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FERTILIZER EXPERIMENTS WITH COTTON

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INTRODUCTION

FROM 1911 through 1922 the Agronomy Department of this station conducted more than two hundred fertilizer experiments to determine the best fertilizer or combination of fertilizers for cotton on each of the principal soil regions of Alabama. These experiments showed conclusively that, with the possible exception of the Piedmont Plateau, cotton should be fertilized with a complete fertilizer when planted on any of the several soil regions of the State. They showed further that a safe minimum application of fertilizer for cotton per acre is 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash. With the results of the earlier work as a basis, other cooperative experiments were started in 1923 to determine the rate and ratio that nitrate of soda, superphosphate, and muriate of potash should be used when applied in greater quantities than the minimum application.

This bulletin records the results obtained from these later experiments on rate and ratio of fertilizing cotton. These investigations include chiefly experiments on Clarkesville soils of the Highland Rim; Decatur and Hagerstown (Dewey) soils of the Limestone Valleys; DeKalb (Hartselle) soils of the Appalachian Plateau; Cecil soils of the Piedmont Plateau; Houston, Sumter, and Oktibbeha soils of the Black Belt; and Norfolk, Kalmia, Ruston, Greenville, and Orangeburg soils of the Coastal Plains. The work was begun in the spring of 1923 and continued through 1927. During the five years 170 conclusive individual experiments were made. The tables show the number of experiments on each soil group.

METHODS

COOPERATIVE experiments by this department are conducted on the farms of men who are known to be especially interested and have above average ability for work of this nature. Many of the cooperators have been doing work of this nature in cooperation with the department for ten to fifteen years. New men are selected almost entirely on recommendation of the county agent, who, in practically every case, spends time in seeing that the experiment is properly carried out.

In this publication the term "an experiment" refers to a single year's work on one series of plots. The method of replication used by this station is to place a single series of plots on any one farm and repeat the experiment on the same soil series in other communities, or, perhaps, in other counties.

The land used for each experiment was selected and measured by a representative of the experiment station. Two hundred seventy-three experiments were located to obtain the average results from the 170 experiments recorded in the tables. Poor, irregular stands and lack of uniformity of the soil as shown by

the yields of the unfertilized plots were the chief causes for the nonuse of the remaining 103 experiments. Fertilizers for each plot and instructions concerning their application were sent to each cooperator. Each experiment was inspected one or more times during the growing season. All of the phosphoric acid, all of the potash, and one-fourth of the nitrogen were applied in the bed immediately before planting; the remaining three-fourths of the nitrogen was applied just prior to the first cultivation after the cotton was chopped.

VALUES ASSIGNED TO FERTILIZERS AND TO COTTON

THE PRICES given below are used as representing near the average price of fertilizers and of seed cotton during the years in which these experiments were conducted:

Nitrate of soda	$60.00 per ton
Superphosphate (acid phosphate)	17.00 per ton
Muriate of potash	40.00 per ton
Seed cotton	0.08 per pound

The assumed value of seed cotton is on the basis of lint cotton at 18 cents per pound and cotton seed at $30.00 per ton. The profit calculations are based on cotton in the field ready to harvest. No charge has been made for picking, ginning, and marketing the increase due to fertilizers; neither is any charge assumed for handling the materials in the spring, interest on money invested in fertilizers, nor other expenses incurred from their use. However, such indeterminable factors as residual effect of fertilizers and cumulative value of extra stalk growth on properly fertilized areas over that on unfertilized land will go a great way toward offsetting charges other than the cost of fertilizers. The tables contain a complete record of the average yields so that the reader may make any other desired calculations.

EXPLANATION OF TERMS AND VALUES

ALL of the fertilized plots in the experiments reported in this publication received a minimum application of 325 pounds of fertilizer per acre, composed of 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash. In the discussion which follows, this application is termed the "base application" and the plot receiving the base application only is termed the "base plot" (Plot 2). Any reference to "second increment," "additional material," "additional nitrogen, phosphoric acid, or potash," or any similar terms have to do with the additional fertilizer or fertilizing material above that used as the base application. The reader should keep in mind that earlier work reported by this station showed the value of the different fertilizer ingredients used in the base application and that this publication is to record the results of experiments carrying heavier fertilization than the base plot.

A study of the tables will show that there are four possible values for each plant food. For example: the yield on Plot 3 minus the yield on Plot 2 gives the increase due to the second increment of potash alone; the yield on Plot 5 minus the yield on Plot 4 gives the increase due to the second increment of potash in the presence of a second increment of nitrogen; the yield on Plot 8 minus the yield on Plot 7 gives the value of potash in the presence of a second increment of phosphoric acid; and the yield on Plot 10 minus the yield on Plot 9 gives the value of the second increment of potash in the presence of second increments of both nitrogen and phosphoric acid. By similar calculations four values can also be obtained for phosphoric acid and for nitrogen. In most of the averages of the experiments herein recorded the greatest increase due to a single fertilizing element was obtained when the other two essential elements were present in the exact proportion as they were used on the base plot. Unless there is a statement to the contrary, any discussion of the value of the increase due to either nitrogen, phosphoric acid, or potash will have reference to their value on Plot 10 and will be obtained as follows:

The yield on Plot 10 minus the yield on Plot 8 equals the value of the second increment of nitrogen.

The yield on Plot 10 minus the yield on Plot 5 equals the value of the second increment of phosphoric acid.

The yield on Plot 10 minus the yield on Plot 9 equals the value of the second increment of potash.

Plot 12, carrying three times the application of the base plot, was added to the experiment in 1924. Since a smaller number of the experiments carrying this rate of application were made than were made of the ratio experiments, the rate work is presented in a separate table from the ratio experiments.

RESULTS OF EXPERIMENTS

Experiments on the Highland Rim:

TABLE 1 records the results of seven experiments which were made to determine the most profitable ratio of applying fertilizer constituents to cotton on the soils of the Highland Rim. All of the experiments were located on Clarkesville silt loam soil, locally known as "Barrens." The land on which the experiments were conducted produced on the average 618 pounds of seed cotton per acre without fertilizers.

