LONG-TERM FERTILITY EXPERIMENTS ON COTTON, CORN, SOYBEANS, SORGHUM, AND PEANUTS, 1929 - 1982

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INTRODUCTION

A MAJOR ACTIVITY of the substation and experiment field system established in Alabama in 1928 has been research on response of crops to fertilizers. Funds provided by the 1928 legislature provided for the establishment of five substations and 10 experiment fields on the major soil types in the State. These stations concentrated on research with fertilizers during the 1930's and 1940's. The number of substations has been increased to 11 and experiment fields reduced to three over the years. Fertility research continues to be a major part of programs on many of these stations.

Fertility research on experiment stations and cooperative experiments on farmers' fields served as the basis for general fertilizer recommendations for the different soil associations through the 1930's and 1940's. It was recognized, however, that soil fertility was changing during this period due to fertilization, crop removal, and management practices. General fertilizer recommendations based on soil type were no longer accurate because phosphorus (P) tended to build up in the soil under high rates of fertilization while nitrogen (N) and potassium (K), which were applied at lower rates, were often depleted. Much research was done in field experiments and in laboratories to develop chemical soil tests that could be used to measure soil fertility and on which to base fertilizer recommendations. This resulted in establishment of the Alabama soil testing program in 1953.

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Soil-Test Calibration Research

Fertilizer recommendations from soil tests in Alabama are based on numerous experiments on substations and experiment fields of the Alabama Agricultural Experiment Station and on farmers' fields. Both yield-response data and soil-test data from experiments are necessary for calibration. Best data for soil-test calibration have been found to come from long-term experiments where treatments were repeated on the same plots over a period of years. This was also necessary to accurately determine rates of individual nutrient elements to which specific crops would respond. These experiments also make it possible to determine effects of the treatments on levels of fertility in the soil. Experiments with rates of fertilizer-nutrient elements have therefore been maintained over long periods to gain reliable soil-test calibration and yield-response data.

Data from two sets of long-term fertility experiments which have been conducted at six and seven locations are reported here. The oldest of these is known as the Two-Year Rotation Fertilizer Experiment (TYR). It was started in 1929 and has run continuously with many revisions in treatments and in crops used in the rotation. The second set of experiments, known as the Rates of NPK Experiment (NPK), was started in 1954 at the same six locations plus the Upper Coastal Plain Substation at Winfield. This experiment has been in cotton, corn, soybeans, and sorghum at different periods from 1954 through 1982. Data from both experiments were published in 1970 in Experiment Station Circular 181.

Procedures used in both experiments are described briefly, and yield results and soil-test data are discussed by location, beginning with soils that were most responsive to fertilization. Data from the two experiments at each location are presented in separate tables. For easier comparisons among the treatments, yields are given as percentages of that of the standard treatment, which received what was considered to be adequate or optimum rates of all nutrient elements. Yields of the standard treatment are presented in bushels, pounds, or tons per acre. To convert percentages to actual yields for the other treatments, multiply percentages shown by yield of the standard treatment for the different crops.

Yield data have been subjected to the analysis of variance procedure to determine which differences are significant at the 5 percent level. Percentages marked by an asterisk are different from the next lower or higher treatment with which they should be logically compared at the 19 to 1 probability level. This means that the odds are 19 to 1 that the differences were due to the treatment and not to commonly occurring variation among plots.

Soil-test values for P and K are also presented. For the TYR, soil-test and index values from samples taken in the fall of 1982 are presented in the last two columns of each table. Original soil-test values from samples taken in 1928 and stored in glass jars until recently analyzed are presented in the footnotes for each location. For the NPK, soil-test values from 1954 through 1982 are presented for each location. Dates of sampling indicated are spring dates for samples taken the previous fall or winter as recommended. These data show the effects of rates of P_2O_5 and K_2O applied on soil fertility. They indicate build-up or depletion and are expressed in pounds per acre or PP2M of P or K extracted by the Mehlich I extractant used in the Auburn University Soil Testing Laboratory. Index values in the last column are ratings and percent sufficiency of the most recent samples. Ratings shown in tables for both experiments are those used for corn and soybeans. Ratings for cotton and some legumes would be lower. These soil-test data have been used to calibrate the soil-test recommendations and keep them based on up-to-date research information since the soil testing laboratory was established in 1953.

PROCEDURES

Two-Year Rotation Fertilizer Experiments (TYR)

These experiments were started in 1929 on a cotton-winter legume-corn rotation, and numerous revisions to keep them up to date are still in progress. Each consists of two adjacent 34-plot tiers with each plot 21 feet by 69.2 feet, or 1/30 acre. Both summer crops are grown each year with two replications of each treatment on both crops, making four replications for soil-test data presented. Winter legumes were used in the rotation except for plots in the N rates comparison until it was changed to a corn-wheat-soybean rotation in 1968. Wheat was continued in the three-crop rotation through 1978. Grain sorghum was substituted for corn in 1982.

Soil is turned in alternate directions every other year to minimize movement of soil from plot to plot. Harvest for yield and soil samples are taken from the two center rows, which are still representative of the treatments after 54 years of cropping. Fertilizers are broadcast annually prior to planting, except on nonlegumes where two-thirds of the nitrogen is sidedressed to minimize leaching and runoff losses. Soil samples are taken from all plots every 2 years as needed and to determine effects of the treatments on soil-test levels and to indicate when lime should be applied to maintain pH at recommended levels.

The treatments include four rates of N on plots that did not have winter legumes prior to 1968. Nitrogen rates varied among crops as indicated by footnotes under the yield tables. The standard treatment, which is assigned a value of 100 percent yield in the tables, received 120-60-60 in pounds per acre of N-P_2O_5-K_2O. The no-P treatment had no P since 1957, but received 30 pounds per acre of P_2O_5 from 1929 through 1957. The K rates have been continuous since 1958, with the no-K treatment not having received any K since 1928, if ever. The no-lime treatment has had no lime since 1928. The no-Mg treatment has been limed as needed with calcitic lime while other treatments were limed with dolomitic lime. The no-sulfur (S) treatment has had no S since 1977, prior to which it received S from superphosphate or gypsum as did all other treatments. The micronutrient (ME) treatment received a mixture of adequate amounts of zinc (Zn), boron (B), manganese (Mn), copper (Cu), and molybdenum (Mo) broadcast before planting corn every other year, beginning in 1959. The untreated plots shown at the bottom of each table received no fertilizer or lime from 1929 until the last one listed (treatment 17) was limed and fertilized with the standard 120-60-60 beginning in 1979. Soil-test values of original samples stored in 1929 are shown in footnotes under each yield table. Data on build-up or depletion of P and K during 50 years of fertilization at all locations were published in the Soil Science Society of America Journal, Vol. 45, 1981.

Rates of NPK Experiments (NPK)

Experiments with six rates of N, five rates of P_2O_5, six rates of K_2O, and two rates of lime were started at seven locations in 1954. Plots were 21 feet wide and 35 feet long with four replications in randomized blocks. The crop was cotton from 1954 through 1961, corn from 1962 through 1964, and cotton again from 1965 through 1969. Yield data for these periods were published in 1970 in Experiment Station Circular 181.

Nutrient rates were varied one at a time with other nutrients and lime held constant and adequate. The standard rates were 120-100-100 in pounds per acre of N-P_2O_5-K_2O for cotton and corn. The standard rates were 0-100-100 for soybeans and peanuts. Soil samples were taken from all plots every 2 or 3 years for use in soil-test calibration. Soil pH was maintained at 5.8 to 6.5 except for the unlimed treatment. Gypsum was applied annually to all plots to supply 30 pounds per acre S except for treatment 6, which was made a no-S treatment in 1970. Boron (B) was applied at 1.5 pounds per acre for peanuts.

All locations were put in residual study of P and K for cotton from 1970 through 1972. Nitrogen rates were applied as usual, but no P or K was applied except to the standard treatment, No. 5, which continued to receive 100 pounds per acre of P_2O_5 and K_2O. Rates of P_2O_5 and K_2O were resumed at Brewton, Monroeville, Wiregrass, and Sand Mountain in 1973, 1974, and 1975, when the crop was soybeans or peanuts. Rates of P_2O_5 and K_2O were discontinued again at these locations in 1976 and 1977. Experiments at Prattville, Upper Coastal Plain, and Tennessee Valley locations were in residual study for P and K continuously from 1970 through 1977. Rates of P and K were resumed at all locations in 1978.

Crops were changed to get response and calibration data on as many important crops as possible. After 3 years in soybeans from 1973 through 1975, experiments were planted in corn from 1976 through 1979 or 1980. In 1980 the crop was changed to sweet sorghum at Sand Mountain, Brewton, and Wiregrass as a part of the Experiment Station research effort on biomass for alcohol production. The other locations were returned to soybeans in 1980. Peanuts were grown again at the Wiregrass Substation in 1981 and 1982.

RESULTS AND DISCUSSION

The data from both experiments are presented by location, beginning with the Sand Mountain Substation, on which the Hartsells fsl soil is generally one of the most productive and most responsive to fertilizers of all Alabama soils. Because of the volume of data, only brief discussions are presented by crops. The levels of N, P, and K to which responses were found are indicated and significant responses to other nutrients are pointed out. Relationships between soil-test levels and response are summarized along with the effects of treatments on soil-test values. Readers should study the tables for more details than those mentioned in the brief discussions. Results from the last 24 years of the 54-year-old TYR will generally be discussed first. Data from the most recent 18 years of the 29-year-old NPK experiments will follow.

Poor yields due to drought, poor stands, late spring freezes, heavy rains, insect or disease damage, or other causes were experienced some years at all locations. Data from such years are generally not reliable for use in making fertilizer recommendations. Therefore, average yields shown do not include data from years when such problems were encountered, and years from which data were used are indicated in the tables.

SAND MOUNTAIN SUBSTATION, HARTSELLS FSL (TABLES 1, 2, AND 3)

Cotton

Response to N. The Two-Year Rotation (TYR) experiment included a few plots which did not have vetch in the rotation from 1959 to 1967. These were used to compare 0, 60, and 120 pounds per acre of N for cotton and corn, table 1. The data show a response of 900 pounds per acre of seedcotton [(92-58), percent x 2,650] to 60 pounds per acre of N, with a response of only 210 pounds per acre [(100-92) percent x 2,650] to an additional 60 pounds per acre of N. The NPK experiment, table 2, showed a 100-pound-per-acre increase from 90 N over 60 N in 1965-69. The small decrease from 150 N over 120 N indicates that the 90 N rate would have been adequate for cotton. The increase from 120 N over 90 N in 1970-71 is not valid because no K_2O was applied during this residual period, except to the 120 N rate, and K deficiency limited the yield response to N and P.

