidence that profitable yield increases will be obtained for N, even under these special situations. The only yield increase for N in these 12 tests, most of which were conducted during recent years, was on a farmer's field in Macon County where inoculation was a complete failure. This failure apparently was caused by dehydration and death of the inoculum as the seed were planted in hot, dry soil in June and did not germinate until 2 weeks later. No nodules could be found on the roots of these bean plants. To assure good inoculation and stands soybeans should be planted in soil with sufficient moisture to germinate the seed and sustain seedling growth.

Further evidence that commercial nitrogen is not needed for soybeans in Alabama is the fact that 60 to 70 bushels per acre of beans have been produced on sandy soils low in soil nitrogen without additions of nitrogen fertilizer. Also, recent research using nodulating and non-nodulating lines of the same variety of soybeans with a wide range in rates of applied nitrogen show that root nodulating bacteria provide enough N to the plant to prevent this element from limiting yields.

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[3] Unpublished data from Dr. A. E. Hiltbold, Professor, Department of Agronomy and Soils.

TABLE 20. EFFECTS OF FERTILIZER NITROGEN ON SOYBEAN YIELDS

Test No.	Location, years of experiment, and soil class[1]	Nitrogen per acre	Per acre yield: Without N	Per acre yield: Difference with N
		Lb.	*Bu.*	*Bu.*
1	Gulf Coast Substation (1954-57), fsl	25	34	−2
		50[2]	34	+1
2	Gulf Coast Substation (1958-65), fsl	25	33	+1
		50[2]	33	+2
3	Gulf Coast Substation (1968), fsl	63	34	−1
4	Brewton Experiment Field (1954-58), sl	25	26	+1
		50[2]	26	+1
5	Brewton Experiment Field (1962-67), sl	25	33	0
6	Plant Breeding Unit (1967), fsl	50[3]	47	−3
7	Plant Breeding Unit (1968), fsl	50[3]	18	+2
8	Agronomy Farm, Auburn (1965-66), sl	67	28	0
9	Johnson Bros. Farm, Macon County (1967), vfsl	120[4]	6	+19
10	Johnson Bros. Farm, Macon County (1967), vfsl	120[4]	34	+11
11	Faulkner Farm, Perry County (1967), cl	80	44	0
12	Lower Coastal Plain Substation (1967-69), sl	50	24	0

[1] Abbreviations: fsl = fine sandy loam; sl = sandy loam; vfsl = very fine sandy loam; and cl = clay loam.

[2] Split application, 25 lb. nitrogen at planting and the same amount as sidedressing at last cultivation.

[3] Soybeans after rye seed crop, which left about 2 tons of straw per acre.

[4] These tests were conducted at different locations in one field. The untreated soil on one test area was low in N; the other was relatively high. Bean plant roots had no nodules on them.

PHOSPHORUS AND POTASSIUM

Although the soybean plant is not highly responsive to **direct** applications of phosphorus (P) and potassium (K) profitable yields can be obtained only if adequate levels of P and K in the soil are maintained. In rotations with other crops, particularly in double-cropping, enough P and K should be applied to the other crop, or crops, in the sequence to maintain these elements in the soil at a level sufficient for beans and the other crops.

Row applications of fertilizer are not recommended for soybeans, including so-called "pop-up" treatments, as the soybean seedling is too sensitive to salt injury *(10)*. If fertilizer is added directly for soybeans it should be broadcast.

Phosphorus Fertilization

The data in Table 21 show that soybeans at four of the five locations testing "low" or "very low" gave increases in yields ranging from 5 to 21 bushels per acre. On the other hand, no lo-

TABLE 21. RESPONSE OF SOYBEANS TO PHOSPHORUS ON SOILS OF VARIOUS FERTILITY LEVELS, 1967-69

Location of experiment	Soil type	Phosphorus level in untreated soil	Yields per acre		
			Without phosphorus	With phosphorus[1]	Increase for phosphorus
			Bu.	*Bu.*	*Bu.*
Black Belt Substation, Marion Junction	Vaiden clay	Very low	21.3	34.4	13.1
Gulf Coast Substation, Fairhope	Malbis fine sandy loam	Very low	10.1	30.9	20.8
Sand Mountain Substation, Crossville	Hartsells fine sandy loam	Low	25.8	38.6	12.8
Brewton Experiment Field	Benndale sandy loam	Low	22.0	27.0	5.0
Monroeville Experiment Field	Lucedale very fine sandy loam	Low	30.5	29.8	— 0.7
Tenn. Valley Substation, Belle Mina	Decatur clay loam	Medium	21.0	22.2	1.2
Prattville Experiment Field	Lucedale sandy loam	High	36.4	37.9	1.5
Wiregrass Substation, Headland	Dothan sandy loam	High	29.4	27.9	— 1.5
Lower Coastal Plain Substation, Camden	McLaurin sandy loam	Very high	25.2	24.3	— 0.9

[1] Rates of phosphorus applied varied at different locations but was adequate in all tests not to limit yields. Results are averages of 1968 and 1969 except Gulf Coast and Lower Coastal Plain Substation tests are 1967-69 yields and Prattville Experiment Field 1969 only.

FIG. 14. Crop failure on 900 acres of newly-cleared acid clay soil in the Black Belt that was neither limed nor fertilized. Soil tested pH 4.9 and showed practically no readily soluble phosphorus. Photographed August 30, 1967.

cation gave a significant yield increase when the soil tested "medium" or higher in P.

Most lands in Alabama that have not been fertilized or cropped are likely to be deficient in P. Figure 14 shows soybeans in a 900-acre field on newly cleared land in Alabama's Black Belt which was neither fertilized nor limed the first year it was planted in beans. The pH of this clay soil was 4.9 and the soil test for P was extremely low and barely enough to measure. The crop was a complete failure because of low soil pH and P deficiency, as 1967 was an excellent rainfall year for soybeans.

Potassium Fertilization

A 50-bushel soybean crop removes about 100 pounds of K in the seed which is approximately 60 per cent of the total K taken up by the crop. Since K is subject to leaching, particularly from sandy soils, it is obvious that fertilizer K must be added to give high yields and maintain soil levels.

In an experiment at Auburn on Norfolk sandy loam, Table 22, rates of K from 0 to 99 pounds per acre were applied annually for 3 years. Cover Photo 3 shows K deficiency symptoms on soybeans

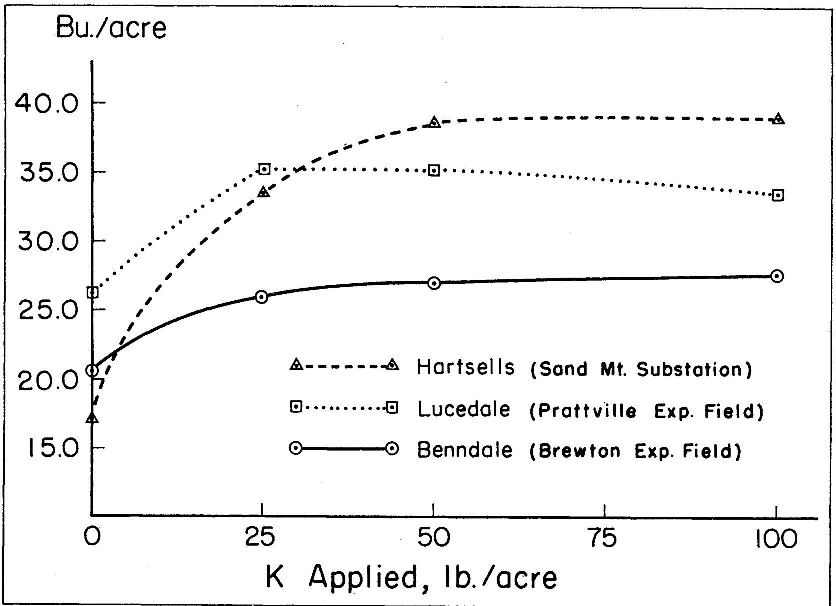

FIG. 15. Response of soybeans to potassium on soils testing "low" in this element.

where none was applied and response to this nutrient, in this experiment. Both seed and straw were removed in this test and yield increases were obtained from each increment of K up to the maximum used. The soil, however, did not show much buildup in K even at the highest rate of fertilization.