The base application on Plot 2, 100 pounds of nitrate of soda, 200 pounds of superphosphate (acid phosphate), and 25 pounds of muriate of potash per acre, produced an increase of 342 pounds of seed cotton at a profit of $22.16 over the unfertilized plot. The greatest increase, 689 pounds of seed cotton per acre, and the greatest profit, $44.72, were obtained on Plot 10, fertilized with 200 pounds of nitrate of soda, 400 pounds of superphosphate, and 50 pounds of muriate of potash per acre.

Table 1.—Average Results of 7 Fertilizer Experiments with Cotton on the Highland Rim.

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	640	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	960	342	22.16	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	979	361	23.18	19	1.02
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	1056	438	26.84	96	4.68
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	1073	455	27.70	113	5.54
6	---	No fertilizer	590	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	1089	471	30.78	129	8.62
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	1156	538	35.64	196	13.48
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	1226	608	38.74	266	16.58
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	1307	689	44.72	347	22.56
11	---	No fertilizer	623	---	----	---	----
		Average No Fertilizer	618				

The use of additional nitrogen, phosphoric acid, or potash alone over that used in the base application increased the yield and profit in every case. This was also true when these plant foods were increased in pairs. However, the greatest profit and the greatest increase over the base application was obtained where all of these elements were increased in exactly the same ratio as they were used on the base plot. The addition of a second increment of the three fertilizing materials on Plot 10 produced an increase of 347 pounds of seed cotton per acre at a profit of $22.56 over the base application.

A study of Table 1 reveals that, for cotton on these soils,

phosphoric acid, nitrogen, and potash were of importance in the order named. The second increment of superphosphate produced 234 pounds of seed cotton per acre; the second increment of nitrate of soda produced 151 pounds, and the second increment of muriate of potash produced 81 pounds of seed cotton per acre. These results were obtained by comparing Plots 5 and 10, 8 and 10, and 9 and 10, respectively. Earlier experiments also emphasized the importance of phosphoric acid as an ingredient of the base mixture. (See Ala. Sta. Bul. 219.) This statement must not be construed as meaning that nitrogen and potash are of but little value because, as is shown in Table 19, the increase due to nitrogen was worth $4.03 for each dollar invested in this material and each dollar invested in muriate of potash returned $12.96.

Six experiments comparing three different rates of fertilizing cotton with a mixture made in the proportions of 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash have been made on Clarkesville silt loam (Table 2). The results show that 325 pounds of this mixture produced an increase of 362 pounds of seed cotton per acre at a profit of $23.76; 650 pounds of the mixture produced an increase of 731 pounds of seed cotton and a profit of $48.04; while 975 pounds of the mixture produced a still greater increase but with a profit of only $47.12. From these results it is evident that 650 pounds of fertilizer per acre is a safe maximum on the soils of the Highland Rim.

Table 2.—Average Results of 6 Experiments on Rate of Fertilizing Cotton on the Highland Rim.

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	666	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	1028	362	23.76
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	1397	731	48.04
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	1450	784	47.12

Experiments on the Limestone Valleys:

Thirty-seven experiments have been made on the soils of the limestone valleys bordering the Tennessee and the Coosa Rivers. Due to the small number of experiments made on soils

other than the Decatur and Hagerstown (Dewey) series and to the similarity of the results on all soils of this region, all the data from this soil region have been averaged with the Decatur soil group. Decatur soils are red with intense red subsoil; Hagerstown soils are brown with light brown to reddish brown subsoil. Both soils are known logically as "red lands." The soils on which these experiments were located made an average yield of 413 pounds of seed cotton per acre without fertilizers. The results of these experiments are presented in Table 3.

Table 3.—Average Results of 37 Fertilizer Experiments with Cotton on the Limestone Valley Soils*.

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	414	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	697	284	17.52	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	720	307	18.86	23	1.34
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	805	392	23.16	108	5.64
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	832	419	24.82	135	7.30
6	---	No fertilizer	409	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	739	326	19.18	42	1.66
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	765	352	20.76	68	3.24
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	848	435	24.90	151	7.38
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	890	477	27.76	193	10.24
11	---	No fertilizer	417	---	----	---	----
		Average No Fertilizer	413				

* Thirty-four experiments on Decatur and Hagerstown soils, two on Holston and one on Colbert soil.

The use of 100 pounds of nitrate of soda, 200 pounds of superphosphate (acid phosphate), and 25 pounds of muriate of potash as a base application increased the yield by 284 pounds of seed cotton per acre at a profit of $17.52. The largest increase and the largest profit, 477 pounds of seed cotton and $27.76, respectively, were obtained from the use of double the base application, or 200 pounds of nitrate of soda, 400 pounds of superphosphate, and 50 pounds of muriate of potash per acre.

It is a common belief in the limestone sections of Alabama that these lands produce all the stalk that is necessary for a full crop of cotton from the use of only 100 pounds of nitrate of soda per acre. The belief is that additional phosphoric acid should be used without additional nitrogen. However, this opinion is not substantiated by the experimental data herein presented. For example, Plot 7 which received 200 pounds more superphosphate per acre than did the base plot made only 42 pounds more seed cotton at a profit of $1.66, while Plot 4 which received 100 pounds more nitrate of soda per acre than the base plot made an increase of 108 pounds at a profit of $5.64 per acre over the base application. When comparisons of the values of additional increments of nitrogen and phosphoric acid over the base application are made, nitrogen continues to show much the greater increase. For example, comparing Plots 5 and 10 shows that the second increment of phosphoric acid produced 58 pounds of seed cotton per acre when used in addition to second increments of nitrogen and potash; comparing Plots 8 and 10 shows that nitrogen produced 125 pounds of seed cotton under similar conditions. In this connection it should be noted that a second increment of potash produced an increase of 42 pounds of seed cotton per acre when used in addition to second increments of nitrogen and phosphoric acid.

For maximum profits on these soils the second increment must carry nitrogen, phosphoric acid, and potash in the proportions used in the base application. This is proven by the fact that the largest increase, 193 pounds of seed cotton per acre, and the greatest profit over the base application, $10.24, were obtained where the additional application was composed of a second increment of each of the three fertilizer ingredients. As shown in Table 19, each dollar invested in superphosphate returned $2.73; each dollar in nitrate of soda returned $3.33; and each dollar invested in muriate of potash returned $6.72. All of these returns, however, are much below the returns obtained per dollar invested in fertilizers for the Highland Rim soils.