Response to P. The TYR, table 1, shows a 19 percent, or 500 pounds per acre, increase from 60 pounds per acre P_2O_5 at low soil P. The NPK also shows a response to 60 over 40 P_2O_5, indicating that 60 P_2O_5 was the best rate for cotton, table 2. This is the rate presently recommended for *Medium* soil-test levels by the soil testing laboratory. No response was found from the 100 P_2O_5 rate over 60 P_2O_5 because this rate had raised the soil-test level to High by 1965, table 3. During the residual period 1970-71, the

TABLE 1. RELATIVE YIELDS (PERCENT) OF CORN, GRAIN SORGHUM, COTTON, SOYBEANS, AND WHEAT IN THE 2-YEAR ROTATION FERTILIZER EXPERIMENT ON HARTSELLS FSL AT THE SAND MOUNTAIN SUBSTATION, 1959-82

Treatment[1, 2]		Cotton[3],	Soybeans[4]		Corn[3]			Grain sorghum,[5] 1982	Wheat[6], 7 of 11 years, 1968-78	Soil test, 1983	
No.	Variable, lb./acre	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	3-yr. av., 1979-82	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	2 of 3 years, 1979-81			Lb./acre	Index
16	No N	58	105	98	20	46	35	47	33	—	—
11	30, 60, or 90 N	92*	103	94	69*	88*	87*	71	84*	—	—
14	60, 90, or 120 N	100	100	100	100*	100*	100*	100	100*	Ca 990	H 200
10	120 or 150 N	—	—	94	—	—	92	81	—	—	—
12	No P	81*	71*	67*	73*	76*	67*	85	78*	P 13	L 60
6	No K	24	39	37	61	47	39	56	91	K 39	L 30
7	30 K_2O	89*	87*	81*	95*	89*	86*	54	98	59	60
14	60 K_2O	2,650*lb.	38*bu.	48*bu.	110 bu.	131*bu.	83*bu.	105 bu.	45 bu.	140	H 90
15	120 K_2O	98	103	98	105	100	93	92	96	172	H 100
4	No lime	89*	55*	58*	77*	56*	41*	16*	58*	Ca 260	pH-5.0
5	No magnesium	97	87*	85*	102	98	97	83	96	Mg 38	L 80
2	No sulfur since 1977	—	—	90*	—	—	82*	87	—	—	—
8	Plus micronutrients	101	97	96	91	95	82	83	98	—	—
1	Untreated	23	42	35	8	20	21	13	—	—	—
17	Untreated until 1979	30	45	94	10	24	80	107	13	—	—

[1]Original soil-test values in 1929 were: pH - 6.2, P - 32 lb./acre (M), K - 100 lb./acre (M), Mg - 42 lb./acre (L), Ca - 550 lb./acre (H).

[2]Final soil-test values of the 120-60-60 treatment, no. 14, were: pH - 6.2, P - 118 lb./acre (VH), K - 140 lb./acre (H), Mg - 161 lb./acre (H), Ca - 990 lb./acre (H).

[3]N rates for cotton 1959-67 were 0, 60, and 120 lb./acre. For corn, 1959-78 rates were 0, 60, and 120 lb./acre, and 1979-81 were 0, 90, 120, and 150 lb./acre.

[4]N rates for soybeans 1968-82 were 0, 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat 1968-78 were 0, 50, and 80 lb./acre.

*Indicates significant difference at 5 percent level.

TABLE 2. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, CORN, AND SWEET SORGHUM FROM DIFFERENT RATES OF N, P, AND K ON THE SAND MOUNTAIN SUBSTATION, 1965-82

Treatment no.	Lb./acre applied	Seedcotton 1965-69(4)[1] '65,'66,'68,'69	Seedcotton 1970-72(2) '70,'71 residue	Soybeans, 1973-75(3)	Corn, 1976-79(4)	Sweet sorghum, 1980-82(3)
	N[2]		Nitrogen			
1	0	43	39	99	27	51
2	30	84*	72*	101	—	90*
3	60	96*	81*	98	—	96
4	90	100	85	—	89*	100
5	120	100	100*	—	100	100
6	150	97	89	—	100	—
	180	—	—	—	98	—
	P_2O_5		Phosphorus			
7	0	43	46	74	60	67
8	20	74*	71*	91*	85*	88*
9	40	95*	82*	104*	89	82
10	60	99	87	101	97*	97
5	100	100	100*	100	100	100
	K_2O		Potassium			
11	0	29	19	84	81	72
12	20	75*	47*	93*	93*	82*
13	40	91*	64*	100	106*	86
14	60	104*	77*	103	103	94
15	80	98	86*	108	101	94
5	100	2,460 lb./acre	2,560* lb./acre	37 bu./acre	112 bu./acre	22.1 tons/acre
16	No lime	78*	84*	74*	73*	62*
6	No sulfur since 1969	—	—	104	100	96
	CV	16	12	11	18	13
	LSD (05)	9	9	9	12	9

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre rates of N were used on soybeans.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 3. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K ON HARTSELLS FSL AT THE SAND MOUNTAIN SUBSTATION, 1954-83

Rates of P_2O_5 or K_2O,[1] lb.	Values, pounds/acre							Soil-test rating	1983 index, pct.
	1954	1965	1969	1972 residue	1975	1980	1983		
				Soil-test phosphorus (P)					
0	16	7	11	15	13	10	10	Low	40
20		13	22	22	17	15	19		70
40		19	33	32	26	23	26		80
60		28	58	51	37	42	44	Medium	100
100		54	81	106	107	96	106	High	210
				Soil-test potassium (K)					
0	67	48	47	61	69	50	42	Low	40
20		65	88	80	85	74	55		60
40		75	110	100	116	99	74		70
60		98	122	125	127	123	93	Medium	80
80		106	136	140	149	144	108		80
100		122	152	190	185	180	147	High	90
Soil pH, no lime	5.4	5.2	4.8	4.9	5.0	5.0	4.9		

[1]Rates of P_2O_5 and K_2O applied annually except in 1970, 1971, 1972, 1976, and 1977. The 100-lb./acre rate of P_2O_5 and K_2O was applied each year since 1954.

low P treatments continued to produce at the previous levels but 40- and 60-pound-per-acre rates were limited by K deficiency.

Response to K. This soil produced low cotton yields without K fertilization. The two experiments agree closely in response of cotton to K. They showed average increases of about 1,900 pounds per acre of seedcotton from 60 K_2O when soil-test K was *Low*. No increase was found in either experiment from more than 60 pounds per acre of K_2O. The 60 pounds per acre rate increased the soil-test K level to *High* in both experiments. The residual study showed that this *High* level is temporary without K fertilization and that where none is applied, soils should be sampled annually to prevent loss in yield as was found in 1970-71.

Other nutrients. Cotton showed average decreases of 290 and 540 pounds per acre of seedcotton where lime was not applied in the two experiments. Soil pH dropped to about 4.8 to 5.0 and leveled off, but drastically reduced cotton yields. Use of calcitic instead of dolomitic lime reduced the soil test Mg to *Low 80* but did not significantly reduce cotton yield. The micronutrient mixture of B, Zn, Mn, Fe, and Cu in the TYR did not increase cotton yields.

Soybeans

Response to N. Both experiments included rates of 30 and 60 pounds per acre N on soybeans. No response to N was found. This supports the recommendation that N not be applied to soybeans on soils where soybeans have been grown previously.

Response to P. Responses of 11 and 16 bushels per acre were found for the two periods in which the TYR was in soybeans. This was expected on this soil which was *Low* in P. The NPK experiment produced a 9-bushel-per-acre response to 40 pounds per acre of P_2O_5 in 1973-75. The 40-pound-per-acre rate produced top yields and maintained soil P at *Medium*. Higher rates were required to raise this soil to *High*, but the higher rates did not result in higher yields.

Response to K. Soybeans responded to K in both experiments. The increase from K ranged from 5 to 9 bushels per acre for 40 to 60 pounds per acre of K_2O. The 60-pound-per-acre rate of K_2O raised the soil-test level to *High* in both experiments.

Other nutrients. Where lime was not applied and pH dropped to 5.0, yields were reduced 10 to 20 bushels per acre. Allowing Mg to drop to *Low* from use of calcitic instead of dolomitic lime in the TYR reduced soybean yields 5 to 7 bushels per acre. No response to the micronutrient mixture in the TYR was found. There was a 5-bushel-per-acre response to S in the TYR but none in the NPK.

Corn

Response to N. Corn yields for the standard 120-60-60 treatment in the TYR averaged 116 bushels per acre for the 15 years reported and 112 bushels per acre for 4 years in the NPK. The 120-pound-per-acre N rate was best in both experiments, although rates went to 150 pounds per acre in the TYR and 180 pounds per acre in the NPK in recent years. This supports the present statewide recommendation of 120 pounds per acre of N for corn. The soil-test recommendation includes a comment that corn on sandy soils, such as the Hartsells, may respond to 150 pounds per acre of N. Since there is no satisfactory soil test to determine the capacity of Alabama soils to supply N for growing crops, recommendations are based on the crop to be grown. The organic matter content of all Alabama soils is low and they do not vary much in their capacity to supply N. These Sand Mountain soils have generally been the most responsive to N of any soils in the state.

Response to P. Corn has produced good responses to 60 pounds per acre of P_2O_5 in both experiments. This rate has raised the soil-test P level to *Very High* in the TYR and to *High* in the NPK. This soil has the highest P requirement of any of the soils included in these experiments.

Response to K. Corn responded to 60 pounds per acre K_2O_5 in the TYR and to 40 pounds per acre in the NPK. The 60-pound-per-acre rate raised the soil-test level to *High* in both experiments.

Other nutrients. Corn yields decreased in successive periods without lime to only 41 percent of normal yield in the TYR at pH 5.0. Yield was reduced 24 bushels per acre for 1976-79 at pH 5.0 in the NPK experiment. Response of 15 bushels per acre to S was found in 1979-81. Magnesium and micronutrients have not increased corn yields in the TYR.

Wheat

The N rates for wheat in the TYR in 1968-78 were 0, 50, and 80 pounds per acre, with 20 pounds per acre applied at planting and the remainder topdressed in the spring. The average yield of treatment 14 for 7 years was 45 bushels per acre. The 80 N rate produced 7 bushels per acre more than 50 N. Wheat produced a 10-bushel-per-acre response to P and 8-bushel-per-acre response to the first 30 pounds per acre of K_2O, with no increase from higher rates. Allowing soil pH to drop to 5.0 decreased wheat yields 19 bushels per acre. Use of dolomitic instead of calcitic lime did not significantly increase yield even though soil Mg levels were *Low*.

Grain Sorghum and Sweet Sorghum

Grain sorghum for the first time in TYR in 1982 showed indications of increase in yield from N, P, K, lime, Mg, and S. Since the experiment includes only two replications, data were not analyzed statistically. This crop is highly responsive to N, K, and lime and better information on rates will be available after the experiment is repeated or from averages among locations.

Sweet sorghum was grown in the NPK experiment in 1980-82 to determine its response to fertilizers and lime and to evaluate it as a biomass crop for alcohol production. The entire crop was removed from the area. Fresh weight yields showed large responses to 60 N, 60 P_2O_5, 60 K_2O, and to lime. Soil samples taken in the fall of 1982 showed that 100 pounds per acre of P_2O_5 and K_2O were required to maintain *High* soil-test levels of P and K where such large amounts were removed in the crop. The present recommendation of 60 pounds per acre of P_2O_5 and K_2O for corn or sorghum silage on *Medium* P and K soils was adequate to produce top yields and maintain the *Medium* level through this 3-year period, table 3.

BREWTON EXPERIMENT FIELD, BENNDALE FSL (TABLES 4, 5, AND 6)

This Benndale fsl soil is a gray terrace soil with cation exchange capacity (CEC) of about 4 milliequivalents per 100 grams. There is little clay in the subsoil. This soil is the coarsest and least fertile of all soils used for these experiments. The subsoil is *Very Low* in P with no movement below the plowed layer in over 50 years of fertilization. The subsoil is low in K and has a pH of 5.0 at 3-foot depth, even where lime has been applied to the surface for 50 years. This soil has low moisture holding capacity but makes good yields when well-fertilized and rainfall is adequate.