Field experiments at nine other locations measured response of soybeans to K fertilizer. No response was obtained on six of these areas where the soils tested "medium" or "high" in K. Definite

TABLE 22. RESPONSE OF SOYBEANS TO POTASSIUM ON NORFOLK SANDY LOAM, AUBURN[1]

Pounds of K[2] per acre applied annually	Yields per acre			
	1967	1968	1969	3-year av.
	Bu.	*Bu.*	*Bu.*	*Bu.*
0	13	5	2	7
33	48	23	21	31
66	59	32	37	43
99	68	35	41	48

[1] Continuous soybeans for 3 years with beans and straw removed each year. "Very low" to "low" in potassium except the plots receiving highest rate of fertilizer which tested low "medium" before planting in 1969.

[2] In terms of K_2O these rates are 0, 40, 80, 120 pounds per acre.

yield increases were obtained on the three soils testing "low" in K as shown in Figure 15. On the Hartsells soil, which produced the highest yield of the nine experiments, 25 pounds per acre of K more than doubled the yield and the second increment of 25 pounds of K gave an additional 5-bushel increase.

WEEDS AND THEIR CONTROL

GALE A. BUCHANAN, D. L. THURLOW, AND HOWARD T. ROGERS[1]

THE MOST DIFFICULT WEEDS to control in soybeans in the Southeastern States are cocklebur, pigweeds, sicklepod[2], prickly sida[3], morningglories, sesbania, johnsongrass, crotalaria, nutsedges, and Florida beggarweed *(2)*. These species account for about 90 per cent of the unsolved weed problems in Alabama, although a few other weeds are serious problems in some areas *(20)*.

In certain areas weed populations appear to be shifting and present new problems. For example, in the Black Belt region of Alabama, where a large acreage of soybeans has been planted on old pastureland, prickly sida is increasing rapidly as a problem.

Control of weeds in soybeans has received considerable attention in Alabama. This research has been reported in detail *(4,5,6, 7,8,12)*.

FIG. 16. Sicklepod, one of the major weeds in soybeans, occurs in cultivated fields throughout the southeastern United States.

[1] Associate Professors and Professor, respectively, Department of Agronomy and Soils.
[2] Sometimes referred to as coffeeweed. See Fig. 16.
[3] Sometimes referred to as teaweed or ironweed.

MECHANICAL METHODS

Although interest in herbicides is growing rapidly, mechanical methods alone or in combination with herbicides are still common. Soybean weed control is most important early in the season as normally the plants shade the space between rows in about 5-6 weeks. The rotary hoe is an efficient tool for early season weed control and should be used before or no later than when weeds emerge. This tool is usually more effective when a crust has formed on the soil surface after light rains. Rotary hoes can be used until soybean plants are 4 to 6 inches tall. One or two cultivations with sweeps normally complete mechanical control. Frequently, rains that favor germination and growth of weeds also prohibit mechanical cultivation and intensify the need for herbicides.

CHEMICAL METHODS

Major weed species, soil types, and locations where herbicides have been tested on soybeans in Alabama are listed in Table 23. Preplant and preemergence applications of herbicides were applied in 15 to 17 gallons of water per acre and directed postemergence sprays in 20 to 25 gallons. Grass, broadleaf weeds, and soybean plant counts were made 4 to 6 weeks after application of herbicides. Weed control and soybean injury ratings were made periodically throughout the season. Only two ratings, early and

TABLE 23. LOCATIONS, SOIL TYPES, AND MAJOR WEED SPECIES WHERE HERBICIDES WERE EVALUATED, 1967-70

Location	Soil type	Major weed species present
Sand Mountain Substation (SMS) Crossville	Hartsells fine sandy loam	Crabgrass, carpetweed, morningglory, crotalaria
Tennessee Valley Substation (TVS) Belle Mina	Decatur clay loam	Crabgrass, morningglory, prickly sida, cocklebur
Plant Breeding Unit (PBU) Tallassee	Cahaba sandy loam	Crabgrass, morningglory, crowfootgrass, goosegrass, sicklepod, prickly sida
Black Belt Substation (BBS) Marion Junction	Vaiden clay	Green foxtail, prickly sida
Gulf Coast Substation (GCS) Fairhope	Malbis sandy loam	Crabgrass, fall panicum, goosegrass, crowfootgrass, sicklepod, Florida purslane, prickly sida
Monroeville Experiment Field (MEF) Monroeville	Lucedale sandy loam	Crabgrass, goosegrass, crowfootgrass, sicklepod
Auburn Agronomy Farm (AUB) Auburn	Chesterfield sandy loam	Crabgrass, goosegrass, crowfootgrass, morningglory, sicklepod, pigweed, ragweed

late, are reported in most of the tables herein as they follow closely actual counts. These ratings are reported on a 0 to 100 scale with 0 indicating no effect and 100 complete control of the weeds or death of the soybeans.

Preplant Treatments

These chemicals are applied prior to planting and usually are incorporated into the soil. An exception to this is Paraquat, a contact-type herbicide which is not mixed with the soil, but is used to kill the tops of weeds growing on the land before planting. This allows the grower to plant in a clean seedbed where the soil had been prepared earlier in the year.

Trifluralin (Treflan) has been widely used for weed control in soybeans for the past 5 years. Control of annual grass weeds has been consistently excellent even at rates at low as 0.25 pound per acre, Table 24. Broadleaf weed control generally has been either poor or at best inconsistent. Trifluralin has not caused any reduction in yield of soybeans when used at normal rates. The herbicidal performance of nitralin (Planavin) has been almost identical, to trifluralin, Table 24. Grass control has been consistently high but broadleaf control has often been erratic. No yield reduction of soybeans has been noted when treated with nitralin at rates of 1.0 pound per acre or less.

A conspicuous lack of broadleaf weed control by both trifluralin and nitralin detracts immeasurably from their importance as soybean herbicides. These herbicides usually fail to give satisfactory control of prickly sida, all morningglories, sicklepod, sesbania, cocklebur, ragweed, jimsonweed, and Florida beggarweed. Control of Florida purslane, pigweeds, and lambsquarters has generally been satisfactory.

Evaluation of time of application of both trifluralin and nitralin was carried out from 1967 to 1969 at the Black Belt Substation, Table 25. Control of annual grasses was generally good at all herbicide rates and at all dates of application. When averaged across all rates, grass weed control was only slightly better with planting-time application of herbicide than with applications made in late winter or very early spring. However, if only the 1.0 pound per acre rate is considered, it is readily apparent that the later application was slightly more effective. It does appear that trifluralin or nitralin can be applied up to several weeks prior to planting soybeans and still perform satisfactorily.

TABLE 24. EFFECT OF DIFFERENT HERBICIDES ON WEED CONTROL AND INJURY TO SOYBEANS

Chemical	Year	Location[2]	Rate lb./A.[3]	Weed control[1]				Injury to soybeans	
				Grass		Broadleaf			
				Early	Late	Early	Late	Early	Late
Preplant treatments									
Trifluralin	1967	PBU	0.50	94	97	100	----	0	0
(Treflan)			0.75	82	95	98	----	0	0
			1.00	95	95	94	----	5	0
		GCS	0.75	----	95	----	0	0	0
			1.00	----	95	----	40	0	0
		SMS	0.25	92	88	88	71	0	0
			0.50	88	92	88	67	0	0
			0.75	93	92	92	85	0	0
	1968	BBS	1.00	91	85	97	0	2	0
	1969	PBU	0.50	----	80	----	50	0	0
			1.00	----	100	----	100	10	0
	1970	MEF	0.25	----	98	----	0	--	0
			0.50	----	100	----	0	--	0
			0.75	----	100	----	8	--	0
			1.00	----	100	----	3	--	0
Nitralin	1967	PBU	0.50	94	95	94	----	0	0
(Planavin)			0.75	74	95	85	----	0	0
		SMS	0.50	94	86	93	68	0	0
			0.75	97	97	95	88	10	0
	1969	PBU	0.50	----	90	----	0	--	3
			1.00	----	95	----	0	--	3
	1970	MEF	0.25	----	95	----	0	--	0
			0.50	----	100	----	0	--	3
			0.75	----	96	----	0	--	8
			1.00	----	99	----	0	--	0
Vernolate	1967	PBU	2.00	95	50	55	----	0	0
(Vernam)			3.00	100	100	92	----	0	0
			4.00	100	100	84	----	5	0
		GCS	2.00	----	90	----	0	--	0
			3.00	----	90	----	70	--	0
			4.00	----	95	----	98	--	0
		SMS	2.00	98	93	95	86	0	0
			3.00	100	52	95	87	5	0
			4.00	100	96	95	95	15	0
	1968	BBS	2.00	95	95	----	100	5	0
			3.00	93	94	----	100	17	0
	1969	PBU	2.00	----	100	----	0	--	13
			3.00	----	98	----	0	--	20