To determine the most profitable rate of applying fertilizers on Limestone Valley soils, twenty-seven experiments were conducted from 1924 to 1927, inclusive, (Table 4). The results show that an increase of 515 pounds of seed cotton per acre at a profit of $30.80 was obtained where 650 pounds of fertilizer made of 200 pounds of nitrate of soda, 400 pounds of superphosphate, and 50 pounds of muriate of potash per acre was used.

Table 4.—Average Results of 27 Experiments on Rate of Fertilizing Cotton on Limestone Valley Soils.

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	466	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	774	308	19.44
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	981	515	30.80
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	1120	654	36.72

When these ingredients were applied in the same ratio, but at a rate of 975 pounds of fertilizer per acre, the increase was 654 pounds of seed cotton produced at a profit of $36.72. Some years during the period of these experiments the heavier rate of application was used at a loss; consequently, the use of the 650 pound application is recommended.

Experiments on the Appalachian Plateau:

The average results of 19 experiments on DeKalb (Hartselle) soils of the Appalachian Plateau are reported in Table 5. The DeKalb series is made up of the yellowish-gray soils with yellow subsoil common to this section. The experiments on ratio of applying fertilizer ingredients were conducted on soils that made an average yield of 406 pounds of seed cotton per acre without fertilizer.

The base mixture produced an increase of 384 pounds of seed cotton per acre at a profit of $25.52 over the average of the unfertilized plots. This is the greatest average increase and profit produced on any soil region by the base application. Doubling the application used on the base plot increased the yield over the unfertilizer plots by 635 pounds of seed cotton at a profit of $40.40 per acre.

Adding a second increment of potash alone increased the yield of seed cotton only 14 pounds at a profit of $0.62 per acre. This same quantity of potash, when used in connection with additional increments of nitrogen and phosphoric acid, produced an increase of 56 pounds of seed cotton at a profit of $3.98 per acre. A second increment of nitrogen alone increased the yield by 151 pounds of seed cotton at a profit of $9.08 per acre. However, a comparison of Plots 8 and 10 shows that a second increment of nitrogen was most effective when used in the presence

Table 5.—Average Results of 19 Fertilizer Experiments with Cotton on the Appalachian Plateau

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	394	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	790	384	25.52	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	804	398	26.14	14	0.62
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	941	535	34.60	151	9.08
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	939	533	33.94	149	8.42
6	---	No fertilizer	416	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	866	460	29.90	76	4.38
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	869	463	29.64	79	4.12
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	985	579	36.42	195	10.90
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	1041	635	40.40	251	14.88
11	---	No fertilizer	409	---	----	---	----
		Average No Fertilizer	406				

of second increments of both phosphoric acid and potash, in which case a second increment of nitrogen made 172 pounds of seed cotton at a profit of $10.76. Like nitrogen and potash, additional phosphoric acid was most effective when used in the presence of additional increments of the other ingredients. When used alone the second increment of phosphoric acid produced an increase of 76 pounds of seed cotton per acre, but when the same quantity of this material was used along with additional nitrtogen and potash, the increase due to phosphoric acid was 102 pounds of seed cotton. (Compare Plots 5 and 10.)

For each dollar invested in a second increment of phosphoric acid in the presence of second increments of the other two ingredients, the increase was worth $4.80; for each dollar invested in nitrogen under similar conditions the increase was worth $4.59; and for each dollar invested in potash the increase was worth $8.96 (Table 19). A ton of nitrate of soda made 3440 pounds of seed cotton per acre; a ton of superphosphate, 1020 pounds; and a ton of muriate of potash, 4480 pounds. (The reader should keep in mind that the statements in this bulletin refer to second increments unless otherwise noted.)

Table 6.—Average Results of 14 Experiments on Rate of Fertilizing Cotton on the Appalachian Plateau.

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	391	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	769	378	25.04
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	1062	671	43.28
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	1204	813	49.44

A fertilizer made of 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash was used at three rates on 14 experiments located on the Appalachian Plateau soils. The average of these results shows that all three rates were profitable. However, the 975 pound application produced only 142 pounds more seed cotton at a profit of only $6.16 per acre over the 650 pound rate. This small increase is significant in years when cotton sells above 15 cents per pound but when cotton sells much below that price this application may be unprofitable. The 650 pound application produced an increase of 671 pounds of seed cotton per acre at a profit of $43.28.

Experiments on the Piedmont Plateau:

The extreme difficulty of obtaining suitable plot land on the Piedmont Plateau was the cause of only ten experiments being made in this region. Five of these ten experiments were made on the same farm and all of the experiments were of necessity located on poor-producing soils. Consequently, the results on this soil region are not as conclusive as the results from the regions which

have already been discussed. All of the experiments were made on Cecil soils. The average yield of the unfertilized plots was only 167 pounds of seed cotton per acre.

The average increase and profit due to the base application was 271 pounds of seed cotton and $16.48 per acre, respectively. Doubling the rate of the base application gave the greatest increase and the greatest profit, 481 pounds of seed cotton and $28.08 per acre, respectively.

Table 7.—Average Results of 10 Fertilizer Experiments with Cotton on the Piedmont Plateau

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	158	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	438	271	16.48	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	458	291	17.58	20	1.10
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	605	438	26.84	167	10.36
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	596	429	25.62	158	9.14
6	---	No fertilizer	161	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	512	345	20.20	74	4.22
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	513	346	20.28	75	3.80
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	622	455	26.50	184	10.02
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	648	481	28.08	210	11.60
11	---	No fertilizer	183	---	----	---	----
		Average No Fertilizer	167				

Table 8.—Average Results of 9 Experiments on Rate of Fertilizing Cotton on the Piedmont Plateau

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	177	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	457	280	17.20
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	652	475	27.60
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	763	586	31.28

When increases over the base plot are considered, it will be found that potash alone, phosphoric acid alone, and the combination of the two gave only small increases. Where nitrogen was used in addition to the base application, a substantial increase over the base plot was secured. The greatest yield and the greatest profit due to fertilizers resulted when all fertilizing ingredients were used in the ratio of the base application.