TABLE 4. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, CORN, GRAIN SORGHUM, AND WHEAT IN THE 2-YEAR ROTATION FERTILIZER EXPERIMENT ON BENNDALE FSL AT THE BREWTON FIELD, 1959-82

Treatment[1, 2]		Cotton[3], 6 of 9 yr. av., 1959-67	Soybean[4]		Corn[3]			Grain sorghum[5], 1982	Wheat[6], 7 of 11 years, 1968-78	Soil test, 1983	
No.	Variable, lb./acre		7 of 11 years, 1968-78	3-yr. av., 1979-82	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	2 of 3 years, 1979-81			Lb./acre	Index, pct.
16	No N	60	92	100	32	64	69	74	46	—	—
11	30, 60 or 90 N	107*	90	100	90*	102*	104*	89*	104*	—	—
14	60, 90 or 120 N	100	100	100	100	100	100	100	100	Ca 730	H 240
10	120 or 150 N	—	—	97	—	—	97	115	—	—	—
12	No P	97	72*	84*	94	87*	79*	88*	75*	P 12	VL 50
6	No K	38	64	42	85	53	22	65	92	K 34	L 60
7	30 K_2O	95*	100*	97*	101*	97*	91*	112*	100*	66	M 80
14	60 K_2O	2,280 lb.	39 bu.	38 bu.	81 bu.	97 bu.	77 bu.*	68 bu.	24 bu.	122	H 110
15	120 K_2O	98	103	100	107	99	108	97	96	142	H 120
4	No lime	88*	38*	29*	94	53*	16*	21*	71*	Ca 160	pH 5.0
5	No magnesium	96	78*	76*	106	97	99	101	105	Mg 23	L 100
2	No sulfur since 1977	—	—	97	—	—	101	96	—	—	—
8	Plus micronutrients	110*	107	105	106	100	105	103	96	—	—
1	Untreated	13	23	18	15	8	1	12	—	—	—
17	Untreated until 1979	15	26	84	14	19	77	82	12	—	—

[1]Original soil-test values in 1929 were: pH - 5.9, P - 28 lb./acre (M), K - 40 lb./acre (L), Mg - 28 lb./acre (H), Ca - 560 lb./acre (H).

[2]Final soil-test values in 1983 of the 120-60-60 treatment, no. 14, were: pH - 6.4, P - 124 lb./acre (VH), K - 122 (H), Mg - 122 (H), Ca - 730 (H).

[3]N rates for cotton in 1959-67 were 0, 60 and 120 lb./acre. For corn, 1959-78 rates were 0, 60, and 120 lb./acre, and in 1979-81, 0, 90, 120, and 150 lb./acre.

[4]N rates for soybeans in 1968-82 were 0 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat in 1968-78 were 0, 50, and 80 lb./acre.

*Indicates significant difference at 5 percent level.

TABLE 5. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, CORN, AND SWEET SORGHUM FROM DIFFERENT RATES OF N, P, AND K ON THE BREWTON FIELD, 1965-82

Treatment no.	Lb./acre applied	Seedcotton 1965-69(4)[1] '65, '66, '68, '69	Seedcotton 1970-72(2) '70, '71 residue	Soybeans, 1973-75(3)	Corn, 1976-79(4)	Sweet sorghum, 1980-82(3)
	N[2]		Nitrogen			
1	0	50	66	105	30	64
2	30	81*	82*	105	—	76*
3	60	94*	94*	104	90*	100*
4	90	103*	96	—	97	100
5	120	100	100	—	100	104
6	150	97	90*	—	101	—
	P_2O_5		Phosphorus			
7	0	88	91	78	81	84
8	20	96*	103*	90*	84	90
9	40	100	88	95	93*	101*
10	60	99	100	102	90	102
5	100	100	100	100	100	100
	K_2O		Potassium			
11	0	45	53	83	77	63
12	20	82*	74*	90*	87	72
13	40	94*	90*	99*	103*	102*
14	60	100	94	101	95	101
15	80	103	102	94	102	110
5	100	2,530 lb.	2,250 lb.	40 bu.	128 bu.	17.0 ton
16	No lime	98	103	74*	52*	57*
6	No sulfur since 1969	—	—	94	102	110
	CV	11	11	8	14	21
	LSD (05)	7	9	6	12	16

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre rates of N were used on soybeans.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 6. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K ON BENNDALE FSL AT THE BREWTON FIELD, 1954-83

Rates of P_2O_5 or K_2O[1]	Values, pounds/acre 1954	1965	1969	1972 residue	1975	1980	1983	Soil-test rating	1983 index, pct.
				Soil-test phosphorus (P)					
0	18	20	22	16	20	15	22	Low	70
20		32	37	32	26	27	32	Medium	80
40		42	58	41	48	38	51		110
60		61	80	57	57	68	60	High	120
100		82	111	112	102	130	121		240
				Soil-test potassium (K)					
0	64	52	65	55	61	48	52		70
20		73	76	65	78	70	69	Medium	80
40		92	98	85	107	101	76		80
60		98	105	90	107	118	86		90
80		104	115	100	150	110	102	High	100
100		110	120	123	146	148	110		100
Soil pH	5.6	5.5	5.4	5.6	5.6	5.5	5.3		

[1]Rates of P_2O_5 and K_2O applied annually except in 1970, 1971, 1972, 1976, and 1977. The 100-lb./acre rate of P_2O_5 and K_2O was applied each year since 1954.

Cotton

The best rate of N for cotton in the two experiments was 90 pounds per acre, which is the rate recommended. Yield in the TYR was increased more than 1,000 pounds seedcotton by 60 N with no further increase from 120 N. In the NPK, 90 pounds N increased yield 900 pounds per acre and was the best rate over the 6 years reported. No response to P was found in the TYR when soil-test P was *Medium*. In the NPK, yield was increased by 20 pounds per acre of P_2O_5 when soil-test P was *Low*. No further increase was found from the higher rates. Application of 20 pounds per acre of P_2O_5 raised soil P to *Medium* and 40 pounds raised it to *High*. During 3 years without P in 1970-72, the residue from the 20-pound P_2O_5 rate produced top yields.

Cotton produced large responses to K in both experiments. The best rate was 60 pounds per acre of K_2O in both cases with no response from higher rates. The average increase from 60 K_2O was 1,400 pounds per acre of seedcotton. All rates applied increased the K level in this sandy soil, and the residue maintained yields at previous levels for 3 years, 1970-72. The soil-test K ratings indicated in table 6 are those used for corn and soybeans on which 81 pounds per acre of soil-test K is rated *High*. The higher K requirement for cotton to reach index values greater than 100 requires 121 pounds per acre of soil-test K for a *High* soil-test rating. When pH was allowed to drop to 5.4, yield was reduced 230 pounds per acre of seedcotton. Cotton showed a 10 percent increase from the micronutrient mixture. This was most likely from B, which is recommended on all soils.

Soybeans

Soybean yields from the standard treatments in the two experiments averaged 39 bushels per acre for the 13 years reported. No response to N was found in either experiment. Response to P of 11 bushels per acre was produced in the TYR from 1968-78 after soil-test level of the no-P treatment dropped into the *Low* range. The best rate of P in the NPK was 40 to 60 pounds per acre of P_2O_5 when the soil was *Medium* in P. This supports the present recommendation of 40 pounds per acre at *Medium*.

The first 30-pound-per-acre increment of K_2O increased soybean yields 14 to 22 bushels per acre at *Low* soil-test K in the TYR. No further increase was found from 60 over 30 pounds per acre of K_2O. The best rate of K_2O in the NPK was 40 pounds per acre at *Medium* soil-test K. This shows that on this sandy soil producing good yields of soybeans, the present recommendation of 40 pounds per acre K_2O at *Medium* is adequate and that higher rates increased the soil-test K level to *High*. No response to K was found when soil-test levels were *High*. Large responses to lime and to Mg were produced when the soil pH was not maintained by liming with dolomitic lime.

Corn

When corn was rotated with cotton in the TYR, 120 pounds per acre of N increased yield 8 bushels per acre over 90 N. When rotated with soybeans in 1968-81 and following soybeans in the NPK, the best rate of N for corn was 90 pounds per acre. Such data have led to the present comment used with recommendations for corn that when following soybeans, N rates for corn may be reduced by 30 pounds per acre.

Response of corn to P in the TYR increased with time as the P level of the no-P treatment dropped from *Medium* to *Low*. The data indicate that the recommended rate of 40 pounds per acre P_2O_5 annually or 80 pounds in alternate years is adequate for *Medium* P soils in a corn-soybean rotation.

Plots in the TYR that have not received any K since 1929 are severely deficient and produce very low yields. Applications of 40 to 60 pounds per acre of K_2O annually are needed on this sandy soil to produce top yields and to maintain the desirable level in the soil.

As the pH of unlimed plots has dropped to around 5.0, yields of corn have been severely limited. Corn plants will not produce satisfactorily on this soil under such acid conditions. Magnesium deficiency from use of calcitic lime continuously instead of dolomite has not limited corn yields on this soil, although soil-test Mg dropped to 23 pounds per acre by 1983.

Wheat, Grain Sorghum, and Sweet Sorghum

Wheat yields at this location were lower than on the other stations, averaging only 24 bushels per acre for 7 years. The data indicate that 50 pounds per acre of N, 30 pounds per acre of P_2O_5 at VL50, and 30 pounds per acre of K_2O at L60 were adequate for wheat on this soil. Wheat also produced a response to lime at pH 5.0, but not to Mg at H110 or to micronutrients.

Grain sorghum yield in 1982 in the TYR was limited to 68 bushels per acre by drought. Response was found to 90 pounds per acre N, to P, to 30 pounds per acre K_2O, and to lime. Sweet sorghum in the NPK in 1980-82 responded to 60 N, to 40 P_2O_5, to 40 K_2O, and to lime. Soil-test K dropped between 1980 and 1983 because of the high rate of removal where 17 tons of green sorghum was removed from the plots annually.

WIREGRASS SUBSTATION, DOTHAN FSL (TABLES 7, 8 AND 9)

This gray fine sandy loam soil is representative of a large acreage throughout the Lower Coastal Plains of Alabama. It has a sandy clay loam subsoil at about 10-inch depth which accumulates K, Mg, and Ca as they leach from the surface soil. The surface soil on the Wiregrass was *High* in soil P due to previous fertilization when the TYR was started in 1929. The area used for the NPK was also *High* in P when it was started in 1954. Summer crops have never responded to P on this substation. Response to P was found on winter legumes when they were used in rotations to supply N for summer crops. Quick perusal of the relative yield data from the no-P treatments in both experiments, tables 7 and 8, will show that crops on this soil still do not respond to P after 54 and 29 years of continuous cropping without P fertilizer. Therefore, discussion of response to P will be omitted for the different crops.

The soil-test data in tables 7 and 9 show that soil-test P dropped to *Medium* in the TYR and to *Low* in the NPK in 1983 where none was applied. These experiments should begin to show response if continued. Response at *Medium* is less likely to occur when the level is dropping than when it is rising from annual applications.

Cotton

Both experiments produced about two bales of cotton from 60 pounds per acre of N for the 10 years of data reported. Higher rates did not increase the yield in either experiment, and the 120 N rate decreased the yield in the TYR. Rates from 60 up to 150 pounds per acre N produced about the same yield in the NPK for the 4 years reported.

Yield of seedcotton in the TYR was increased 1,100 pounds per acre by 30 pounds per acre of K_2O, with no further increase from

TABLE 7. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, PEANUTS, CORN, GRAIN SORGHUM, AND WHEAT IN THE TWO-YEAR ROTATION FERTILIZER EXPERIMENT ON DOTHAN FSL AT THE WIREGRASS SUBSTATION, 1959-82

Treatment[1, 2]		Cotton[3],	Soybeans[4]		Peanuts[4], 1982	Corn[3]			Grain Sorghum[5], 1982	Wheat[6], 7 of 11 years, 1968-78	Soil tests 1983	
No.	Variable	6 of 9 years, 1959-67	7 of 11 years, 1968-78	3 years, 1979-81		6 of 9 years, 1959-67	7 of 11 years, 1968-78	3 years, 1979-81			Lb./acre	Index, pct.
16	No N	73	92	91	106	84	65	62	53	41	—	—
11	30, 60, or 90 N	107*	92	100	95	110*	99*	104*	99*	88	—	—
14	60, 90, or 120 N	100	97	100	100	100	100	100	100	100	Ca 980	H 330
10	120 or 150 N	—	—	100	103	—	—	102	118	—	—	—
12	No P	97	103	97	112	94	102	105	92	98	P 42	M 90
6	No K	58	97	88	94	86	93	86	74	100	K 76	M 80
7	30 K_2O	106*	103	97*	97	97*	99	96	101	97	144	H 120
14	60 K_2O	2,610 lb.	35 bu.	33 bu.	3,220 lb.	79 bu.	100 bu.	78 bu.	95 bu.	41 bu.	193	H 160
15	120 K_2O	102	100	94	91	93	97	100	114	94	221	H 180
4	No lime	90*	89*	85*	89*	81*	91*	77*	18*	95	Ca 280	pH 5.1
5	No Mg	107	104	97	104	101	99	100	101	98	Mg 46	H 180
2	No S since 1977	—	—	88*	100	—	—	86*	89*	—	—	—
8	Plus ME	107	100	100	96	94	99	103	107	93	—	—
1	Untreated	22	69	48	85	24	28	38	13	—	—	—
17	Untreated until 1979	22	57	73	95	22	33	74	99	17	—	—

[1]Original soil-test values in 1929: pH - 5.8; P - 66 lb./acre (H); K - 90 lb./acre (H); Mg - 35 lb./acre (H); Ca - 340 lb./acre (H).