(Continued)

TABLE 24 (*Cont.*). EFFECT OF DIFFERENT HERBICIDES ON WEED CONTROL AND INJURY TO SOYBEANS

Chemical	Year	Location[2]	Rate lb./A.[3]	Weed control[1] Grass Early	Weed control[1] Grass Late	Weed control[1] Broadleaf Early	Weed control[1] Broadleaf Late	Injury to soybeans Early	Injury to soybeans Late
Vernolate (Vernam)	1970	MEF	2.00	----	95	----	4	--	6
			2.50	----	98	----	20	--	6
			3.00	----	98	----	60	--	10
			4.00	----	100	----	65	--	20
Preemergence treatments									
Chloramben (Amiben)	1967	AUB	2.00	----	95	----	50	--	0
			3.00	----	99	----	72	--	0
			2.00[4]	----	97	----	40	--	0
			3.00[4]	----	98	----	20	--	0
		GCS	3.00	97	90	95	65	0	0
		SMS	2.00	98	100	91	96	3	0
			3.00	100	100	96	96	3	0
			4.00	100	96	98	93	15	0
			2.00[4]	98	100	92	93	0	0
			3.00[4]	100	96	95	95	0	0
	1968	BBS	2.00	99	89	----	97	5	0
			3.00	99	98	----	97	7	0
			4.00	----	47	----	30	--	0
		SMS	2.00	60	23	----	----	0	0
			3.00	52	25	----	----	0	0
			4.00	67	57	----	----	0	0
		GCS	2.00	92	----	41	10	0	0
			3.00	90	----	61	0	0	0
		TVS	2.00	----	----	15	30	0	0
			3.00	----	----	37	52	0	0
	1969	BBS	2.00	91	83	91	60	0	0
			3.00	99	95	99	99	0	0
		PBU	2.50	100	73	----	99	0	0
		GCS	3.00	96	73	73	40	0	0
	1970	GCS	2.50	----	58	----	19	--	0
Alachlor (Lasso)	1967	SMS	1.00	97	100	92	93	0	0
			1.50	99	98	92	73	0	0
			2.00	98	100	93	90	0	0
			3.00	96	100	95	90	0	0
	1968	BBS	2.00	95	92	100	----	0	0
			3.00	99	97	100	----	0	0
			5.00	100	99	100	----	0	0
		SMS	1.00	86	64	----	----	0	0
			2.00	94	88	----	----	0	0
			4.00	93	96	----	----	0	0
	1969	BBS	2.00	93	63	98	30	0	3
			3.00	92	92	93	63	0	17
			4.00	99	93	96	63	0	13

(Continued)

TABLE 24 *(Cont.)*. EFFECT OF DIFFERENT HERBICIDES ON WEED CONTROL AND INJURY TO SOYBEANS

Chemical	Year	Location[2]	Rate lb./A.[3]	Weed control[1]				Injury to soybeans	
				Grass		Broadleaf			
				Early	Late	Early	Late	Early	Late
Alachlor (Lasso)	1969	GCS	1.00	----	----	----	0	--	0
			2.00	----	----	----	0	--	0
			3.00	----	----	----	23	--	0
			4.00	----	----	----	67	--	0
		SMS	1.50	99	58	53	13	0	0
			3.00	100	79	99	66	0	0
			4.50	100	70	95	66	0	0
	1970	SMS	2.00	71	66	68	43	5	0
			3.00	100	100	65	73	10	0
			4.00	99	99	89	94	14	0
			5.00	100	100	93	85	10	3
			2.00[5]	96	98	84	56	0	0
			3.00[5]	100	100	100	96	0	0
			4.00[5]	99	99	93	99	0	0
			5.00[5]	100	100	89	66	0	0
Preforan	1967	AUB	3.00	----	90	----	10	0	0
			6.00	----	95	----	72	0	0
	1968	GCS	3.00	----	90	57	22	8	0
			6.00	----	90	42	10	20	0
			9.00	----	91	80	0	26	0
	1969	GFS	2.00	----	----	----	20	--	0
			4.00	----	----	----	0	--	0
			6.00	----	----	----	0	--	0
		SMS	2.00	86	0	53	0	0	0
			4.00	94	10	71	15	0	0
			6.00	98	30	95	33	0	0
	1970	SMS	4.50	99	98	99	100	0	0
			6.00	99	98	100	94	0	0
		MEF	4.50	----	74	----	0	--	4
			6.00	----	74	----	0	--	3

(Continued)

TABLE 24 *(Cont.)*. EFFECT OF DIFFERENT HERBICIDES ON WEED CONTROL AND INJURY TO SOYBEANS

Chemical	Year	Location[2]	Rate lb./A.[3]	Weed control[1]				Injury to soybeans	
				Grass		Broadleaf			
				Early	Late	Early	Late	Early	Late
Postemergence treatments									
Linuron	1967	AUB	0.25	15	20	15	20	0	5
(Lorox)			0.50	0	85	22	75	0	5
			1.00	90	82	47	55	0	10
			2.00	100	97	87	95	0	35
	1968	GCS	0.50	96	13	85	92	0	3
			1.00	98	46	100	100	10	0
			2.00	100	66	100	96	10	33
			4.00	100	75	100	91	11	78
	1969	GCS	0.50	----	----	86	64	0	--
			1.00	----	----	93	83	0	--
			2.00	----	----	97	80	10	--
			4.00	----	----	99	91	16	--
	1970	GCS	1.00	----	74	----	64	--	20

[1] All ratings are expressed as per cent of check plots that received no herbicides.
[2] Abbreviations: AUB = Agronomy Farm (Auburn); BBS = Black Belt Substation (Marion Jct.); GCS = Gulf Coast Substation (Fairhope); MEF = Monroeville Experiment Field; PBU = Plant Breeding Unit (Tallassee); SMS = Sand Mountain Substation (Crossville); TVS = Tennessee Valley Substation (Belle Mina).
[3] Rate is given in lb./A. of active ingredient.
[4] Ester of chloramben.
[5] Preemerge applications. Other test in 1970 was preplant and incorporate.

Vernolate (Vernam) gave excellent control of annual grass weeds, Table 24. Broadleaf control was often unacceptable. Morningglories, Florida beggarweed, sicklepod, and cocklebur are not usually adequately controlled by vernolate. One of the most attractive features of vernolate is its excellent activity against the nutsedges. Vernolate can be incorporated into the soil either with a disk harrow or a power-driven rotary hoe. Recent studies on peanuts show either similar or better performance of vernolate when injected into the soil *(13)*. Although vernolate often causes leaf malformation in young soybeans, yield reductions have not been measured.