In nine experiments where the base application was used at three rates, as reported in Table 8, the plot receiving double the base application produced an increase of 475 pounds of seed cotton per acre at a profit of $27.60. There was a still further increase with a small profit from the use of three times the base application. But, like the results of the 975 pound application on the Appalachian Plateau Region, this small profit could be easily turned to a loss by a small decrease in the price of cotton. A safe fertilizer for the Piedmont Plateau is a 650 pound application made of 200 pounds of nitrate of soda, 400 pounds of superphosphate, and 50 pounds of muriate of potash per acre.

Experiments on the Black Belt:

The experiments on soils of the Black Belt were not started until 1925. Consequently, the data in tables 9 to 12, inclusive, cover only the years 1925, 1926, and 1927. During this three-year period 18 experiments were conducted. Two general divisions have been made of the experiments conducted on this soil region. Experiments on soils that were known to contain some calcareous material were classified in the Houston soil group and those showing no lime within the first 24 to 36 inches were placed in the Oktibbeha group. The Houston group includes both Houston and Sumter soils, which are known to the local people as "lime lands." The Oktibbeha group, locally

known as "post-oak" soils, includes all experiments on true Oktibbeha soils and may include experiments on soils of the Eutaw series.

Results on the Houston Soil Group.—As shown in Table 9 the soils of the Houston group produced an average yield of 696 pounds of seed cotton per acre without fertilizers. This is the greatest yield obtained on any soil region where no fertilizers were used. In contrast with the high yield of the unfertilized plots is the low response of these soils to fertilizers. The increase due to the base application was only 122 pounds of seed

Table 9.—Average Results of 10 Fertilizer Experiments with Cotton on the Black Belt (Houston Soil Group).

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	696	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	818	122	4.56	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	811	115	3.50	—7	—1.06
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	850	154	4.12	32	—0.44
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	856	160	4.10	38	—0.46
6	---	No fertilizer	694	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	821	125	3.10	3	—1.46
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	880	184	7.32	62	2.76
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	880	184	4.82	62	0.26
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	866	170	3.20	48	—1.36
11	---	No fertilizer	699	---	----	---	----
		Average No Fertilizer	696				

Table 10.—Average Results of 10 Experiments on Rate of Fertilizing Cotton on the Black Belt (Houston Soils).

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	696	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	818	122	4.56
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	866	170	3.20
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	942	246	4.08

cotton per acre produced at a profit of only $4.56. Additional increments of phosphoric acid and potash on Plot 8 and of nitrogen and phosphoric acid on Plot 9 made sufficient increase to produce a slight profit but the additional financial risk is not justified by the small profits. All other additional applications were used at a financial loss.

The poor response of the Houston soil group to more fertilizer than the base application is further emphasized by the data in Table 10. These results show that, although there was a slight increase with the addition of each 325 pound increment of fertilizers, the most profitable rate of application was on the base plot. The use of only 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash is recommended on this soil group.

Experiments on the Oktibbeha Soil Group.—Eight experiments were conducted on this soil group during 1925, 1926, and 1927. As will be seen in Table 11, the unfertilized plots made an average yield of 382 pounds of seed cotton per acre. The base application of 100 pounds of nitrate of soda, 200 pounds of superphosphate and 25 pounds of muriate of potash produced an increase of 169 pounds of seed cotton per acre and a profit of $8.32. The greatest profit and the largest increase $20.88 and 391 pounds of seed cotton, respectively, were secured on Plot 10 which received a second increment of each of the fertilizing materials used on the base plot.

From the data in the table it can be seen that satisfactory profits were obtained over the base application only when nitrogen and phosphoric acid, and nitrogen, phosphoric acid, and potash were used. When these fertilizing ingredients were used either alone or in any other combinations the additional material was either ineffective or produced only a slight profit.

The greatest response to the second increment of nitrogen and the second largest response to the use of phosphoric acid were obtained from the experiments in this soil group. Additional nitrogen was most effective when used in addition to a second increment of superphosphate only, on Plot 9. On this plot, the second increment of nitrogen produced an increase of 208 pounds of seed cotton per acre—compare Plots 9 and 7. The reader should bear in mind, however, that the true value of a fertilizer ingredient is its value in the presence of optimum quantities of the other necessary ingredients. Since the largest

Table 11.—Average Results of 8 Fertilizer Experiments with Cotton on the Black Belt (Oktibbeha Soil Group).

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	349	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	551	169	8.32	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	523	141	5.58	—28	—2.74
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	599	217	9.16	48	0.84
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	585	203	7.54	34	—0.78
6	---	No fertilizer	380	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	548	166	6.38	—3	—1.94
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	621	239	11.72	70	3.40
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	756	374	20.02	205	11.70
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	773	391	20.88	222	12.56
11	---	No fertilizer	418	---	----	---	----
		Average No Fertilizer	382				

Table 12.—Average Results of 8 Experiments on Rate of Fertilizing Cotton on the Black Belt (Oktibbeha Soils).

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	382	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	551	169	8.32
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	773	391	20.88
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	933	551	28.48

increase and the greatest profit were obtained on Plot 10, this plot apparently carries the optimum quantites of phosphoric acid and potash; therefore, the true value of nitrogen is found by comparing Plots 8 and 10. In which case the true value of the additional increment of nitrogen is 152 pounds of seed cotton per acre. Comparing Plots 5 and 10 shows that additional phosphoric acid produced 188 pounds of seed cotton per acre. Potash was much less effective than either nitrogen or phosphoric acid although it was profitable in the presence of additional increments of these two plant foods.

By referring to Table 19, it will be seen that each dollar invested in superphosphate, over that used on the base plot, produced $8.85 worth of cotton; each dollar in nitrate of soda produced $4.05; and each dollar in potash, $2.72 worth of cotton. Stated in another way, one ton of superphosphate made 1880 pounds of seed cotton; each ton of nitrate of soda made 3040 pounds; and each ton of muriate of potash made 1360 pounds of seed cotton.