[2]Final soil-test values of the no. 14, 120-60-60, treatment: pH - 6.2; P - 129 lb./acre (VH); K 193 lb./acre (H); Mg - 10 lb./acre (H); Ca - 980 lb./acre (H).

[3]N rates for cotton in 1959-67 were 0, 60, and 120 lb./acre. For corn in 1959-78, rates were 0, 60, and 120 lb./acre N, and in 1979-81, 0, 90, 120, and 150 lb./acre N.

[4]N rates for soybeans and peanuts in 1959-67 were 0, 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat in 1959-67 were 0, 50, and 80 lb./acre.

*Indicates significant difference at 5 percent level.

TABLE 8. RELATIVE YIELDS (PERCENT) OF COTTON, PEANUTS, CORN, AND SWEET SORGHUM FROM DIFFERENT RATES OF N, P, AND K ON THE WIREGRASS SUBSTATION, 1965-82

Treatment no.	Lb./acre applied	Seedcotton 1965-69(2)[1] '65, '66	Seedcotton 1970-72(2) '70, '72 residue	Peanuts, 1973-75(3)	Corn, 1976-79(3) '76, '78, '79	Sweet sorghum, 1980	Peanuts, 1981-82(2)
	N[2]		Nitrogen				
2	0	82	62	94	43	95	98
3	30	83	88*	97	—	105	96
5	60	102*	100	101	88*	125	99
4	90	90	102	—	98	100	—
11	120	100	100	—	100	125	—
6	150	98	103	—	95	—	—
	P_2O_5		Phosphorus				
12	0	100	98	98	95	117	104
14	20	90	98	96	98	123	102
13	40	97	97	94	105	119	103
16	60	96	98	96	99	99	102
11	100	100	100	100	100	100	100
	K_2O		Potassium				
7	0	54	37	80	85	86	94
8	20	96*	78*	95*	103*	122	102
9	40	104	95*	99	105	109	99
15	60	91	106	98	102	105	103
10	80	93	103	96	103	112	106
11	100	2,650 lb.	2,420 lb.	3,920 lb.	91 bu.	20.7 tons	4,470 lb.
1 & 17	No lime	63*	38*	57*	33*	0*	36*
6	No sulfur since 1969	—	—	100	99	106	101
	CV	12	19	9	15	21	7
	LSD (05)	10	16	7	15	NS	9

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre N rates were used on peanuts.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 9. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K DOTHAN FSL AT THE WIREGRASS SUBSTATION, 1954-83

Rates of P_2O_5 and K_2O[1]	Values, pounds/acre							Soil-test rating	1983 index, pct.
	1954	1965	1969	1972 residue	1975	1981	1983		
Soil-test phosphorus (P)									
0	59	38	45	45	31	22	22	Low	70
20		58	64	60	44	28	28		80
40		86	81	80	60	47	40	Medium	90
60		84	112	100	107	66	89		180
100		111	124	112	111	109	91	High	180
Soil-test potassium (K)									
0	88	79	84	84	62	85	84		90
20		110	120	100	81	82	88	Medium	90
40		111	140	140	140	126	119		100
60		126	160	160	168	135	126		100
80		130	180	175	175	154	135	High	110
100		134	200	200	200	182	154		130
Soil pH	5.6	5.5	5.4	5.3	5.2	4.5	4.9		

[1]Rates of P_2O_5 applied annually except in 1970, 1971, 1972, 1976 and 1977. The 100-lb./acre rate of P_2O_5 and K_2O was applied each year since 1954.

60 and 120 pounds per acre. The 20-pound-per-acre rate of K_2O produced 96 percent yield in the NPK in 1965-66, but dropped to 78 percent when none was applied in 1970-72. This shows that where low rates are used, they must be applied every year on these sandy soils. When soil-test levels are increased to *High* by application of 60 pounds per acre K_2O or more, the residual effect may last for several years. Cotton produced good response to lime in both experiments. Yield was also increased by the micronutrient mixture, presumably from the 0.5 pound per acre of B in the mixture.

Peanuts

Peanuts are known to be quite unresponsive to direct applications of fertilizer and it is generally recommended that they be grown in rotation with other well-fertilized crops. Peanuts were grown in the NPK experiment in 1973-75 and again in 1981-82. They were used in the TYR in 1982 for the first time in 54 years. The greatest response in both experiments was to lime. Increases from lime of 1,690 and 2,860 pounds per acre of peanuts were found in the two periods of the NPK. The unlimed treatment in the TYR produced 89 percent yield, or 2,870 pounds per acre of peanuts, where no lime had ever been applied and where the pH was 5.1. The untreated plot, which had received no fertilizer or lime for 54 years, produced 85 percent yield. A small response to the first increment of 20 or 30 pounds per acre of K_2O was found at *Medium* soil-test K levels in both experiments. No increase was produced by more than 30 pounds per acre of K_2O. Peanuts did not respond to N, P, Mg, S, or micronutrients in these experiments. These data show that the recommendation that peanuts be grown in rotation with well-fertilized crops is sound. This is advisable because they remove large amounts of nutrients from the soil and will reduce fertility to such a low level that following crops will not grow satisfactorily if these nutrients are not maintained at satisfactory levels.

Corn

Data from both experiments show that 90 pounds per acre of N was adequate for yield levels produced at this location. Drought stress at some period during most growing seasons kept average yields below 100 bushels per acre. If all years were included, the averages would be lower. Other soils in the Coastal Plains that have higher water holding capacity or are located where summer rainfall is more dependable will produce higher yields and respond to rates of N up to 120 pounds per acre.

Corn produced about 12 bushels per acre response to 20 and 30 pounds per acre K_2O with no additional response to higher rates. Application of 30 to 40 pounds per acre of K_2O raised soil-test K to *High* in both experiments. The K level in both experiments remained at the *Medium* level for corn, peanuts, and soybeans without applications of K_2O for 54 and 29 years in these experiments.

Corn responded to lime and S but did not show response from Mg or micronutrients. These data show that present recommendations from the soil testing laboratory should be adequate for corn on sandy soils of the coastal plain.

Soybeans

Soybeans showed little response to fertilizers in the TYR from 1968 through 1981. There was about a 3-bushel-per-acre average increase from 30 pounds per acre of N, but this difference was not statistically significant. There were also small increases from 30 K_2O, from lime, and from S in the 1979-81 period. These data show that soybeans have a lower fertility requirement than cotton and that present soil-test recommendations are more than adequate for this crop.

Wheat and Sweet Sorghum

Wheat yields in the three-crop rotation averaged 41 bushels per acre from the standard treatment. It responded to 80 pounds per acre N but did not respond to P, K, lime, Mg, or micronutrients. Sweet sorghum in the NPK in 1980 had a poor stand and responded only to 20 K_2O and to lime. Sorghum is so sensitive to low pH that the seedlings did not survive at pH 4.5 in 1980.

MONROEVILLE EXPERIMENT FIELD, LUCEDALE FSL (TABLES 10, 11, AND 12)

This reddish fine sandy loam topsoil and its clay loam subsoil have considerable capacity to retain added nutrients and supply them to future crops. Soil-test P and K data in table 12 show that there was little change in the levels of these nutrients in the sur-

TABLE 10. RELATIVE YIELDS (PERCENT) OF CORN, GRAIN SORGHUM, COTTON, SOYBEANS, AND WHEAT IN THE 2-YEAR ROTATION FERTILIZER EXPERIMENT ON LUCEDALE FSL AT THE MONROEVILLE FIELD, 1959-82

Treatment[1, 2]		Cotton[3],	Soybeans[4]		Corn[3]			Grain sorghum[5], 1982	Wheat[6], 7 of 11 years, 1968-78	Soil test 1983	
No.	Variable, lb./acre	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	4-yr. av., 1979-82	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	2-yr. av., 1979-81			Lb./acre	Index, pct.
16	No N	80	89	95	46	66	61	77	62	—	—
11	30, 60 or 90 N	107	95	105	87*	100*	101*	87	104*	—	—
14	60, 90 or 120 N	100	100	100	100*	100	100	100	100	Ca 1420	H 470
10	120 or 150 N	—	—	—	—	—	102	88	—	—	—
12	No P	108	95	105	94*	92*	96	81*	96	P 17	L 60
6	No K	65	90	59	92	84	82	61	100	K 53	L 60
7	30 K_2O	101*	97*	95*	100*	100*	104*	87	108	83	M 70
14	60 K_2O	2,020 lb.	39 bu.	39 bu.	77 bu.	90 bu.	113 bu.	90 bu.	26 bu.	155	H 100
15	120 K_2O	100	103	105	101	101	97	100	100	182	H 110
4	No lime	83*	59*	79*	75*	66*	39*	22*	88*	Ca 350	pH 4.9
5	No magnesium	94	92*	90*	98	98	105	90	97	Mg 55	H 110
2	No sulfur	—	—	95	—	—	84*	94	—	—	—
8	Plus micronutrients	115	103	103	97	100	104	82	100	—	—
1	Untreated	29	36	54	27	36	30	21	—	—	—
17	Untreated until 1979	34	33	87	27	40	75	86	23	—	—

[1]Original soil-test values in 1929 were: pH - 5.8, P - 30 lb./acre (M), K - 84 lb./acre (M), Mg - 60 lb./acre (H), Ca - 580 lb./acre (H).

[2]Final soil-test values in 1983 of the 120-60-60 treatment, no. 14, were: pH - 6.1, P - 118 lb./acre (VH), K - 155 (H), Mg - 280 (H), Ca - 1,420 (H).

[3]N rates for cotton in 1959-67 were 0, 60, and 120 lb./acre. For corn in 1959-78, rates were 0, 60, and 120 lb./acre N, and in 1979-81, were 0, 90, 120, and 150 lb./acre N.

[4]N rates for soybeans in 1968-82 were 0, 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat 1968-78 were 0, 50, and 80 lb./acre.

*Indicates significant difference at 5 percent level.