Preemergence Treatments

In the Midwest, chloramben (Amiben) is widely used for weed control in soybeans, but results obtained with this herbicide in Alabama have been inconsistent, Table 24. As with most herbicides used on soybeans, grass control has been better than broadleaf control with chloramben. This herbicide may cause

TABLE 25. INFLUENCE OF TRIFLURALIN AND NITRALIN ON ANNUAL GRASS CONTROL AND SOYBEAN YIELDS WHEN APPLIED IN MID-, LATE-WINTER, SPRING, AND AT PLANTING TIME[1]

Herbicide	Rate/ A.[3]	Date of appli- cation	Grass control[2]						Av.	Soybean yield/A.	
			Early			Late					
			1967	1968	1969	1967	1968	1969		1967	1969
	Lb.		*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Bu.*	*Bu.*
Trifluralin	1.0	Jan.-	97	65	94	78	32	100		25.3	23.5
(Treflan)	2.0	Feb.	100	81	100	73	88	100	86	25.0	23.7
	4.0		100	72	100	100	62	99		24.2	24.3
	1.0	Mar.-	98	47	75	90	15	75		21.9	22.6
	2.0	Apr.	98	85	98	92	77	98	85	19.1	22.1
	4.0		100	92	100	98	96	100		26.1	21.5
	1.0	May-	100	93	100	90	91	99		20.2	25.5
	2.0	June	100	97	100	96	97	98	96	19.5	28.5
	4.0		100	93	100	97	74	99		16.8	27.7
Nitralin	1.0	Jan.-	95	67	94	80	22	100		20.0	21.4
(Planavin)	2.0	Feb.	100	86	75	98	97	100	89	25.5	28.6
	4.0		100	95	100	98	97	100		19.1	23.5
	1.0	Mar.-	100	87	74	04	90	73		24.8	26.5
	2.0	Apr.	100	90	99	97	90	97	93	19.3	27.1
	4.0		100	90	100	98	94	99		22.3	28.0
	1.0	May-	100	90	100	93	97	99		17.2	30.7
	2.0	June	100	97	98	96	99	97	96	19.7	28.6
	4.0		100	98	98	98	100	75		12.5	26.9
Check		..	0	0	0	0	0	0		13.9	22.3

[1] Experiment conducted on acid clay soil, Black Belt Substation.
[2] Ratings expressed as per cent of check plots that received no herbicides.
[3] Rate is given in lb./A. of active ingredient.

slight stunting of the soybean plant, especially when large rains occur immediately after application, but this usually does not result in a yield reduction. Control of annual grass weeds has been extremely consistent with alachlor (Lasso) *(8)*. In only two experiments during the 4-year period was it evident that grass control was not acceptable at the 2.0 pounds per acre rate when evaluated late in the growing season. Earlier ratings or late season ratings of plots treated with higher rates revealed satisfactory control of annual grass weeds. Control of broadleaf weeds has been much more erratic. Favorable broadleaf weed control ratings indicated control of pigweed, Florida purslane, carpetweed and other small-seeded broadleaf weeds. Large-seeded broadleaf weeds such as morningglory, cocklebur, and sicklepod were not adequately controlled. Alachlor has caused only slight "injury" to soybeans in a few experiments, which has not resulted in measureable loss of yield.

TABLE 26. EFFECTS OF DIRECTED AND OVER-THE-TOP APPLICATIONS OF CHLOROXURON (TENORAN) ON WEED CONTROL AND SOYBEAN INJURY, GULF COAST SUBSTATION

Year	Surfactant or oil[1]	Rate of chloroxuron[3]	Grass control[2]		Broadleaf control[2]		Soybean injury[2]	
			Early	Late	Early	Late	Early	Late
		Lb./A.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1967	None	1.5[4]	0	80	33	50	0	0
	None	3.0[4]	0	86	28	33	0	0
	Surfactant	1.0[4]	0	75	40	40	0	0
	Surfactant	1.5[4]	0	85	70	76	0	0
	Surfactant	3.0[4]	0	60	93	85	0	0
	None	1.5	46	90	45	43	0	0
	None	3.0	13	63	46	33	0	0
	Surfactant	1.0	43	83	80	70	0	0
	Surfactant	1.5	78	88	83	78	0	0
	Surfactant	3.0	46	90	91	88	0	0
1968	Surfactant	0.5	----	----	16	10	0	0
	Surfactant	1.0	----	----	30	6	0	0
	Surfactant	2.0	----	----	40	36	0	0
	Surfactant	4.0	----	----	46	45	0	0
	Oil	0.5	----	----	30	13	0	0
	Oil	1.5	----	----	90	38	0	0
	Oil	2.0	----	----	90	81	0	0
	Oil	3.0	----	----	80	81	0	30
1969	Surfactant	0.5	----	----	0	4	0	----
	Surfactant	1.0	----	----	35	6	18	----
	Surfactant	2.0	----	----	18	31	4	----
	Surfactant	3.0	----	----	50	25	10	----
	Oil	0.5	----	----	38	11	38	----
	Oil	1.0	----	----	69	35	53	----
	Oil	2.0	----	----	95	60	58	----
	Oil	3.0	----	----	98	54	60	----

[1] Surfactant used varied from year to year. Non-phytotoxic oil at rate of 2 gallons per acre.
[2] Ratings are expressed as per cent of check plots that received no herbicides.
[3] Rate is given in lb./A. of active ingredient.
[4] Post directed spray. All other treatments were applied over-the-top.

Preforan is currently used for soybean weed control in the midwestern United States. It has been extensively evaluated in Alabama and generally grass weed control has been acceptable, Table 24. However, control of broadleaf weeds with this chemical has been erratic. Some early injury of soybeans has been noted as revealed by stunting and crinkling of leaves.

Postemergence Treatments

Chloroxuron (Tenoran) has given acceptable control of broadleaf weeds in some, but not all, experiments during the 3 years it has been evaluated, Table 26. In 1967 the addition of a surfactant improved performance. Directed applications were more effec-

TABLE 27. INFLUENCE OF DINOSEB ALONE AND IN COMBINATION WITH NAPTALAM (ALANAP) ON WEED CONTROL AND INJURY TO SOYBEANS APPLIED AS POSTEMERGENCE DIRECTED SPRAY

Year	Location[2]	Rate per acre[3]		Grass control[1]		Broadleaf control[1]		Soybean injury[1]	
		Dinoseb	Nap-talam	Early	Late	Early	Late	Early	Late
		Lb.	*Lb.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1967	AUB	1.5	----	10	40	40	20	0	0
		3.0	----	60	90	65	75	0	0
		4.5	----	60	90	67	55	0	0
		6.0	----	0	85	70	62	0	0
		1.5	3.0	80	85	80	85	0	15
		1.5	3.0	----	90	----	87	----	----
		3.0	6.0	----	90	----	80	----	----
		4.5	9.0	----	95	----	96	----	----
	GCS	1.5	3.0	20	53	13	40	0	0
		3.0	6.0	13	56	23	23	0	0
		4.5	9.0	0	68	56	36	0	0
1968	GCS	1.0	2.0	----	90	81	95	13	0
		2.0	4.0	----	86	85	91	11	3
		4.0	8.0	----	93	83	91	18	0
		8.0	16.0	----	91	91	88	15	3
1969	BBS	1.0	2.0	86	88	95	85	0	0
		2.0	4.0	87	87	97	87	0	0
		3.0	6.0	95	95	95	98	0	0
	PBU	1.0	2.0	15	0	----	15	----	0
		2.0	4.0	73	18	----	92	----	0
		3.0	6.0	98	35	----	98	----	0

[1] Ratings are expressed as per cent of check plots that received no herbicides.
[2] AUB = Agronomy Farm, Auburn; GCS = Gulf Coast Substation; BBS = Black Belt Substation; PBU = Plant Breeding Unit, Tallassee.
[3] Rates given in lb./A. of active ingredient.

tive than over-the-top sprays. Four pounds per acre of this herbicide did not give acceptable weed control in 1968, but this may have been because of the large size of the weeds at time of treatment. Adding a non-phytotoxic oil to chloroxuron improved its performance but caused some foliar burn of the soybeans. Chloroxuron applied either alone or with a surfactant or non-phytotoxic oil has not caused a measurable yield reduction.

Linuron (Lorox) applied at 1.0 pound per acre as a directed spray controlled broadleaf weeds in 1968 and 1969, Cover Photo 8 and Table 24. In 1970, the 1.0 pound rate did not give acceptable control. Treatment with rates above 1.0 pound per acre has, on occasion, caused a reduction in soybean yields.