Each of the eight experiments on this soil region carried the base plot application at three different rates. Table 12 shows the results of these rate experiments. The most profitable rate of application was three times the base application or 975 pounds of fertilizer per acre. This rate of fertilization resulted in a profit of $28.48 per acre, which is a greater profit than that from twice the minimum application by $7.60 per acre.

Experiments on the Coastal Plain:

In this publication the experiments conducted on the Coastal Plain have been divided into two distinct groups. The gray sandy soils with yellow or reddish-yellow sandy or fine sandy subsoil are presented as the "Norfolk Group." This group in-

cludes all experiments on the Norfolk, Kalmia and Ruston series. The second group, under the heading "Greenville Group," is made up of all soils with gray surface and red subsoil or red surface and red subsoil. In the Greenville Group are included experiments on the Greenville, Orangeburg, and Cahaba series. No separation of the soils of the Upper and Lower Coastal Plain Regions has been made.

A comparison of the Greenville and the Norfolk soil groups shows the following interesting facts: (1) Soils of the Greenville Group usually produce slightly more per acre without the

Table 13.—Average Results of 34 Fertilizer Experiments with Cotton on the Coastal Plain (Greenville Soil Group).

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	399	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	710	297	18.56	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	724	311	19.18	14	0.62
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	839	426	25.88	129	7.32
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	854	441	26.58	144	8.02
6	---	No fertilizer	413	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	763	350	21.10	53	2.54
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	789	376	22.68	79	4.12
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	895	482	28.66	185	10.10
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	926	513	30.64	216	12.08
11	---	No fertilizer	426	---	----	---	----
		Average No Fertilizer	413				

Table 14.—Average Results of 24 Experiments on Rate of Fertilizing Cotton on the Coastal Plain (Greenville Soils).

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	493	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	829	336	21.68
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	1059	566	34.88
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	1184	691	39.68

use of fertilizers than do the soils of the Norfolk group; (2) the response to fertilizers is usually less on the Greenville than on the Norfolk group; and (3) potash is needed on both soil groups but the response to potash is greater on the Norfolk than on the Greenville group.

Results on the Greenville Soil Group.—Thirty-four experiments were conducted on the Greenville Soil Group from 1923 to 1927, inclusive. The average yield without fertilizers was 413 pounds of seed cotton per acre. The base application produced 297 pounds of seed cotton per acre more than the unfertilized plots at a profit of $18.56. The greatest increase, 513 pounds of seed cotton, and the greatest profit, $30.64 per acre, were obtained on Plot 10 where the base plot application was doubled.

The application of nitrate of soda, superphosphate, and muriate of potash at a rate greater than the base application increased the profit from fertilizers in every case. The greatest profit was obtained on Plot 10 where each of the materials was used in the same ratio as in the base application.

A study of the table shows that nitrogen in the form of nitrate of soda was a highly effective fertilizer on the soils of this group. In every combination it produced a substantial increase, being of greatest value when used in the presence of additional increments of phosphoric acid and potash on Plot 10 where it produced an increase of 137 pounds of seed cotton per acre. Phosphoric acid in the form of superphosphate in connection with additional nitrogen and potash produced an increase of 72 pounds, and muriate of potash under similar conditions produced 31 pounds of seed cotton per acre.

Under the condition of these experiments, one dollar invested in a second increment of superphosphate returned $3.39, one dollar in a second increment of nitrate of soda returned $3.65,

and one dollar in a second increment of muriate of potash, $4.96 (Table 19). When viewed from another angle it will be seen that for each ton of superphosphate used on this soil group 720 pounds of seed cotton were obtained; for each ton of nitrate of soda, 2740 pounds of seed cotton; and for each ton of muriate of potash, 2480 pounds of seed cotton.

Three rates of applying the base plot application were used on 24 of the Greenville group experiments (Table 14). These data show that all three rates of application produced satisfactory profits, with the safest application of the three probably be-

Table 15.—Average Results of 45 Fertilizer Experiments with Cotton on the Coastal Plain (Norfolk Soil Group).

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over average of unfertilized plots	Profits from fertilizers	Increase over base plot	Profit over base plot
	Lbs.		Lbs.	Lbs.	$	Lbs.	$
1	---	No fertilizer	354	---	----	---	----
	100	Nitrate of soda					
	200	Superphosphate					
2	25	Muriate of potash	716	360	23.60	---	----
	100	Nitrate of soda					
	200	Superphosphate					
3	50	Muriate of potash	733	377	24.46	17	0.86
	200	Nitrate of soda					
	200	Superphosphate					
4	25	Muriate of potash	780	424	25.72	64	2.12
	200	Nitrate of soda					
	200	Superphosphate					
5	50	Muriate of potash	828	472	29.06	112	5.46
6	---	No fertilizer	361	---	----	---	----
	100	Nitrate of soda					
	400	Superphosphate					
7	25	Muriate of potash	761	405	25.50	45	1.90
	100	Nitrate of soda					
	400	Superphosphate					
8	50	Muriate of potash	770	414	25.72	54	2.12
	200	Nitrate of soda					
	400	Superphosphate					
9	25	Muriate of potash	833	477	28.26	117	4.66
	200	Nitrate of soda					
	400	Superphosphate					
10	50	Muriate of potash	913	557	34.16	197	10.56
11	---	No fertilizer	353	---	----	---	----
		Average No Fertilizer	356				

Table 16.—Average Results of 42 Experiments on Rate of Fertilizing Cotton on the Coastal Plain (Norfolk Soils).

Amt. fert. per acre	Kind of Fertilizer	Yield seed cotton per acre	Increase over unfertilized plots	Profits from fertilizers
Lbs.		Lbs.	Lbs.	$
---	No fertilizer (Average 3 plots)	371	---	----
100	Nitrate of soda			
200	Superphosphate			
25	Muriate of potash	740	369	24.32
200	Nitrate of soda			
400	Superphosphate			
50	Muriate of potash	946	575	35.60
300	Nitrate of soda			
600	Superphosphate			
75	Muriate of potash	1014	643	35.84

ing the rate of 650 pounds per acre composed of 200 pounds of nitrate of soda, 400 pounds of superphosphate, and 50 pounds of muriate of potash per acre.