TABLE 11. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, AND CORN FROM DIFFERENT RATES OF N, P, AND K ON THE MONROEVILLE FIELD, 1965-82

Treatment no.	Lb./acre applied	Seedcotton, 1965-69 (4) [1] '65,'66,'68,'69	Seedcotton, 1970-72 (2) '70,'71 residue	Soybeans, 1973-75 (2) '74,'75	Corn, 1976-80 (2) '76,'78	Soybeans, 1981-82 (2)
	N[2]		Nitrogen			
1	0	55	70	94	51	96
2	30	88*	81*	100	—	95
3	60	102*	96*	93	84*	99
4	90	102	107	—	92	—
5	120	100	100		100	—
6	150	103	105	—	97	—
	P_2O_5		Phosphorus			
7	0	89	91	73	74	89
8	20	96*	106*	93*	95*	104*
9	40	97	104	91	93	101
10	60	100	101	98	103	102
5	100	100	100	100	100	100
	K_2O		Potassium			
11	0	59	68	79	91	86
12	20	91*	88*	89	102	94*
13	40	99*	94	90	98	102
14	60	101	102	92	94	96
15	80	101	116	95	94	99
5	100	1,950 lb.	1,910 lb.	29 bu.	88 bu.	33 bu.
16	No lime	99	92	76*	56*	81*
6	No sulfur since 1969	—	—	97	93	99
	CV	11	12	12	23	10
	LSD (05)	7	11	11	21	8

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre N rates applied on soybeans.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 12. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K ON LUCEDALE FSL AT THE MONROEVILLE FIELD, 1954-83

Rates of P_2O_5 and K_2O[1]	Values, pounds/acre							Soil-test rating	1983 index, pct.
	1954	1965	1969	1972 residue	1975	1981	1983		
				Soil-test phosphorus (P)					
0	29	21	24	16	22	24	25	Low	70
20		33	46	30	36	33	35	Medium	90
40		51	60	40	50	43	51		110
60		68	80	52	67	54	75	High	150
100		94	110	100	123	130	148		300
				Soil-test potassium (K)					
0	75	68	80	70	79	83	78		70
20		88	91	77	98	115	120	Medium	80
40		109	109	91	142	124	149		90
60		121	122	111	173	153	159	High	100
80		125	131	121	207	174	186		110
100		141	148	170	220	235	233		130
Soil pH	5.4	5.3	5.3	5.3	5.2	5.3	4.8		

[1]Rates of P_2O_5 applied annually except in 1970, 1971, 1972, 1976, and 1977. The 100-lb./acre rate of P_2O_5 and K_2O was applied each year since 1954.

face soil where none was applied under continuous cropping from 1954 through 1982. This shows that this soil supplied substantial amounts of these nutrients without much drop in fertility. Applications of 40 pounds per acre of P_2O_5 and K_2O were adequate to raise the level of both nutrients to *High* for corn and soybeans.

Cotton

Data in table 10 show that 60 pounds per acre of N was adequate to produce 2,160 pounds of seedcotton with no further increase from the higher rate. No response to P was found at *Medium* soil-test P in the TYR, while a small increase from 20 pounds per acre P_2O_5 was indicated in the NPK where the level was *Low*. Cotton produced large increases from 30 to 40 pounds per acre of K_2O, with no further increase from higher rates, which increased soil-test levels to *High* in both experiments. Small increases from lime were produced at a pH of about 5.3. The micronutrient mixture which included B increased yield about 300 pounds per acre in the TYR. During 2 years without P or K in 1970-71, plots continued to produce at the previous level.

Soybeans

During the first few years when soybeans were used in the TYR, they showed about a 4-bushel-per-acre increase from 30 pounds per acre of N. This did not occur in later years or in the NPK, so it is doubtful if this was a real difference. They did not respond to P_2O_5 in the TYR where the soil-test level was *Medium*, but did respond to the first 20 pounds per acre of P_2O_5 in the NPK during both periods. The soil-test level was *Low* on the no-P treatment. Response to 20 and 30 pounds per acre of K_2O was found in both experiments where the K level was *Low* to *Medium*. Large response to lime was found in both experiments. Lack of Mg reduced yields about 4 bushels per acre, or 10 percent. No differences were found for S or micronutrients.

Corn

The best rate of N for corn in the TYR was 90 pounds per acre, which averaged 95 bushels per acre for the 9 years reported from 1968-81. In the 2 years reported for the NPK, 120 pounds per acre N increased yield 7 bushels per acre over 90 N. Increases in yield from the first increment of P were found in both experiments. In the NPK which was *Low* in soil-test P, 20 pounds per acre of P_2O_5 increased yield 18 bushels per acre and raised the soil-test level to *Medium*. No further increase was found from 40 P_2O_5, which raised the level to *High*. The first increment of 20 and 30 pounds per acre of K_2O produced top yields and maintained the *Medium* soil level. Use of 60 pounds per acre of K_2O increased soil levels to *High* in both experiments, but did not increase yield over the lower rates. Corn responded to lime and to S but not to Mg, which was *High* in this soil, or to micronutrients.

Wheat and Grain Sorghum

Wheat averaged only 26 bushels per acre for the years reported and responded to only 50 pounds per acre of N, 20 pounds of which was applied in the fall and 30 pounds in the spring. It also responded to lime but not to P, K, Mg, or micronutrients. Grain sorghum produced 90 bushels per acre in 1982 and produced large responses to 90 N, 60 P_2O_5, 60 K_2O, lime, and possibly Mg. The two replications for only 1 year are not adequate to determine significance of small differences. Grain sorghum has higher fertility requirements for P, K, and lime than do corn and soybeans.

PRATTVILLE EXPERIMENT FIELD, LUCEDALE SCL (TABLES 13, 14, AND 15)

This soil is similar to the Lucedale fsl at Monroeville but has more clay and a higher cation exchange capacity of about 6 milliequivalents per 100 grams. The soil at Prattville, like the Dothan soil on the Wiregrass Substation, had been built up to a *High* level of P by fertilization before the experiment field was acquired by the Agricultural Experiment Station in 1928. It has not responded to P on summer crops. This was the case for all crops in both of these experiments. The soil-test P in the no-P plot of the TYR dropped to *Medium* by 1983 but has not yet shown response. In the NPK, the P level remains *High* after 29 years without P application, table 15. Both experiments have produced response to 20 to 30 pounds per acre of K_2O on most crops.

Cotton

A large response to 60 pounds per acre N was found in both experiments, with small insignificant increases from the next higher

TABLE 13. RELATIVE YIELDS (PERCENT) OF CORN, GRAIN SORGHUM, COTTON, SOYBEANS, AND WHEAT IN THE 2-YEAR ROTATION FERTILIZER EXPERIMENT ON LUCEDALE SCL AT THE PRATTVILLE FIELD, 1959-82

Treatment[1, 2]		Cotton[3],	Soybeans[4]		Corn[3]			Grain	Wheat[6],	Soil test 1983	
No.	Variable, lb./acre	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	2 of 4 years, 1979-82	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	3-yr. av., 1979-81	sorghum[5], 1982	7 of 11 years, 1968-78	Lb./acre	Index, pct.
16	No N	57	92	90	34	60	60	53	33	—	—
11	30, 60, or 90 N	93*	103	103	79*	87*	97*	82*	79*	—	—
14	60, 90, or 120 N	100	100	100	100*	100*	100	100*	100*	Ca 1180	H 390
10	120 or 150 N	—	—	—	—	—	99	95	—	—	—
12	No P	97	100	93	95	103	103	97	97	P 38	M 90
6	No K	41	77	83	83	84	87	79	100	K 67	M 70
7	30 K_2O	95*	97*	100*	98*	101*	101*	86*	103	120	M 80
14	60 K_2O	2,480 lb.	39 bu.	29 bu.	93 bu.	76 bu.	67 bu.	78 bu.	39 bu.	230	H 130
15	120 K_2O	100	95	97	100	97	88	87	100	340	H 190
4	No lime	90*	62*	62*	96	91*	58*	21*	79*	Ca 300	pH 4.8
5	No magnesium	100	97	110	102	97	106	112	102	Mg 57	H 110
2	No sulfur	—	—	97	—	—	91	100	—	—	—
8	Plus micronutrients	102	103	93	100	105	106	97	103	—	—
1	Untreated	20	44	55	18	41	36	27	—	—	—
17	Untreated until 1979	21	23	90	15	33	97	105	15	—	—

[1]Original soil-test values in 1929 were: pH - 5.7, P - 62 lb./acre (H), K - 120 lb./acre (M), Mg - 90 lb./acre (H), Ca - 960 lb./acre (H).

[2]Final soil-test values in 1983 of the 120-60-60 treatment, no. 14, were: pH - 6.2, P - 169 lb./acre (NH), K - 230 (H), Mg - 187 (H), Ca - 1,180 (H).

[3]N rates for cotton in 1959-67 were 0, 60, and 120 lb./acre. For corn in 1959-78, rates were 0, 60, and 120 lb./acre N, and in 1979-81, 0, 90, 120, and 150 lb./acre N.

[4]N rates for soybeans in 1968-82 were 0, 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat in 1968-78 were 0, 50, and 80 lb./acre.

*Indicates significant difference at 5 percent level.

TABLE 14. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, AND CORN FROM DIFFERENT RATES OF N, P, AND K ON THE PRATTVILLE FIELD, 1965-82

Treatment no.	Lb./acre applied	Seedcotton 1965-69(4)[1] '65, '66, '68, '69	Seedcotton 1970-72(3) residue	Soybeans, 1973-75(3) residue	Corn, 1976-80(5)	Soybeans, 1981-82(2)
	N[2]		Nitrogen			
1	0	41	51	97	51	95
2	30	70	73*	105	—	95
3	60	96*	94*	93	94*	96
4	90	100	103*	—	99	—
5	120	100	100	—	100	—
6	150	101	101	—	105	—
	P_2O_5		Phosphorus			
7	0	98	101	100	100	107
8	20	100	96	103	109	102
9	40	98	98	101	101	96
10	60	101	94	101	107	103
5	100	100	100	100	100	100
	K_2O		Potassium			
11	0	91	76	100	100	103
12	20	99*	89*	95	97	100
13	40	98	102*	95	93	99
14	60	106	101	106	101	101
15	80	100	98	108	103	107
5	100	2,560 lb.	2,660	28 bu.	51 bu.	34 bu.
16	No lime	91*	101	86*	100	81*
6	No sulfur since 1969	—	—	98	98	97
	CV	11	10	7	16	16
	LSD (05)	7	9	7	15	12

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre N rates applied on soybeans.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 15. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K ON LUCEDALE SCL AT PRATTVILLE, 1954-83

Rates of P_2O_5 and K_2O[1]	Values, pounds acre								Soil-test rating	1983 index, pct.
	1954	1965	1969	1972 residue	1975 residue	1977 residue	1981	1983		
				Soil-test phosphorous (P)						
0	93	98	100	88	90	82	73	86		170
20		133	110	95	94	94	83	90	High	180
40		162	142	126	116	114	111	129		260
60		178	150	148	142	128	105	131	V High	260
100		213	184	200	197	230	207	176		350
				Soil-test potassium (K)					Medium	
0	175	174	161	120	95	106	118	165		100
20		179	164	135	104	129	143	173	High	100
40		205	207	170	136	140	172	240		130
60		243	234	192	147	166	192	261		140
80		267	277	217	168	202	232	284	V High	160
100		284	282	290	260	270	280	309		170
Soil pH	5.6	5.5	5.4	5.3	5.3	5.2	5.0	5.2		

[1]Rates of P_2O_5 applied annually except in 1970 through 1977 when only the 100-lb./acre rate was applied.

rate. Therefore, it appears that somewhere between 60 and 90 pounds per acre of N would be the best rate on this soil. No response to P was found in either experiment at *High* soil-test levels. The first 30 pounds per acre of K_2O in the TYR increased yield 1,340 pounds seedcotton per acre with no significant increase from the higher rates. Less response to K was found in the NPK where the soil-test level was higher than in the TYR. A 10 percent increase from lime was found in both experiments, but no increase from Mg occurred because this soil was *High* in Mg where none had been applied since 1929.

Soybeans

An increase of about 3 bushels per acre of soybeans from 30 pounds per acre of N was found in both periods reported. This increase was found at several locations. It was most likely due to the fact that soybeans followed corn or wheat which received different rates of N and produced widely divergent yields of grain and crop residues. The soybeans that received no N followed corn that received no N. Where soybeans received no N and followed well-fertilized corn or wheat, this difference did not occur. The organic matter content and perhaps other soil factors were adversely affected by years of cropping without nitrogen fertilization.

No response to P on soybeans was found in either experiment. Good response to 30 K_2O was found in the TYR at *Medium* soil K, but none in the NPK where the soil-test K level was *High*. Soybeans responded to lime in both experiments but not to Mg, S, or micronutrients. Soybeans produced higher relative yields on the old untreated plots than did the other crops, and yields returned to 90 percent of maximum within 3 years after liming and fertilization were resumed following 48 years of cropping without treatment.