Foliar applications of linuron are extremely active as shown by both weed control ratings and soybean injury. Linuron is, how-

TABLE 28. INFLUENCE OF DIRECTED APPLICATIONS OF PARAQUAT WITH SURFACTANT ON BROADLEAF WEED CONTROL, SOYBEAN INJURY, AND YIELD OF SOYBEANS

Year	Location[2]	Rate/A.[3]	Broadleaf control[1]		Soybean injury[1]		Soybean yield per acre	
			Early	Late	Early	Late	Cul-tivated	Uncul-tivated
		Lb.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Bu.*	*Bu.*
1967	AUB	0.25	97	100	0	0	----	----
		0.50	100	100	0	0	----	----
1968	GCS	0.25	97	98	18	8	49	----
		0.50	98	99	40	5	40	----
		1.00	100	92	50	38	35	----
		2.00	100	36	60	86	13	----
		Check	----	----	----	----	30	----
1969	GCS	0.25	93	93	35	----	41	38
		0.50	95	83	63	----	33	39
		1.00	92	7	85	----	2	20
		2.00	88	0	93	----	0	1
		Check	----	----	----	----	44	34

[1] Ratings are expressed as per cent of check plot that received no herbicides.
[2] AUB = Agronomy Farm, Auburn; GCS = Gulf Coast Substation.
[3] Rate given in lb./A. of active ingredient.

ever, an extremely effective herbicide if care is exercised in its application. Equipment must be properly adjusted to ensure that in directed application the herbicide comes in contact *only* with the lower 2-3 inches of the soybean plant.

Dinoseb alone and combined with naptalam showed variable performance as a directed postemergence herbicide treatment over a 4-year period at four locations, Table 27. The effectiveness of dinoseb as a contact spray is affected by temperature and size of weeds. Naptalam, which is active on many of the large-seeded broadleaf weeds, is dependent upon moisture.

Experimental Herbicides

Several chemicals which are experimental and not yet approved for use on this crop have been tested for weed control on soybeans. One of these, GS-16068, tested at one location only, gave acceptable broadleaf weed control 3 of 4 years when applied as postemergence directed spray at 1 to 2 pounds per acre. This herbicide was applied at different stages of growth of the soybean plant in 1969 and was found to be most effective when bean plants were 8 inches and weeds 2 to 4 inches high. EL-119, Bay-94337, and Bas-3870 are being evaluated. Preliminary results indicate they will control annual grasses, but, like many herbicides currently evaluated for weed control in soybeans, they are erratic in their effects on large-seeded broadleaf weeds. Paraquat, an extremely active contact-type herbicide, has been tested as a postemergence directed spray and as a "knockdown" chemical prior to planting. As a post directed spray at 0.25 pound per acre this material killed weeds but at higher rates injured soybeans, Table 28. This herbicide needs evaluation at lower rates.

Paraquat, linuron, and alachlor were used in no-tillage experiments and the results reported in another section of this bulletin.

DISEASES AND THEIR CONTROL

E. A. CURL AND R. RODRIGUEZ-KABANA[1]

As SOYBEAN ACREAGE INCREASES in Alabama, growers can expect an increase in disease problems. When new lands are cleared and planted to soybeans, diseases may cause little damage for the first 2 or 3 years. Many parasites are present, however, in the soil and on various weed hosts. In dense plantings of soybeans they are able to multiply rapidly by producing millions of spores or other structures until the "inoculum level" is so high that large areas in fields may be destroyed or yields greatly reduced by disease.

The Southern States afford a favorable climate for many plant pathogens (parasites). The grower should become familiar with the more serious diseases and, at the same time, be aware of certain other diseases that probably will appear as soybean culture increases. There are at least 50 known diseases of soybeans. The major ones are caused by bacteria, viruses, fungi, and nematodes. Some others are not inflicted by parasites, but may be brought on by nutrient deficiencies and various other physiological disturbances. Plants often show disease-like symptoms as a result of drought, herbicide injury, or excessive fertilization.

The parasitic diseases of plants may be grouped according to the primary causal agent or to the principal plant parts affected.

GENERAL LEAF AND STEM BLIGHT

Leaf-spot disease are caused by both bacteria and fungi. Under highly favorable conditions some of these can cause considerable damage in loss of leaf surface area or premature defoliation, resulting in reduced yields. Many bacterial diseases occur on aerial parts of soybean, but two are most likely to be encountered in the South. These are called Bacterial Pustule and Wildfire. These are closely related, since Wildfire tends to affect only parts of leaves already damaged by Bacterial Pustule.

Many leaf and stem diseases are caused by fungi; these usually also attack pods and seeds. Three are most commonly seen.

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Downy Mildew is probably the most prominent of all soybean diseases. It can be readily recognized by greenish-yellow irregular spots on the upper surface of diseased leaves and a gray fungus growth that occurs on the lower surface. Target Spot disease causes a reddish-brown irregular spot on leaf surfaces from pinpoint size to one-half inch in diameter. Larger spots often form zones or concentric rings resembling targets. Frogeye Leaf Spot appears as lesions with gray or tan centers with a reddish-brown border.

Both bacterial and fungal foliage diseases are best controlled by use of adapted resistant varieties, Table 6. Some of the parasites overwinter on old diseased plant parts. These should be turned under by deep plowing after harvest when practical. Crop rotation with non-legume crops will help prevent the organisms from multiplying and increasing to levels that might cause serious outbreaks of disease.

PURPLE SEED STAIN

This condition is common in most soybean-growing states, and is believed to be caused by species of the fungus, *Cercospora*. The organism may also attack leaves, stems, and pods causing small to spreading brown spots. Seed become pink to dark purple and may develop cracks, thus lowering their grade and value. Young seedlings become infected when diseased seed are planted. Some recommended varieties are resistant, Table 6.

FUNGAL DISEASES OF ROOT AND STEM

Some destructive diseases of soybeans are caused by fungi that live on organic matter in soil, sometimes for many years. Some produce numerous resting structures called sclerotia which further assure long survival of the fungi.

Sclerotial Blight, also called Southern Blight, is caused by the soil fungus *Sclerotium rolfsii*. The disease is most likely to occur during mid-summer periods of high temperature following rainfall. The organism inhabits organic matter near the soil surface and attacks host plants at the soil line causing stem rot and rapid death. Losses in fields of dense growth may be severe, but usually small scattered areas of dead plants appear among healthy plants. The fungus is recognized by the white cottony growth at the base

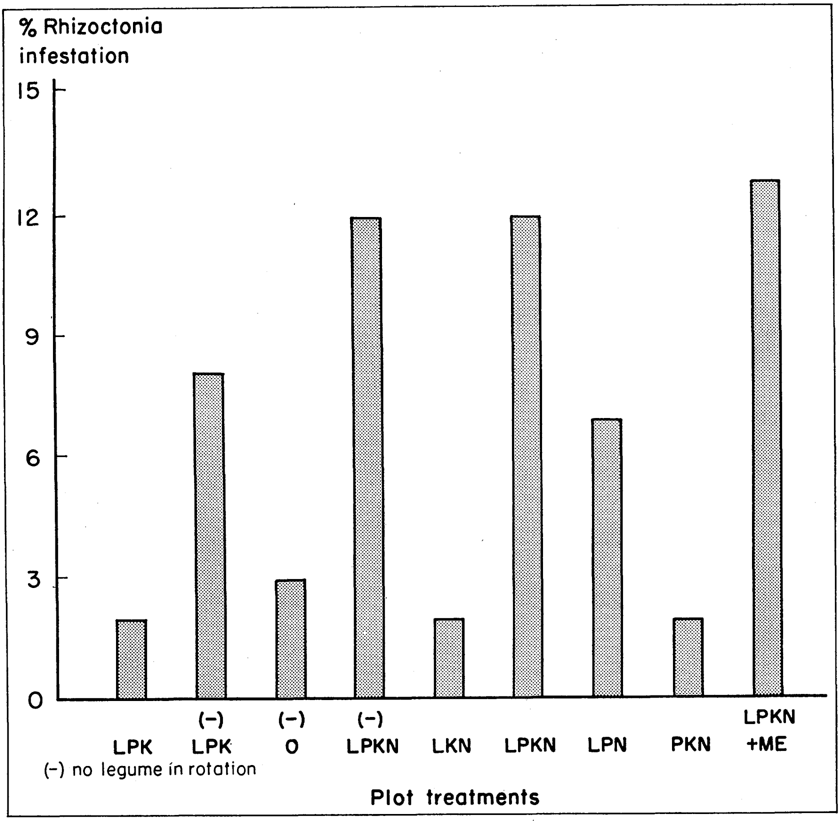

FIG. 17. Rhizoctonia **infestation in fertilizer test plots in September. Plots had received varied treatments from complete fertilization (LPKN) to treatments deficient in certain components. L = lime; P = phosphorus; K = potassium; N = nitrogen from ammonium nitrate; ME = minor elements; (—) = no winter legume in the 3-year rotation of cotton, corn-wheat, and soybeans.**

of infected stems and numerous tan to brown spherical sclerotia slightly larger than clover seed.