Results on the Norfolk Soil Group.—The average results of forty-five experiments, which were made to determine the ratio of applying fertilizer ingredients on the gray soils with yellow subsoils, are recorded in Table 15. The land on which these experiments were conducted produced an average yield of 356 pounds of seed cotton per acre without fertilizer.

The base application produced an increase of 360 pounds of seed cotton at a profit of $23.60 over the average of the unfertilized plots. The greatest increase and profit, 557 pounds of seed cotton and $34.16 per acre, respectively, resulted from the use of second increments of all of the fertilizer ingredients in the exact ratio of the base application. A study of the increase due to additional applications over the base application shows that each fertilizer ingredient, whether used alone or in combination, produced a profitable increase but that for the maximum profit all three ingredients, nitrate of soda, superphosphate, and muriate of potash, must be used to make up the second increment of fertilizer. When 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash were added to the base application there was an increase of 197 pounds of seed cotton at a profit of $10.56 per acre.

If Plots 9 and 10 are compared it will be seen that 25 pounds of muriate of potash increased the yield of seed cotton by 80 pounds per acre, or a ton of muriate of potash under the conditions of these experiments would increase the yield by 6400 pounds of seed cotton. Stated in another way, each dollar invested in muriate of potash returned $12.80. Comparing Plots 5 and 10 in Table 15, it will be seen that the additional increment

of superphosphate increased the yield of seed cotton by 85 pounds per acre, or under the same conditions a ton of superphosphate would increase the yield by 850 pounds. Each dollar invested in superphosphate returned $4.00. This comparison shows an increase of 143 pounds of seed cotton due to 100 pounds or 2860 pounds of seed cotton per acre due to a ton of nitrate of soda. For each dollar invested in nitrate of soda the return was $3.81.

Three different rates of applying the base application were used on forty-two experiments on this soil group. The results show that profits of $24.32, $35.60, and $35.84 were received from applications of 325 pounds, 650 pounds, and 975 pounds of fertilizer, respectively. From the results it is evident that a per acre application of 200 pounds of nitrate of soda, 400 pounds of superphosphate and 50 pounds of muriate of potash is satisfactory for cotton on the Norfolk group.

VALUES OF SECOND INCREMENTS OF NITROGEN, PHOSPHORIC ACID, AND POTASH

IT HAS been previously stated that four possible values can be obtained for each of the different fertilizer ingredients used in these experiments. Table 17 shows each of these four values for each of the ingredients on the various soil groups. The largest increase due to a particular ingredient was usually obtained when the other two ingredients were present as additional increments in the exact ratio of the base application. Exceptions to this statement are found only on the Piedmont Plateau and the Black Belt. Since the data on the Houston soil group of the Black Belt show that more fertilizer than the base application is of doubtful value on this group, the results on these soils are not taken into consideration in the further discussion in this publication, although the data are given in the tables.

Attention is called to the range in values of the different ingredients when used alone and in combination on several soil regions. For example, on the Highland Rim an additional increment of nitrogen alone produced 96 pounds of seed cotton per acre while the same quantity of nitrogen produced 151 pounds of seed cotton when used in addition to second increments of phosphoric acid and potash. On this soil region a second increment of phosphoric acid alone produced an increase of 129 pounds of seed cotton in comparison with an increase of 234 pounds when used with second increments of nitrogen and potash. The value of a second increment of potash on this region increased from 19 pounds of seed cotton when used alone to 81 pounds in the presence of the other two ingredients. On the Limestone Valley soils the smallest increase from nitrogen, phosphoric acid, and potash, 108 pounds, 42 pounds, and 23 pounds, respectively, resulted where each of these constituents was used singly in addition to the base application; the greatest increases, 125 pounds, 58 pounds, and 42 pounds, respectively, resulted

Table 17.—Values of Second Increments of Nitrogen, Phosphoric Acid, and Potash When Used Alone and in Various Combinations on Different Alabama Soil Regions.

Soil Region	Pounds seed cotton per acre													
	Average Yield		Increase due to adding a second increment of nitrogen to:				Increase due to adding a second increment of phosphoric acid to:				Increase due to adding a second increment of potash to:			
	Unfert. plot	Base plot	N P K* plot	N P 2K plot	N 2P K plot	N 2P2K plot	N P K* plot	N P 2K plot	2N P K plot	2N P 2K plot	N P K* plot	N 2P K plot	2N P K plot	2N 2P K plot
Highland Rim	618	960	96	94	137	151	129	177	170	234	19	67	17	81
Limestone Valleys	413	697	108	112	109	125	42	45	43	58	23	26	27	42
Appalachian Plateau	406	790	151	135	119	172	76	65	44	102	14	3	—2	56
Piedmont Pleateau	167	438	167	138	110	135	74	55	17	52	20	1	—9	26
Black Belt—Houston	696	818	32	45	59	—14	3	69	30	10	—7	59	6	—14
Black Belt—Oktibbeha	382	551	48	62	208	152	—3	98	157	188	—28	73	—14	17
Coastal Plain—Greenville	413	297	129	130	132	137	53	65	56	72	14	26	15	31
Coastal Plain—Norfolk	356	360	64	95	72	143	45	37	53	85	17	9	48	80

*Base plot. N = 100 pounds of nitrate of soda; P = 200 pounds of superphosphate; K = 25 pounds of muriate of potash.

from the use of each of these in the presence of the other two ingredients. On the Appalachian Plateau soils, the nitrogen value ranged from 119 to 172 pounds of seed cotton per acre, the value of phosphoric acid ranged from 44 pounds to 102 pounds, and the potash value ranged from —2 pounds to 56 pounds of seed cotton per acre. In each case the highest value of the particular ingredient was obtained in the presence of the other two ingredients. On the Norfolk soil group nitrogen alone increased the yield by 64 pounds of seed cotton per acre, phosphoric acid alone by 45 pounds, and potash alone by 17 pounds. When all of these plant foods were used together the increase due to nitrogen was 143 pounds; to phosphoric acid, 85 pounds; and to potash, 80 pounds of seed cotton per acre.