Corn

Corn has generally responded to 120 pounds per acre of N at this location. A series of droughts occurred in recent years and 90 N was adequate where yields were limited by moisture deficiency in both experiments. Corn, like cotton and soybeans, has responded to 30 pounds per acre of K_2O in the TYR but not to the other nutrient elements applied.

Wheat and Grain Sorghum

Wheat responded to 80 N and to lime in the three-crop rotation but not to P, K, Mg, or micronutrients. Grain sorghum responded to 90 N and to K. It produced a tremendous response to lime at pH 4.8.

TENNESSEE VALLEY SUBSTATION, DEWEY SIL (TABLES 16, 17, AND 18)

This red Dewey silt loam is of limestone origin, has a cation exchange capacity of 10-12 milliequivalents per 100 grams, and is the most fertile of the soils used in these experiments. It is rated by the soil testing laboratory on different scales for both P and K from the other soils. It requires lower levels of soil-test P and higher levels of soil-test K to reach *Medium* and *High* ratings and is therefore classified as a Group III soil, which requires CEC greater than 9.5 milliequivalents per 100 grams.

Cotton

Data from both experiments indicate that 60 pounds per acre N is adequate for cotton on this soil. The general recommendation for cotton on all soils since 1970 was 90 pounds per acre N until the rate was reduced to 60 N for these Group III soils in 1982. These and other data led to this change after the Tennessee Valley area became the most extensive part of Alabama for cotton production. Many growers on Dewey and Decatur soils similar to this one were having problems with too much growth from 90 N, which increased problems with insect and disease control and sometimes reduced yields.

Use of P increased yield of cotton about 10 percent in both experiments. This was less increase than was anticipated because both areas were *Low* in P. Soils rated low are expected to produce less than 75 percent of maximum yield without P fertilization. The soil-test P level remained about the same where none was applied for 54 and 29 years in the two experiments. Only 20 pounds per acre of P_2O_5 was required to produce top yields in the NPK. All rates applied increased the soil level. These data indicate that more P is being recommended than is producing response because at *Medium* and *High* levels no response was found.

TABLE 16. RELATIVE YIELDS (PERCENT) OF CORN, GRAIN SORGHUM, COTTON, SOYBEANS, AND WHEAT IN THE 2-YEAR ROTATION FERTILIZER EXPERIMENT ON DEWEY SIL AT THE TENNESSEE VALLEY SUBSTATION, 1959-82

Treatment[1, 2]		Cotton[3], 6 of 9 yr. av., 1959-67	Soybeans[4]		Corn[3]			Grain sorghum[5], 1982	Wheat[6], 7 of 11 years, 1968-78	Soil test 1983	
No.	Variable, lb./acre		7 of 11 years, 1968-78	4-yr. av., 1979-82	6 of 9 yr. av., 1959-67	7 of 11 years, 1968-78	2-yr. av., 1979-81			Lb./acre	Index, pct.
16	No N	85	109	98	54	68	43	93	40	—	—
11	30, 60, or 90 N	93	106	92	87*	92*	96*	99	93*	—	—
14	60, 90, or 120 N	100	100	100	100*	100*	100	100	100	Ca 2010	H 400
10	120 or 150 N	—	—	—	—	—	85	104	—	—	—
12	No P	90	91*	92*	89*	96	91*	122	89*	P 13	L 70
6	No K	93	91	90	98	94	98	101	102	K 116	M 70
7	30 K_2O	102*	100*	98*	99	95	102	95	96	155	M 80
14	60 K_2O	2,500 lb.	32 bu.	50 bu.	80 bu.	103 bu.	99 bu.	101 bu.	45 bu.	372	H 150
15	120 K_2O	99	100	100	98	100	96	104	98	369	H 150
4	No lime	108	72*	84*	100	104	103	120	96	Ca 1550	pH 5.4
5	No magnesium	106	103	96	105	101	100	94	91	Mg 150	H 330
2	No sulfur since 1977	—	—	94	—	—	95	88	—	—	—
8	Plus micronutrients	98	97	100	100	98	102	127	104	—	—
1	Untreated	57	50	58	27	43	33	60	—	—	—
17	Untreated until 1979	50	34	86	16	45	70	87	18	—	—

[1]Original soil-test values in 1929 were: pH - 5.7, P - 14 lb./acre (L), K - 220 lb./acre (H), Mg - 150 lb./acre (H), Ca - 1600 lb./acre (H).

[2]Final soil-test values in 1983 of the 120-60-60 treatment, no. 14, were: pH - 6.2, P - 100 lb./acre (VH), K - 372 (H), Mg - 386 (H), Ca - 2,010 (H).

[3]N rates for cotton in 1959-67 were 0, 60, and 120 lb./acre. For corn in 1959-78, rates were 0, 60, and 120 lb./acre N, and in 1979-81, 0, 90, 120, and 150 lb./acre N.

[4]N rates for soybeans in 1968-82 were 0, 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat in 1968-78 were 0, 50, and 80 lb./acre.

*Indicates significant difference at 5 percent level.

TABLE 17. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, AND CORN FROM DIFFERENT RATES OF N, P, AND K ON THE TENNESSEE VALLEY SUBSTATION, 1965-82

Treatment no.	Lb./acre applied	Seedcotton		Soybeans, 1973-75(3) residue	Corn, 1976-80(3) '76, '78, '79	Soybeans, 1981-82(2)
		1965-69(4)[1] '65, '66, '68, '69	1970-72(3) residue			
	N[2]		Nitrogen			
1	0	57	69	94	39	96
2	30	87*	94*	100	—	107
3	60	101*	106*	103	80*	106
4	90	103	100	—	101*	—
5	120	100	102	—	100	—
6	150	101	92*	—	104	—
	P_2O_5		Phosphorus			
7	0	92	102	95	98	103
8	20	97	100	99	104	100
9	40	103	104	95	96	100
10	60	103	101	101	99	99
5	100	100	100	100	100	100
	K_2O		Potassium			
11	0	93	103	91	100	98
12	20	97	106	97	99	98
13	40	99	103	95	106	105
14	60	100	101	104	102	107
15	80	101	102	104	100	110
5	100	2,800 lb.	2,760 lb.	46 bu.	107 bu.	50 bu.
16	No lime	99	104	92*	103	96
6	No sulfur (since 1969)	—	—	96	102	107
	CV	14	10	10	14	13
	LSD (05)	12	8	8	18	NS

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre N rates applied on soybeans.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 18. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K ON DEWEY SIL AT THE TENNESSEE VALLEY SUBSTATION, 1954-83

Rates of P_2O_5 and K_2O[1]	Values, pounds/acre							Soil-test rating	1983 index, pct.
	1954	1965	1969	1972 residue	1978 residue	1981	1983		
				Soil-test phosphorus (P)					
0	8	11	13	15	13	9	15	Low	70
20		12	18	19	16	17	16		80
40		16	24	24	20	21	18	Medium	80
60		21	29	26	22	23	20		80
100		33	48	66	40	38	36	High	120
				Soil-test potassium (K)					
0	175	129	125	140	123	151	141	Medium	80
20		142	147	158	140	205	215		100
40		194	183	190	200	301	218		100
60		229	240	230	210	290	229	High	100
80		248	252	262	230	338	212		100
100		240	280	300	260	390	277		120
Soil pH	5.6	5.6	5.5	5.4	5.4	5.7	5.6		

[1]Rates of P_2O_5 applied annually except in 1970 through 1977 when only the 100-lb./acre rate was applied.

Cotton responded to only 20 or 30 pounds per acre K_2O in the two experiments. Considerable variation in soil-test K was found among seasons. Soil-test K fluctuates from one season of the year to another or among years much more than does soil-test P. This is due to differences in rainfall and in crop growth and is greater in soils testing *High* than when K levels are lower. This demonstrates why growers should keep soil-test records so they can evaluate changes between samplings. It also demonstrates why the fertility index is more useful to growers than are pounds per acre figures, which fluctuate much more on these soils that retain large amounts of K.

Cotton did not respond to lime on this soil at pH 5.4. This demonstrates why these Group III soils are allowed to drop below pH 5.6 before lime is recommended. The sandy soils of groups I and II receive lime recommendations for most crops when they drop below pH 5.8. Cotton did not respond to Mg or micronutrients.

Soybeans

Soybeans produced about a 10 percent yield response to both P and K in the TYR, and to K in the NPK. The lowest rates of 20 to 30 pounds per acre of P_2O_5 and K_2O were adequate to produce top yields and to increase soil-test levels of both nutrients. The data indicate that present recommendations based on soil tests are more than adequate for this soil. Response to lime was found in both experiments, but none to the other nutrients.

Corn

The best rate of N for corn varied from 90 to 120 pounds per acre N. This supports the present recommendation of 120 pounds per acre for this crop since no further increase was found from 150 N in either experiment. Response of 8 to 10 bushels per acre to P was found in the TYR but not in the NPK. Little or no response to K was found in either experiment, even after 54 years without K application. Corn did not respond to lime at pH 5.4, or to Mg, S, or micronutrients on this soil.

Wheat and Grain Sorghum

Wheat yields averaged 45 bushels per acre for the 7 years reported. It responded to 80 pounds per acre N and to P, but not to

K or lime. The 91 percent yield without Mg indicates a response, but this is doubtful because this soil is much higher in Mg than any of the other soils.

Grain sorghum in its first year, 1982, produced well, but there was much variation between the two replications and differences are of doubtful significance. The high yields without P, lime, and with micronutrients do not agree with previous data on other crops.

UPPER COASTAL PLAIN SUBSTATION, SAVANNAH SCL (TABLES 19 AND 20)

This substation was not established until 1946 so does not have the TYR experiment. The NPK was established in 1954 along with the other locations. This gray soil has a CEC of about 8 milliequivalents per 100 grams, which is about the same as the two Lucedale soils. The site was originally *Low 70* in P and *Medium 90* in soil-test K, and was therefore expected to produce some response to both nutrients. The recommendation for a corn-soybean rotation would be 120-160-80 pounds of N-P_2O_5-K_2O for corn with no fertilizer to the soybeans. For cotton, the recommendation would be 90-100-50 annually.

Cotton

Yields at this location were lower than at most other locations and data showed considerable variation. The best rate of N for cotton was 60 to 90 pounds per acre. Response to 20 to 40 pounds per acre of P_2O_5 and K_2O are indicated. Cotton also produced responses of about 200 pounds per acre of seedcotton to lime at pH 5.1.

Soybeans

The first time this experiment was in soybeans, 1973 through 1975, the P and K treatments were in a residual study and received no P or K from 1970 through 1977 except for the standard treatment, which received 100 pounds per acre of each every year. Yields averaged 47 bushels per acre for 3 years with no response to N. The residue from 20 pounds per acre of P_2O_5 was adequate, although the soil-test level of these plots was *Medium* in 1971 and dropped slightly into the *Low* range by 1975. When rates were re-

TABLE 19. RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, AND CORN FROM DIFFERENT RATES OF N, P, AND K ON THE UPPER COASTAL PLAIN SUBSTATION, 1965-82

Treatment no.	Lb./acre applied	Seedcotton 1965-69(4)[1] '65, '66, '68, '69	Seedcotton 1970-72(2) '71, '72 residue	Soybeans, 1973-75(3) residue	Corn, 1976-80(2) '76, '79	Soybeans, 1981-82(2)
	N[2]		Nitrogen			
1	0	59	70	100	52	92
2	30	67*	84*	99	—	111
3	60	90*	100*	96	99*	109
4	90	85	92	—	109	—
5	120	100	100	—	100	—
6	150	92	94	—	95	—
	P_2O_5		Phosphorus			
7	0	83	91	91	90	70
8	20	88	97	98	111	100*
9	40	87	95	102	101	98
10	60	94	99	105	120	104
5	100	100	100	100	100	100
	K_2O		Potassium			
11	0	85	60	88	103	98
12	20	94	75*	92	102	97
13	40	93	93*	93	103	95
14	60	94	91	97	104	102
15	80	92	94	98	112	110
5	100	1,930 lb.	2,330 lb.	47 bu.	73 bu.	27 bu.
16	No lime	88*	91*	92*	91	102
6	No sulfur since 1969	—	—	102	93	97
	CV	14	9	8	21	21
	LSD (05)	12	8	8	32	22

[1]Numbers in parenthesis are years included in the average.
[2]Only the 30- and 60-lb./acre rates applied on soybeans.
*Indicates a significant difference from the next lower or higher rate at the 5 percent level.