Since the fungus has a very wide host range, resistant varieties have not been developed. Generally, crop rotation has been of little value against Sclerotial Blight, but may help suppress certain other diseases. Excessive buildup of sclerotia may occur where continuous soybean or other legume crops are grown. Land preparation practices that allow for deep burial (4 inches) of surface organic debris may reduce chances of infection by this fungus.

Seed and Seedling Rots are caused primarily by three soil-inhabiting fungi. Species of *Pythium, Phytophthora,* and *Rhizoctonia* cause preemergence "damping-off" in cool wet soils early in the season. The action of these organisms results in sparse stands or yellowing and wilting of seedlings with a brown rot above and below the soil line. Whole root systems may be affected. Brown Stem Rot, caused by a species of *Cephalosporium,* was recently found widespread in Georgia and suggested as a potential threat to other southeastern soybean areas *(18).*

Chemical seed treatments have been of little value against these pathogens, but some resistance has been developed for *Phytophthora,* Table 6. Current research is being conducted to learn more about the ecology of these and other soil-borne pathogens and determine the feasibility of reducing disease severity by manipulating cultural practices. Figure 17 shows the relative amount of *Rhizoctonia* in the organic matter of various field plots that have received different fertilization schemes for several years. Highest infestation was in plots which had received the most complete fertilizer program. While these same plots also supported good growth and high yields of surviving plants, soybean seed mortality was high and seedling emergence low. Such studies are designed to learn possible cultural combinations, such as fertilization and rotation, that may reduce disease losses without use of chemicals.

VIRUS DISEASES

Two virus diseases are most likely to be seen in Alabama. Soybean Mosaic is widespread in all soybean-producing areas in the U.S. Infected plants are stunted and leaves are narrow and deeper green than normal; symptoms are similar to those caused by 2,4-D or related herbicides. Plants produce distorted pods and fewer seeds than normal.

Bean Pod Mottle is one of the more common virus diseases in the southern soybean areas. Young infected plants develop a green and yellow mottle on the upper leaf surface, giving a puckered appearance. Symptoms are less conspicuous in older plants, and the disease appears to cause no serious damage. However, it causes poor pod set, reduced seed size, and reduced yields. Often plants are infected by both Bean Pod Mottle and Soybean Mosaic viruses. The Bean Pod Mottle virus is transmitted by bean leaf beetles after feeding on infected beggarweed.

Little progress has been made in control of virus diseases. Virus-free seed should be used where available. Programs for control of both insects and weeds may reduce chances of infection.

DISEASES CAUSED BY NEMATODES

The plant parasitic nematodes are widely distributed and attack many crop, garden, and nursery plants. They have several stages in the life cycle: the egg, four larval stages, and adult male and female. The time from egg to adulthood is about 4 weeks. Large numbers of eggs can be produced by nematodes, and the parasite population may flare up within a growing season. The nematodes can overwinter in the soil or within roots.

Nematode damage to soybeans is mainly by injury to tissue of the roots, usually resulting in fewer roots and reducing capacity to take up water and soil nutrients. This in turn may result in stunting, foliage yellowing, and a greater susceptibility to wilting during dry periods. Damage to plant tissues is caused by feeding activities of nematodes, particularly at the developing root-tips.

Not all important nematode species enter the roots; some feed only at the root's surface, but root tip damage can stop the root's growth.

Nematode damage to soybeans varies depending on tolerance of the variety, the degree of nematode infestation, and the supply of soil nutrients and water available to the plants. Reduced yield of seed may sometimes be considerable, along with reduced stem and foliage quantity.

Nematode detection begins with observation of areas in a field where plants are not growing normally. They may be stunted, off-color, or more prone to show wilting; such areas may expand in successive years. Weakened plants may be more susceptible to other disease agents or pests. The nematode as a primary cause is easily overlooked unless soil and root examinations are made. Unfortunately, the only nematode that produces easily recognized symptoms is the rootknot nematode. Of several important types, it alone produces the conspicuous rootknots or galls.

Spread of nematodes by movement through the soil is limited to a few inches per year. However, they are widely spread in transported soil and infected plant parts. Nematodes of soybeans are not seed-borne.

Common nematodes found associated with soybeans in Alabama and parts of neighboring states are shown in Table 29 *(19)*. It should be noted that these numbers were recorded during July-September, but nematode populations will vary greatly with season. The meadow nematode (*Pratylenchus*) was most prevalent, but the rootknot nematode (*Meloidogyne*) is the most important from the standpoint of damage unless resistant soybean varieties are used. The spiral nematode (*Helicotylenchus*) was found in 74 per cent of soybean plantings in Alabama, Georgia, and Florida. The soybean cyst nematode, which has increased in some southern states, has not yet been found in Alabama.

Plant parasitic nematodes, unlike soil-inhabiting fungi such as *Rhizoctonia*, are more closely associated with living plants than dead organic matter in soil. Thus, the nematodes are more influenced by cropping. In Figure 18 are shown post-harvest determinations of rootknot nematode larval populations per gram of root material in field plots following cotton and a resistant variety of soybean (Bragg). The plots had been variously fertilized as shown in Figure 18. In most plots numbers of larvae were much higher following cotton (highly susceptible) than after soybean, and these numbers fluctuated according to fertilizer treatments.

Rootknot nematodes probably are the most important nematode pest on soybeans in Alabama. The galls produced by these nematodes are easily distinguished from the beneficial nitrogen-fixing bacterial nodules that appear as attachments to the roots and are easily broken off. The nematode knots or galls are root swellings and cannot be removed without breaking the root. Some of the small roots may end in a gall and appear club-shaped.

Control of nematodes of soybeans is possible in various ways. Using nematocidal chemicals is too expensive as a general practice for entire soybean fields, but it is the best solution for treating known infested spots in a field to prevent increase and spread of the nematode.

Soybean varieties are now available that are resistant to certain nematodes, and development of additional resistant and better suited varieties can be expected. Exact identification of kinds of nematodes present is a requirement for effective use of resistant varieties because resistance to one nematode species does not mean resistance to all the others.

Established soybeans generally are tolerant to moderate amounts of nematode infection. Therefore, any practice that can reduce populations in early season can be helpful. For example, a