The data in Table 17 show further that a second increment of nitrogen was almost equally effective on all soils. The range in the value of the increase was between 125 pounds of seed cotton per acre, obtained on the Limestone Valley Region, and 172 pounds, on the Appalachian Plateau Region. The increases due to phosphoric acid were much more variable than for nitrogen, ranging from 52 pounds and 58 pounds of seed cotton per acre, respectively, on the Piedmont Plateau and the Limetone Valleys to 188 pounds and 234 pounds, respectively, on the Oktibbeha group of the Black Belt and the Highland Rim. The increases due to potash varied from 17 pounds on the Oktibbeha group to 81 pounds on the Highland Rim.

A number of comparisons should prove of interest at this point. For example, the response to nitrogen is nearly the same on both the Highland Rim and the Limestone Valleys, while the response to phosphoric acid is approximately four times as great and the response to potash twice as great on the Highland and Rim as on the Limestone Valleys. The Limestone Valleys and the Appalachian Plateau made approximately the same yield of seed cotton per acre without fertilizer, but the response due to the base application and to second increments of nitrogen, phosphoric acid, and potash were greater on the Appalachian Plateau than on the valley soils. The chief difference in fertilizer response between the Greenville group and the Norfolk group of the Coastal Plain is found in their response to a second increment of potash in the presence of second increments of nitrogen and phosphoric acid. The Houston soils group of the Black Belt usually gave poor increases when fertilized with additional increments of nitrogen, phosphoric acid, and potash while the Oktibbeha soils of this same region usually showed highly profitable increases from similar applications.

Table 18 shows the profits due to second increments of nitrogen, phosphoric acid, and potash when used alone and in various combinations. In this table the importance of increasing the fertilizer ingredients in the exact ratio of the base plot is emphasized again; the greatest profit was always made where all three of the ingredients were used.

Table 18.—Profits from Second Increments of Nitrogen, Phosphoric Acid and Potash Alone and in Various Combinations on Alabama Soil Regions.

Soil Region	Fertilizer treatment						
	N	P	K	NP	NK	PK	NPK
Highland Rim	$ 4.68	$ 8.62	$ 1.02	$16.58	$ 5.54	$13.48	$22.56
Appalachian Plateau	9.08	4.38	0.62	10.90	8.42	4.12	14.88
Black Belt—Oktibbeha	0.84	—1.94	—2.74	11.70	—0.78	3.40	12.56
Coastal Plain—Greenville	7.32	2.54	0.62	10.10	8.02	4.12	12.08
Piedmont Plateau	10.36	4.22	1.10	10.02	9.14	3.80	11.60
Coastal Plain—Norfolk	2.12	1.90	0.86	4.66	5.46	2.12	10.56
Limestone Valleys	5.64	1.66	1.34	7.38	7.30	3.24	10.24
Black Belt—Houston	—0.44	—1.46	—1.06	0.26	—0.46	2.76	—1.36

N = 100 lbs. Nitrate of soda
P = 200 lbs. Superphosphate
K = 25 lbs. Muriate of potash

The soil regions are arranged in the table in order of their profits due to the application of second increments of nitrogen, phosphoric acid, and potash. It will be seen that the greatest profit, $22.56 per acre, was obtained on the Highland Rim. This was followed by a profit of $14.88 on the Appalachian Plateau Soils. Profits of approximately ten to twelve dollars per acre were received on all other soil regions. (The loss on the Houston soil group has been previously noted.) On the Highland Rim, $17.02 of the profit received from nitrogen, phosphoric acid, and potash is due to the phosphoric acid, in the combination. On all other soil regions outstanding results were obtained from the use of nitrogen. For example, $10.76 of the $14.88 profit on the Appalachian Plateau, $7.96 of the $12.08 profit on the Greenville group, and $8.44 on the $10.56 profit on the Norfolk group was due to nitrogen in the combination. It must not be construed from the above that potash is of little or no value in these combinations because each dollar invested in potash gave a high return on all except the Houston group.

The data in Table 19 are made up from the returns due to nitrogen, phosphoric acid, and potash when all of these ingredients were used together in addition to the base application. When viewed from the angle of money invested, it will be seen that greatest returns were usually obtained from the money invested in potash. More than twelve dollars were returned for each dollar invested in second increments of this material on the Highland Rim and the Norfolk group; and more than four dollars were returned for each dollar invested in potash on all other soils except the Black Belt. Returns of $11.01 and $8.85, respectively, were obtained from each dollar invested in phosphoric acid on the Highland Rim and the Oktibbeha group. On all other soils the returns were between $2.45 and $4.80 for each dollar invested with the lowest figure, $2.45, being obtained on the Piedmont Plateau. For each dollar invested in nitrogen there was a uniformly satisfactory profit from the different soil regions. However, due to the high cost of nitrogen, the returns ranged between $3.33 and $4.59 for each dollar invested.

One ton of muriate of potash produced 6480 pounds of seed cotton per acre on the Highland Rim, 6400 pounds on the Norfolk group of the Coastal Plain, 4480 pounds on the Appalachian Plateau, and 1360 pounds of seed cotton on the Oktibbeha group of the Black Belt. One ton of nitrate of soda produced 3440 pounds of seed cotton per acre on the Appalachian Plateau, 3120 pounds on the Highland Rim, 3040 pounds on the Oktibbeha group, and 2860 pounds on the Norfolk group. Exclusive of the Houston soils the smallest return from one ton of nitrate of soda was 2500 pounds of seed cotton obtained on the Limestone Valleys. One ton of superphosphate produced 2340 pounds of seed cotton per acre on the Highland Rim, 1880 pounds on the Oktibbeha soils, and as little as 580 pounds on the Limestone Valleys, and 520 pounds on the Piedmont Plateau.

Table 19.—Average Increase Per Acre, Per Ton, and Gross Return Per Dollar Invested in Fertilizers Used in Addition to Base Application.