TABLE 20. SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K ON SAVANNAH SCL AT THE UPPER COASTAL PLAIN SUBSTATION, 1954-83

Rates of P_2O_5 and K_2O[1]	Values, pounds/acre							Soil-test rating	1983 index, pct.
	1954	1965	1969	1972 residue	1975 residue	1981	1983		
				Soil-test phosphorus (P)					
0	30	16	17	12	10	16	21	Low	70
20		27	29	24	22	31	35		90
40		32	33	26	28	39	42	Medium	90
60		53	52	29	32	53	59		120
100		84	78	71	70	124	106	High	210
				Soil-test potassium (K)					
0	118	107	86	75	104	107	102	Medium	80
20		140	110	95	107	139	135		90
40		171	145	110	126	159	166	High	100
60		198	165	140	165	174	180		100
80		221	196	160	152	182	201		110
100		268	243	249	291	260	254		140
Soil pH	5.6	5.1	5.1	5.0	5.0	5.0	6.0		

[1]Rates of P_2O_5 applied annually except in 1970 through 1977 when only the 100-lb./acre rate was applied.

sumed in 1978, the level increased to *Medium* again by 1981. Application of 60 pounds per acre of P_2O_5 was required to increase the level of this soil to *High*.

Soybeans were less responsive to K than was cotton. The residue from 40 to 60 pounds per acre of K_2O maintained the soil-test level at *High* throughout the 8 years without application and produced 45 bushels per acre of soybeans. The data indicate that 20 pounds per acre K_2O annually would have been adequate to produce top yields and maintain a *High* soil-test level.

When the plots were returned to soybeans in 1981 and 1982, there was response to 20 pounds per acre P_2O_5 but none to K_2O. These were the same responses as found on corn in 1976 and 1979.

Soybeans in the first period produced an 8 percent, or 4 bushels per acre, response to lime at pH 5.0. These plots were apparently limed by mistake in 1981, for the pH increased to 6.0 and no response was found in 1981-82.

Corn

Corn suffered from drought during most years in the period 1976-80 and yields from the best 2 years averaged only 73 bushels per acre. It responded to 60 pounds per acre N, with no response to the higher rates. The no-N plots produced 38 bushels per acre so the increase from N was limited by drought to 35 bushels per acre. This helps explain why 60 N was adequate, for much research has shown that 1½ to 2 pounds per acre N is adequate to increase yield 1 bushel per acre.

Corn responded to 20 pounds per acre of P_2O_5 at *Low* soil test P. It did not respond to K at *Medium* although no K was applied from 1970 through 1977 except on the standard treatment. A 10 percent increase in yield from lime was found at pH 5.0.

SUMMARY AND CONCLUSIONS

Average yields and soil-test values for all locations of both experiments are presented in tables 21, 22, and 23. Average response to rates of N are useful in making N recommendations because they do not vary much among locations. All of these soils are low in organic matter and there is not a satisfactory soil test to determine the N-supplying capacity in individual soils. Therefore, results of these N rate studies should agree with present N recommendations for the crops involved.

TABLE 21. AVERAGE RELATIVE YIELDS (PERCENT) OF CORN, GRAIN SORGHUM, COTTON, SOYBEANS, AND WHEAT IN THE 2-YEAR ROTATION FERTILIZER EXPERIMENT AT SIX LOCATIONS, 1959-82

Treatment[1, 2]		Cotton[3], 6 of 9 yr. av., 1959-67 (36)	Soybeans[4]		Corn[3]			Grain sorghum[5], 1982 (6)	Wheat[6], 7 of 11 years, 1968-78 (42)	Soil test, 1983 Av. of 6 locations
No.	Variable, lb./acre		7 of 11 years, 1968-78 (42)	4-yr. av., 1979-82 (18)	6 of 9 yr. av., 1959-67 (36)	7 of 11 years, 1968-78 (42)	2-yr. av., 1979-81 (12)			
16	No N	61	96	95	45	62	55	66	43	—
11	30, 60, or 90 N	100	98	99	87	95	98	89	92	—
14	60, 90, or 120 N	100	100	100	100	100	100	100	100	Ca 1,220
10	120 or 150 N	—	—	—	—	—	96	100	—	—
12	No P	95	89	90	90	93	90	94	89	P 22
6	No K	53	76	67	84	76	69	73	99	K 66
7	30 K_2O	99	97	95	98	97	97	89	100	104
14	60 K_2O	2,420 lb.	37 bu.	40 bu.	87 bu.	100 bu.	86 bu.	89 bu.	37 bu.	202
15	120 K_2O	100	101	99	101	99	97	99	97	238
4	No lime	91	62	66	87	77	56	36	81	Ca 480
5	No magnesium	100	94	92	102	102	101	97	98	Mg 64
2	No sulfur	—	—	94	—	—	90	93	—	—
8	Plus micronutrients	106	101	100	98	100	100	102	99	—
1	Untreated	27	44	45	20	29	27	24	—	—
17	Untreated until 1979	29	36	86	17	32	79	94	16	—

[1]Average original soil-test values in 1929 were: pH - 5.9, P - 39 lb./acre (M), K - 109 lb./acre (M), Mg - 68 lb./acre (H), Ca - 960 lb./acre (H).

[2]Final soil-test values in 1983 of the 120-60-60 treatment, no. 14, were: pH - 6.2, P - 126 lb./acre (VH), K - 202 (H), Mg - 206 (H), Ca - 1,220 (H).

[3]N rates for cotton and corn in 1959-67 were 0, 60, and 120 lb./acre. Rates for corn in 1959-78 were 0, 60, and 120 lb./acre N, and in 1979-81, 0, 90, 120, and 150 lb./acre N.

[4]N rates for soybeans in 1968-82 were 0, 30, and 60 lb./acre.

[5]N rates for grain sorghum in 1982 were 0, 60, 90, and 120 lb./acre.

[6]N rates for wheat in 1968-78 were 0, 50, and 80 lb./acre.

*Indicates significant response at 5 percent level.

TABLE 22. AVERAGE RELATIVE YIELDS (PERCENT) OF COTTON, SOYBEANS, AND CORN FROM DIFFERENT RATES OF N, P, AND K AT SEVEN LOCATIONS, 1965-82

Treatment no.	Lb./acre applied	Seedcotton 1965-69 (26)[1]	Seedcotton 1970-72 (16) residue	Soybeans, 1973-75 (17) residue	Corn, 1976-80 (23)	Soybeans, 1981-82 (8)
	N[2]		Nitrogen			
1	0	55	61	99	42	97
2	30	79	82	101	—	102
3	60	97	96	98	89	102
4	90	97	98	—	98	—
5	120	100	100	—	100	—
6	150	99	96	—	99	—
	P_2O_5		Phosphorus			
7	0	85	89	85	85	92
8	20	92	96	96	98	101
9	40	97	96	98	97	99
10	60	99	98	101	101	101
5	100	100	100	100	100	100
	K_2O		Potassium			
11	0	65	59	88	91	96
12	20	91	80	93	98	97
13	40	95	92	96	102	100
14	60	99	97	101	101	101
15	80	99	99	101	101	106
5	100	2,410 lb.	2,450 lb.	38 bu.	93 bu.	39 bu.
16	No lime	88	88	82	73	90
6	No sulfur since 1969	—	—	99	98	100

[1]Numbers in parenthesis are location years included in the average.
[2]Only the 30- and 60-lb./acre N rates applied on soybeans.

TABLE 23. AVERAGE OF SOIL-TEST VALUES FROM DIFFERENT RATES OF P AND K AT SEVEN LOCATIONS, 1954-83

Rates of P_2O_5 and K_2O[1]	Values, pounds/acre						
	1954	1965	1969	1972 residue	1975 residue	1981	1983
			Soil-test phosphorus (P)				
0	36	33	33	29	29	24	28
20 Medium[2]		44	47	40	34	34	36
40		58	62	53	49	47	51
60 High		70	80	66	66	59	68
100		96	105	110	107	121	113
			Soil-test potassium (K)				
0	101	98	93	86	85	92	95
20 Medium		114	114	102	97	118	122
40		137	142	127	131	155	149
60 High		160	164	150	152	178	162
80		172	184	168	166	188	175
100		186	204	217	215	235	212
Soil pH	5.6	5.4	5.3	5.3	5.3	5.3	5.1

[1]Rates of P_2O_5 and K_2O applied annually except for 1970 through 1977 when all but the 100-lb./acre rates were discontinued for varying numbers of years among locations.

[2]Ratings indicated are those used for corn and soybeans on Group II soils, which have CEC values from 4.6 to 9.0 meq/100 g. Ratings used for other soils and crops can be found in Alabama Agricultural Experiment Station Circular 251, 1981, Soil Test Fertilizer Recommendations for Alabama.

Responses to P, K, Mg, S, lime, and micronutrients are dependent on the level of these nutrients and of pH in the individual soils. Soil tests for P, K, Mg, and pH should be good indicators of the need for fertilizers or lime to correct deficiencies, if the soil-test values are properly calibrated with responses in field experiments. These average values are therefore of limited use, except that they indicate the magnitude of responses that may be anticipated for the various nutrients. For example, there were few average responses to Mg, S, or micronutrients, but some locations did show need for these nutrients. Averages of soil-test values are also of limited use, but they do show the effects of long-term applications on soil fertility.

Responses to Nitrogen

Consistent responses to N were found on corn, cotton, wheat, and sorghum at all locations in the TYR. Determination of the rates to which response was found requires careful study of the tables and the footnotes, because the rates varied among the crops. The numbers of location-years (one year at one location) are indicated in parenthesis for each column.

Corn, in 90 location-years, responded to 90 pounds per acre N, with a small increase of 5 bushels per acre or less from 120 N over 90 N. During most of these years, corn followed soybeans, which usually reduces the N requirement by about 30 pounds per acre. Corn in the NPK produced 98 percent of 93 bushels per acre from 90 pounds per acre N. The 120- and 150-pound-per-acre rates did not increase yields over 90 N. These data agree with the present recommendation, which is 120 N with a comment that when following soybeans the rate be reduced 20 to 30 pounds per acre.

Cotton, in 36 location-years in the TYR from 1959-67, produced 2,420 pounds per acre of seedcotton from 60 pounds per acre of N. The 120 pound-per-acre N rate did not increase the yield over 60 N. Largest increases from N were on the sandy soils and the least increase was found on the Tennessee Valley Substation, which produced 85 percent of top yield without any N. In the NPK experiments, 60 N produced averages of 97 and 96 percent of top yields of 2,410 and 2,450 pounds per acre of seedcotton for the two periods. Increasing the N rate to 150 N slightly reduced yields in both periods. Present recommendations from the soil testing laboratory are 90 pounds per acre N with a comment that where excessive growth has caused problems with late maturity, insects, or boll rot, the rate be reduced by 20 to 30 pounds per acre. These data support this comment, especially for the soils similar to those on the Tennessee Valley Substation.

Wheat in a three-crop rotation (corn-wheat-soybeans) averaged 37 bushels per acre in 42 location-years. Application of 60 pounds per acre N in the spring after 20 N at planting increased yields 4 bushels per acre over only 30 in the spring and 20 in the fall. Four of the six locations showed response to 80 N over 50 N, with the most southerly locations, which produced the lowest yields, not responding.

Sweet sorghum at Sand Mountain and Brewton from 1980 through 1982 in the NPK responded to 60 pounds per acre N at both locations. No further increases were found from 90 and 120 pounds per acre N. *Grain sorghum* in TYR in 1982 at six locations responded to 90 pounds per acre N and averaged 89 bushels per acre for all locations. Present recommendations are 80 pounds per acre N for both sweet and grain sorghum. This limited amount of data indicates that this rate is correct.