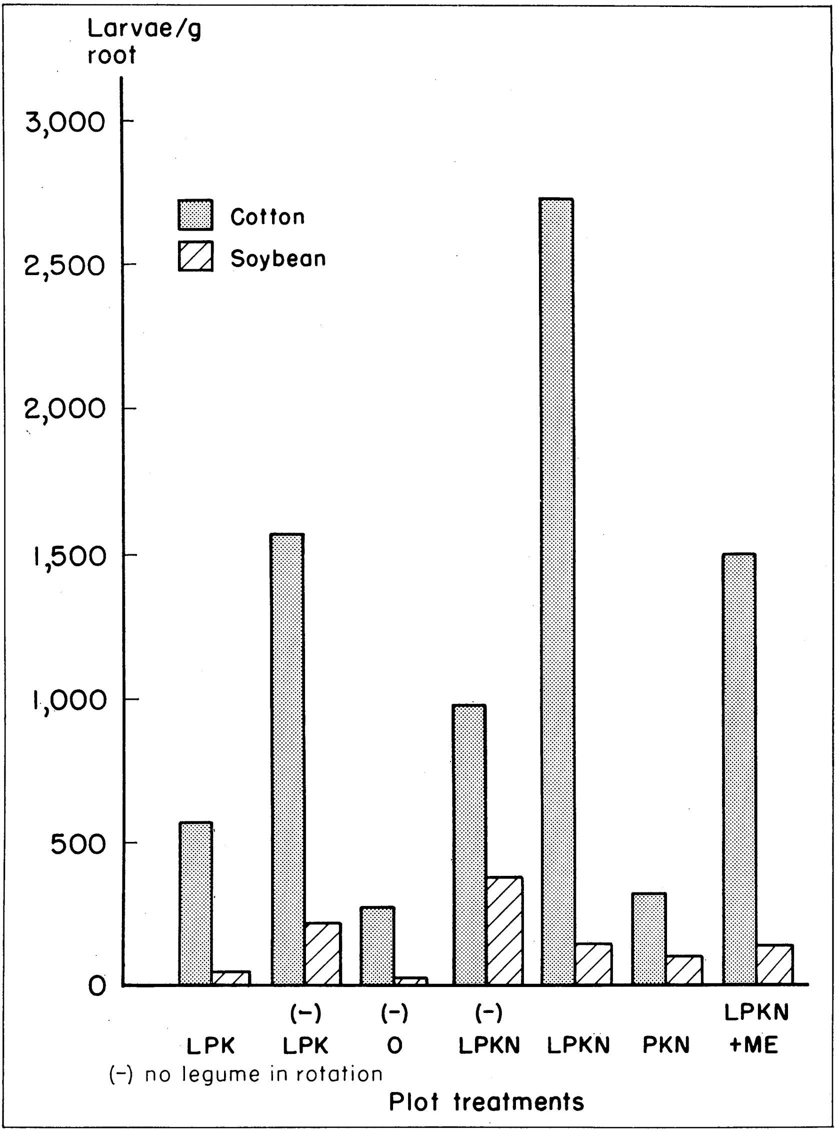

FIG. 18. Post-harvest populations of rootknot nematode larvae in fertilizer test plots following cotton and a nematode-resistant variety of soybeans. L = lime; P = phosphorus; K = potassium; N = nitrogen; ME = minor elements; (—) = no winter legume in the rotation.

planting time that would allow early development of the soybean root system may help plants escape serious damage.

TABLE 29. PLANT PARASITIC NEMATODES FOUND DURING JULY-SEPTEMBER IN SOYBEAN FIELDS IN ALABAMA AND PARTS OF GEORGIA AND FLORIDA

Nematode genus	Common name	Av. no. of nematodes per pint of soil
Pratylenchus	Lesion or meadow	608
Trichodorus	Stubby-root	103
Helicotylenchus	Spiral	125
Tylenchs	--------	62
Meloidogyne (larvae)	Rootknot	59
Xiphinema	Dagger	4
Criconemoides	Ring	1
Hoplolaimus	Lance	1

INSECTS

MAX H. BASS[1]

INSECTS THAT DAMAGE SOYBEANS in Alabama may be grouped as follows: (1) those that damage soybean seedlings, (2) those that feed on foliage, and (3) those that damage beans in the pod. Ten of the more important insects are shown in Figures 19 and 20.

SEEDLING INSECTS

Cutworms are the larvae of small moths that fly at night. When fully grown the larvae are nearly 2 inches long. Several species attack soybeans. All are fat, dark-colored, and greasy looking. They hide beneath the soil surface during the day and emerge at night to feed. Cutworms usually feed on portions of the stem rather than foliage, which results in leaves being clipped or plants being cut.

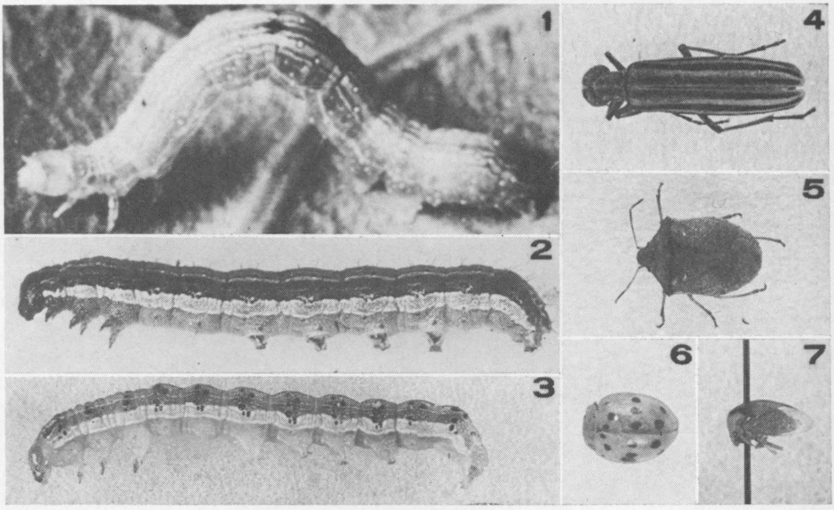

FIG. 19. Ten of the more important soybean insect pests in Alabama are shown in this Figure and Figure 20. (1) Soybean looper, (2) fall armyworm, (3) corn earworm (podworm), (4) blister beetle, (5) stinkbug, (6) Mexican bean beetle, (7) 3-cornered alfalfa hopper.

[1] Professor, Department of Zoology-Entomology.

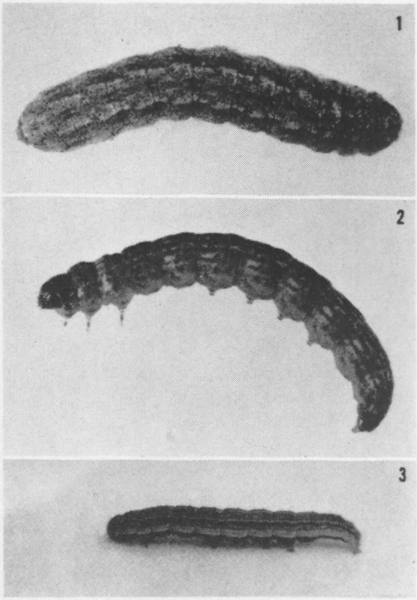

FIG. 20. Rounding out the 10 most important soybean insect pests in Alabama are these three: (1) cutworm, (2) lesser cornstalk borer, and (3) velvetbean caterpillar.

Cutworms, like other insects that affect soybean stands, are usually a problem only early in the season. They should be controlled any time they are present in large numbers. Cutworms are difficult to control in soybeans, but 1 pound of trichlorfon (Dylox®) per acre applied as a bait is usually effective, Table 30.

The three-cornered alfalfa hopper is a green, triangular shaped tree-hopper that jumps and then takes flight when disturbed. Both nymphs and adults suck juice from a number of plants. They frequently occur in damaging numbers on soybeans. The nymphs are particularly damaging because they gradually work their way around the stems as they feed. This girdles the plant and either kills it outright, or weakens it so that it later falls over and dies. The girdling takes place near ground level.

The three-cornered alfalfa hopper should be controlled when nymphs or adults are present in large numbers. Control is not difficult and can be obtained with malathion, 1 pound per acre, or almost any of the other insecticides suggested for soybean insect control.

The lesser cornstalk borer is the slender, brownish-green, cross-striped, active larva of a small brownish-gray moth. The eggs are laid on the stems of seedling plants. After hatching, the larva bores into the young stem and burrows up and down inside the stem for a distance of 1 to 2 inches. This weakens the stem and causes the plant to fall over and die. The larva constructs a tube of sand, silk, and excrement which lies horizontally in the soil and is attached to the stem at the worm's entrance hole. The larva leaves the plant through this tube when the plant dies. Older plants may also be attacked by lesser cornstalk borer larvae.

TABLE 30. CONTROL OF GRANULATE CUTWORM 24 HOURS AFTER TREATMENT, HOUSTON COUNTY, 1969

Treatment	Dead worms per row foot	Live worms per row foot	Control
	No.	*No.*	*Pct.*
Azodrin® EC 1 lb./A.[1]	5.2	0.25	95
Trichlorfon bait 1 lb./A.[2]	3.1	0.50	86
Trichlorfon bait 1 lb./A.[3]	3.5	1.25	74
Trichlorfon bait .5 lb./A.[2]	2.4	1.00	70
Trichlorfon bait .25 lb./A.[3]	2.3	1.25	64
Ciba 9491 EC 1 lb./A.[1]	1.6	0.88	64
Trichlorfon SP 1 lb./A.	2.1	1.25	63
Parathion-carbaryl EC 1 and .5 lb./A.	2.3	2.12	52
Diazinon granules 2 lb./A.	1.5	1.50	50
Methyl parathion, toxaphene, DDT .5, 2, and 1 lb./A.	0.8	1.38	37
Carbaryl SP 1.5 lb./A.	0.8	1.75	31
Methyl parathion EC .5 lb./A.	0.4	4.00	9
Check (untreated)	0	3.13	0

[1] Not labeled for use on soybeans.
[2] Hand-mixed cornmeal bait.
[3] Commercially prepared bait.