Soybeans generally did not show any response to N. Increases of 3 to 4 bushels per acre at Monroeville, Prattville, and Wiregrass are attributed to the soybeans following corn that received no N and produced low yields. This affected the amount of residue returned to the soil by corn and is not a practice that would be recommended. Soybeans that followed well-fertilized corn showed no increase in yield from N.

Peanuts at the Wiregrass Substation showed no response to N in either experiment, although peanuts had not been grown on either area for many years, if ever.

Responses to Phosphorus

The TYR does not include a good rates study on response to P. The no-P plots from 1959-82 had received about 30 pounds per acre P_2O_5 from 1929 through 1957 and were either *Medium* or *High* in P when this comparison was started. They have received no P in 25 years and have dropped to *Low* or *Medium* at all locations. The standard treatment has received 60 pounds per acre of P_2O_5 annually since 1929 and was *High* or *Very High* at all locations throughout this study.

Four of the six locations have consistently produced responses to P. The Hartsells soil on the Sand Mountain Substation has been the most responsive because it has been *Low* in soil-test P since about 1960. The Dothan soil at the Wiregrass Substation and the Lucedale soil at Prattville have not responded to P on any of these crops because they were *Very High* in soil-test P in 1959. They dropped back into the *Medium* range about 1970, but still have not produced response. The other locations have produced moderate response to P at *Medium* and *Low* soil-test levels. Average responses to P of the four responding soils have been about 15 bushels per acre of corn and 7 bushels per acre of soybeans. Average increases of all crops from P at all locations in TYR have been about 10 percent.

The NPK experiments include an excellent P_2O_5 rates study and a period when all but the highest rate were in a residual study. As in the TYR, the Hartsells soil, which was *Low* in P in 1954 and remained at about the same level from 1954 through 1982, produced the greatest response to P. Cotton, corn, and sorghum responded to rates up to 60 pounds per acre of P_2O_5 while soybeans responded to 40 pounds. The Benndale soil at Brewton, which also was *Low*, produced responses to 20 P_2O_5 on cotton and to 40 P_2O_5 on soybeans, corn, and sorghum. Soils at Monroeville, Tennessee Valley, and Upper Coastal Plain, which were all *Low* in P, produced responses to 20 P_2O_5 but not to higher rates. Soils at Prattville and Wiregrass, which were *High* in P, showed no response to P by any crop from 1954 through 1982. The Dothan soil dropped into the *Medium* range about 1960 and to *Low* in 1978, but still did not respond. During the residual period from 1970-72, when P was applied only to the standard treatment, cotton continued to produce at 1965-69 levels at most locations. Some locations were continued in residue through 1977 and all others returned to residue studies in 1976 and 1977 without reduction in yields of soybeans and corn.

All rates from 20 P_2O_5 through 100 P_2O_5 annually increased soil-test P in proportion to amounts applied. When applications were discontinued, levels dropped slowly and in proportion to levels attained. Plots receiving 100 pounds per acre P_2O_5 annually reached *High* at all locations in 7 years of application. All except the Dewey soil reached *Very High* after about 10 more years of application.

Data in both experiments show that soil-test P values were reliable indicators of response. Soils that were *Low* in P generally responded. Soils that were *High* or *Very High* did not respond to P on any crops. *Medium* soils did not respond in most cases, but rates recommended at *Medium* increased soil P consistently. The data show that present recommendations based on soil tests are adequate to produce top yields and where levels are not already *High* to increase soil P reserves. Once these reserves reach *High,* applications may be discontinued so that growers may benefit from P stored in the soil.

Responses to Potassium

The TYR includes a good rate of K study. The no-K treatment has had none applied since the experiment was started in 1929. The other treatments had low rates until 1957 when the present 30-, 60-, and 120-pound-per-acre K_2O rates were started. Soil-test K in the no-K plots was *Low* or *Medium* at all locations in 1957. Cotton responded to 60 pounds per acre K_2O at Sand Mountain and Brewton, on soils *Low* in K. Other sites, which were *Medium,* responded to 30 pounds per acre K_2O. The average response to 30 K_2O at the six locations was 1,140 pounds per acre of seedcotton. Greatest response was on the sandy soils with least on the Dewey soil where K increased the yield only 220 pounds per acre. Corn and soybeans generally responded to only 30 pounds per acre K_2O, except on the Hartsells where some response was found from the second increment of K_2O. Wheat showed little response to K. There were no cases on any crop where 120 K_2O increased the yield over 60 K_2O. Application of 30 K_2O annually maintained soil-test K about constant and the higher rates increased soil K on all soils.

Response to K in the NPK was similar to that in the TYR. Cotton responded to 60 K_2O at Sand Mountain and Brewton; to 20 to 40 K_2O at Monroeville, Prattville, Wiregrass, and Upper Coastal Plain; and to 20 pounds per acre K_2O in the first period at Tennessee Valley. Residual K stored in the soils from 1954 through 1969 enabled them to produce at about the same level as before during 3 years without application of K in 1970-72. Corn and soybeans responded to 40 K_2O at Sand Mountain and Brewton and to 20 K_2O at other locations except Prattville, where soil-test K was *High* for these crops, and at Tennessee Valley where corn did not respond to K. Sweet sorghum responded to 60 K_2O at Sand Mountain and to 40 K_2O at Brewton.

Soil-test K showed more variation among locations and years than did P. This variation among soil types demonstrates why it is necessary to classify the soils into groups based on CEC to give reliable recommendations. Highest levels attained on the Benndale would be rated *Low* on the Dewey. Soil K levels of the no-K treatments dropped little in 30 years, the average drop being from 101 pounds per acre to 95 pounds per acre of soil-test K, table 23. All rates from 20 up to 100 pounds per acre K_2O applied annually increased soil-test values. Greatest proportional increases were found from the 20- and 40-pound-per-acre K_2O rates except for the 100-pound-per-acre rate, which was applied continuously through the residue periods. Soil-test K ratings based on classification of the soils into three groups served as reliable bases for making fertilizer recommendations. The data show that present recommendations based on this system are reliable and should be adequate for these crops on Alabama soils. This includes the recommendation that no K be applied to soils testing *High*.

Responses to Lime

Large responses to lime by cotton and corn were found in the TYR on all except the Dewey soil. Average response to lime by cotton at five locations was 280 pounds per acre of seedcotton. Response by corn increased with time as the pH dropped. Soybeans responded to lime at all locations, averaging 14 bushels per acre response in both periods reported. Grain sorghum was the most sensitive to low pH of all crops grown, averaging a 57-bushel-per-acre response to lime for 1982. Wheat averaged 7 bushels per acre response to lime, ranging from 2 to 20 bushels per acre for the six locations.

The unlimed treatment in the NPK experiments also produced low yields, and the deficiency grew progressively worse with time as the pH dropped. The sandy soils were affected more than those with higher CEC at Prattville and Tennessee Valley. Soil pH gave good indications of the need for lime. Differences in acidity levels that crops will tolerate are used in making lime recommendations from the soil testing laboratory. Soils of Group III with higher CEC produce satisfactorily at lower pH levels than will the lower CEC soils of groups I and II.

Responses to Magnesium and Sulfur

The TYR included a comparison between dolomitic and calcitic lime throughout the periods reported. Differences in yield between treatments 5 and 14 are primarily due to Mg, which is supplied by dolomitic but not by calcitic lime. Cotton and corn did not respond to Mg on any of these soils, although the Benndale and Hartsells are *Low*. Soybeans responded to Mg on the Benndale, Hartsells, and Lucedale at Monroeville, averaging about 6 bushels per acre response. The Lucedale soil at Monroeville had 55 pounds per acre of soil-test Mg in 1983, which is just above the adequate level of 50 pounds per acre for Group II and III soils. The Benndale and Dothan are Group I soils where the critical level is 25 pounds per acre of soil-test Mg. Peanuts did not respond on the Wiregrass Substation where the soil-test Mg was 46 pounds per acre in 1983.

Both experiments have included a no-S treatment in recent years after having S supplied to all plots as superphosphate or gypsum for many years. The no-S treatment in the TYR was started in 1978. Corn has produced response at four of the six locations, with the Benndale and Dewey not responding. Soybeans showed responses of 3 to 4 bushels per acre at all locations except Prattville from 1979-82.

A no-S treatment was started in the NPK experiment in 1970 on plots that had received 30 pounds per acre of S from gypsum annually from 1954 through 1969. This had no doubt built large reserves of S, especially in the subsoils of these plots. The only case where response to S has been found in these experiments was on corn on the Hartsells soil where there was a 30-bushel-per-acre response in the 4-year period 1976-79. Other crops and locations have not yet shown response to S after 13 years without application.

Treatment No. 8 in the TYR included a micronutrient mixture containing Zn, Mn, B, Cu, and Mo applied in alternate years beginning in 1959. The only crop that showed positive responses to this mixture was cotton. Increases of 300, 230, and 180 pounds per acre of seedcotton which were found at Monroeville, Brewton, and Wiregrass are attributed to B, for such sandy soils have been found to respond to this nutrient and 0.3 pound per acre of B is recommended for cotton on all soils in Alabama.

Rejuvenating Wornout Soils

The TYR included treatments No. 1 and 17 which received no fertilizer or lime from 1929 through 1978. Yield tables for all locations include yield percentages for these plots, but little mention has been made of them in previous discussions. They produced low yields at all locations, showing that none of these soils will produce acceptable yields without fertilizer and lime. Non-legume crops, such as corn, cotton, wheat, and sorghum, produced lowest yields on these plots because N becomes the first limiting nutrient under such conditions. Soybeans produced relatively better because yields were limited by P, K, or lime rather than N.

In 1979, treatment 17 was limed and fertilized for the first time in 50 years. Yields of corn and soybeans showed dramatic improvement the first year. For the next 3 or 4 years, 1979-82, corn averaged 79 percent and soybeans 86 percent of the yield of the standard treatment at all locations. Grain sorghum at six locations in 1982 averaged 94 percent while the untreated plots averaged 24 percent of standard yield. These data demonstrate that even when soils were badly mismanaged under continuous cropping for 50 years, they recovered rapidly to near normal production when fertilized and limed according to soil-test recommendations.

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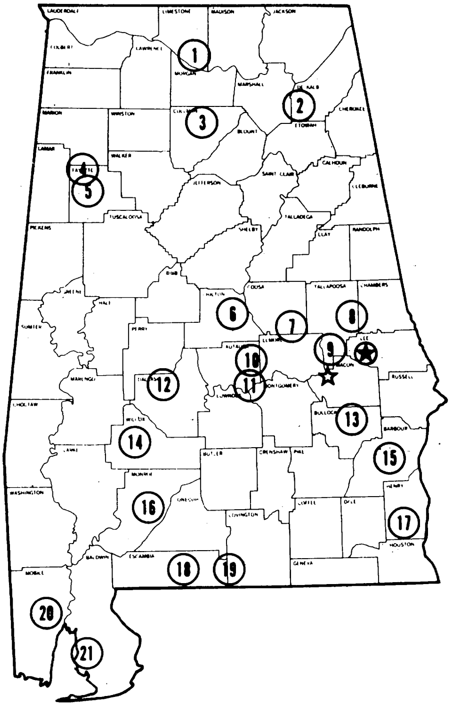

Research Unit Identification

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

1. Tennessee Valley Substation, Belle Mina.
2. Sand Mountain Substation, Crossville.
3. North Alabama Horticulture Substation, Cullman.
4. Upper Coastal Plain Substation, Winfield.
5. Forestry Unit, Fayette County.
6. Chilton Area Horticulture Substation, Clanton.
7. Forestry Unit, Coosa County.
8. Piedmont Substation, Camp Hill.
9. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Substation, Spring Hill
21. Gulf Coast Substation, Fairhope.