In such cases penetration of the stem may be impossible, and in attempting penetration the stem may be girdled. This may kill the plant outright or weaken it so that it later falls over and dies.

The lesser cornstalk borer cannot be adequately controlled with materials presently labeled for use on soybeans. Research on methods of control for this insect is continuing.

FOLIAGE FEEDING INSECTS

Foliage-feeding insects can cause considerable ragging of leaves without actually reducing bean yield, particularly if the feeding occurs before bloom or after bean maturity. If foliage feeding insects appear to be reducing total leaf surface in the field by as much as one-third between bloom and bean maturity, control measures are justified.

Blister beetles are elongate, soft-winged beetles that are about ⅔-inch long. They are usually black and yellow striped, but may be black or gray. They occur fairly frequently and large populations may occur in isolated parts of a soybean field. This general foliage feeder is easily seen.

Blister beetles can be controlled with 1 pound malathion, 2 pounds methoxychlor, 1 pound carbaryl (Sevin®), or 3.5 pounds toxaphene per acre.

The fall armyworm is similar in appearance to the corn earworm and is the larva of a small, night-flying moth. It has a prominent, white, inverted Y on its head. Fall armyworms are general foliage feeders, and are easily seen and collected. Their occurrence is sporadic.

Fall armyworm can be controlled with any of the materials listed for control of the corn earworm.

The soybean looper, sometimes referred to as the cabbage looper or false cabbage looper, is probably the most common pest of soybeans in Alabama. It is the larva of a small, dark gray moth. This larva is a fat "cabbage green" worm that forms loops or humps as it crawls and when fully grown is 1 to 1½ inches long. It feeds on foliage and is most often a pest from late August through September.

The soybean looper is difficult to control, but of materials labeled for use on soybeans, best control is obtained with ½ to 1 pound per acre of methyl parathion or parathion.

The Mexican bean beetle is frequently a pest of soybeans in the Gulf Coast Area of Alabama. This beetle is a destructive insect of the lady beetle family and resembles the other lady beetles in shape. The adult is hemispherical, yellow, and has 16 black spots on its back. Both adults and larvae are foliage feeders and are serious pests where they occur.

Excellent control of the Mexican bean beetle is obtained with 1 pound carbaryl per acre. Other materials that are effective against this beetle, at specified per acre rates, include 1 pound malathion, 2 pounds methoxychlor, and 2 pounds TDE.

The velvetbean caterpillar is the larva of a small night-flying moth that overwinters in the tropics and southern Florida. Adults migrate into Alabama in June or July and begin laying eggs on soybeans. The larvae are slender, green, and have faint white stripes. They are frequently serious foliage feeding pests in southwestern Alabama.

The velvetbean caterpillar can be controlled with 0.5 to 1 pound per acre of methyl parathion or any of the materials listed for control of the corn earworm. The results of a recent experiment to determine control measures for the velvetbean caterpillar are presented in Table 31.

TABLE 31. AVERAGE NUMBER OF LIVE VELVETBEAN CATERPILLARS PER 12 ROW FEET AT 24 AND 48 HOURS AFTER INDICATED TREATMENT, FAIRHOPE, 1970

Treatment	Live worms 24 hr. after treatment	Live worms 48 hr. after treatment
Methyl parathion EC 1 lb./A.	0	0
Methomyl (Lannate®) WP 1 lb./A.[1]	0	0
Azodrin® EC 1 lb./A.[1]	1.00	0.25
EPN-methyl parathion EC .5 and .5 lb./A.	1.50	0.25
EPN EC 1 lb./A.	6.25	0.25
Gardona® EC 1 lb./A.[1]	1.50	0.50
Carbaryl SP 1 lb./A.	7.00	0.50
Azinphosmethyl EC 1 lb./A.	1.00	1.00
DDT EC 1 lb./A.	19.75	2.75
Toxaphene EC 1 lb./A.	17.75	8.00
Check (untreated)	69.00	51.50

[1] Not labeled for use on soybeans.

POD-FEEDING INSECTS

Pod-feeding insects are generally more damaging than foliage feeders since they feed directly on the marketable product.

The corn earworm, sometimes called the podworm, is the larva of a small brownish-yellow moth that flies at dusk. The larvae vary in color from light green to brown and have light and dark stripes running lengthwise on the body. They are about 1½ inches long when fully grown. These caterpillars cut holes in pods, put their heads inside, and eat the beans.

When one corn earworm is found per foot of row control measures should be undertaken, Table 32. Treating with 1 pound carbaryl, 2 pounds TDE, or 1 pound methyl parathion per acre has proved effective.

Stinkbugs include several shield shaped bugs that may be brown or green depending on the species. Both nymphs and adults suck juice from beans in the pods causing discoloration of the beans and subsequent reduction in grade. Heavy populations of stinkbugs may occur in isolated parts of a soybean field and, unless fields are closely examined, such infestations may go unnoticed. Beans are susceptible to stinkbug damage up to maturity.

When large numbers of stinkbugs appear, control can be obtained with one of the following: 2 pounds carbaryl, 1¼ pounds malathion, ½ pound methyl parathion, or ½ pound parathion per acre.

TABLE 32. YIELD FROM CAGED SOYBEANS ARTIFICALLY INFESTED[1] WITH VARIOUS LEVELS OF CORN EARWORMS, PLANT BREEDING UNIT, 1969

Larvae added	Yield	Yield reduction
	Bu./A.	*Bu./A.*
One infestation		
Uninfested check	46.7	----
1/row foot	46.0	0.7
3/row foot	44.6	2.1
5/row foot	43.3	3.4
Two infestations		
Uninfested check	43.9	----
1/row foot	42.8	1.1
3/row foot	40.9	3.0
5/row foot	38.8	5.1

[1] Second instar larvae, approximately ½ inch in length, were released on the soybean pods, blooms, and foliage during the last week in August. The soybeans contained only scattered blooms and most pods were mature in length but not filled when the larvae were released. In treatments involving two infestations, the second, which was exactly like the first, was established 2 weeks after the first.

Other pests that may attack soybeans are: (1) banded cucumber beetle, (2) bean leaf beetle, (3) beet armyworm, (4) garden webworm, (5) grape colaspis, (6) green cloverworm, (7) grasshoppers, (8) whiteflies, (9) spider mites, (10) 12-spotted cucumber beetle, (11) thrips, (12) white-fringed beetle, and (13) yellow-striped armyworm.

The following restrictions should be observed with insecticides used on soybeans: **Do not feed forage treated with toxaphene, TDE, or trichlorfon to dairy animals or animals being finished for slaughter. Do not apply the following insecticides within the indicated days of harvest: carbaryl, 0; malathion, 1; methyl parathion, 20; parathion, 15; methoxychlor, 7; TDE, 28; and toxaphene, 21.**

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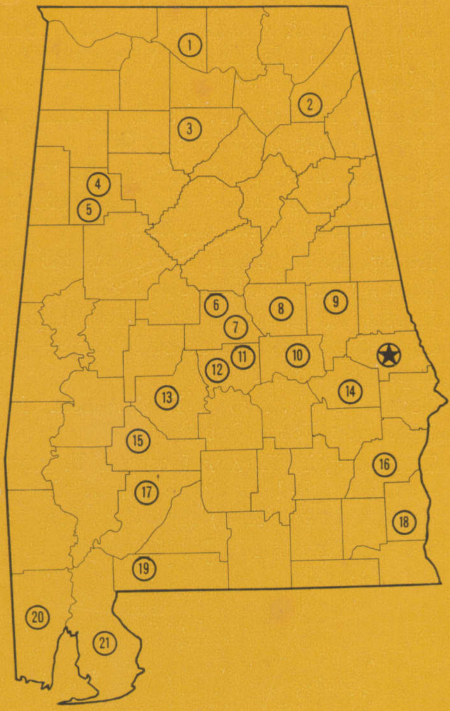

Research Unit Identification

★ 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.