Kind and amount of fertilizer added to base plot per acre	Basis of Value	Highland Rim	Limestone Valleys	Appalachian Plateau	Piedmont Plateau	Black Belt		Coastal Plain	
						Houston soil Group	Oktibbeha soil Group	Greenville soil Group	Norfolk soil Group
Superphosphate (200 lbs. in a balanced fertilizer)	Per acre—lbs.	234	58	102	52	—30	188	72	85
	Per ton—lbs.	2340	580	1020	520	—300	1880	720	850
	Per dollar invested	$11.01	$2.73	$4.80	$2.45	---	$8.85	$3.39	$ 4.00
Nitrate of soda (100 lbs. in a balanced fertilizer)	Per acre—lbs.	151	125	172	135	—14	152	137	143
	Per ton—lbs.	3120	2500	3440	2700	—280	3040	2740	2860
	Per dollar invested	$ 4.03	$3.33	$4.59	$3.60	---	$4.05	$3.65	$ 3.81
Muriate of potash (25 lbs. in a balanced fertilizer)	Per acre—lbs.	81	42	56	26	—14	17	31	80
	Per ton—lbs.	6480	3360	4480	2080	—1120	1360	2480	6400
	Per dollar invested	$12.96	$6.72	$8.96	$4.16	---	$2.72	$4.96	$12.80

EFFECT OF SOIL FERTILITY ON INCREASES DUE TO FERTILIZERS

IN ORDER to study the effect of fertilizers on soils of different fertility, the individual experiments on all soils except the Black Belt have been grouped according to the average yield of the unfertilized plots (Table 20). The first group includes all experiments which were conducted on soils that produced less less than 250 pounds of seed cotton per acre, the second group includes all experiments on soils that produced between 250 pounds and 500 pounds of seed cotton, the third group includes all experiments on soils that produced between 500 and 750 pounds, and the fourth group includes all experiments on soils that produced between 750 pounds and 1000 pounds of seed cotton per acre. The average yield of the unfertilized plots of group one was 151 pounds of seed cotton per acre; of group two, 365 pounds; of group three, 613 pounds; and of group four, 815 pounds.

From the results in the table it is evident that, under the contitions of these experiments, the fertility of the soil has no consistent influence on the increase due to fertilizers. Where 325 pounds of fertilizer per acre was used, the average increase due to fertilizers varied only between 303 pounds and 352 pounds of seed cotton per acre. These two extreme variations were obtained on the groups which gave the lowest and next to lowest average yields without fertilizers. On the more fertile soils of group three and group four, the increases due to fertilizers were only 20 pounds and 22 pounds of seed cotton per acre, respectively, greater than the increase on group one. When the rate of fertilizing was 650 pounds per acre, there was a much greater difference between the increases due to fertilizers on the soils of group one and group two. This is also true between group three and group four. However, the increase on the soils in group three was only 25 pounds of seed cotton per acre greater than that of group one and the increases on this group and group four still remained between that of two less fertile soil groups. In order to throw still further light on this subject, the average results of a smaller number of experiments conducted under the same conditions but fertilized at the rate of 975 pounds per acre have been included in the table. These data show that the experiments in group three gave smallest and those in group two gave the largest increases due to fertilizers. The increase on the soils of group one was 28 pounds greater than the increase on group three.

The individual experiments which were used to make the averages in Bulletin 219 of this station, when grouped as above, show results which are not unlike the results in Table 20 in that no consistent increase due to fertilizers was obtained on soils of different fertility. On these experiments, where 450 pounds of fertilizers per acre were used, the average increase due to fertilizers varied between 243 pounds and 347 pounds of seed cotton

Table 20.—Average Yield, Increase, and Profit Due to Different Rates of Fertilizing Cotton on Soils of Different Natural Fertility

Soil Treatment	Average results of experiments on soils that produced between											
	0 and 250 lbs. seed cotton per acre (Average 49 experiments)			250 and 500 lbs. seed cotton per acre (Average 57 experiments)			500 and 750 lbs. seed cotton per acre (Average 37 experiments)			750 and 1000 lbs. seed cotton per acre (Average 6 experiments)		
	Yield	Increase	Profit	Yield	Increase	Profit	Yield	Increase	Profit	Yield	Increase	Profit
	Lbs.	Lbs.		Lbs.	Lbs.		Lbs.	Lbs.		Lbs.	Lbs.	
No fertilizer	151	---	----	365	---	----	613	---	----	815	---	----
N P K	454	303	$19.04	717	352	$22.96	936	323	$20.64	1140	325	$20.80
2N 2P 2K	644	493	$29.04	959	594	$37.12	1131	518	$31.04	1383	568	$35.04
3N 3P 3K*	805	650	$36.40	1107	743	$43.84	1234	622	$34.16			

* Results not strictly comparable; only 32 experiments on 0-250 group; 50 experiments in 250-500 group; and 34 experiments in 500-750 group.

N = 100 pounds Nitrate of soda
P = 200 pounds Superphosphate
K = 25 pounds Muriate of potash

per acre. The smallest increase due to fertilizers was obtained from the experiments in group one, and the largest on group four; however, the increase on group two was greater than the increase on group three.

SUMMARY

PRIOR to beginning the experiments, the results of which are recorded in this bulletin, the Alabama Experiment Station had determined experimentally that nitrogen, phosphoric acid, and potash were necessary for maximum cotton production on Alabama soils. Using 100 pounds of nitrate of soda, 200 pounds of superphosphate, and 25 pounds of muriate of potash as a base application, experiments were started to determine the ratio at which an additional 100 pounds of nitrate of soda, an additional 200 pounds of superphosphate, and an additional 25 pounds of muriate of potash over the base application should be combined to give most profitable results. Three different rates of applying the base application was also included in each experiment.

The average results from these experiments show that best returns were obtained, except on the Houston soils group of the Black Belt, when 650 pounds of a mixture in the ratio of 100 pounds of nitrate of soda, 200 pounds of superphosphate and 25 pounds of muriate of potash per acre was used. When used in any other ratio smaller profits resulted. This was also true when less than 650 pounds of the mixture was applied. The use of 975 pounds of the mixture was often more profitable than 650 pounds; however, due to the small margin of profit over the 650-pound rate, the 975-pound rate is not generally recommended. On the Houston soils group of the Black Belt the base application is recommended.

The response to the addition to the base application of a second 100 pounds of nitrate of soda, a second 200 pounds of superphosphate, and a second 25 pounds of muriate of potash was greatest on the soils of the Highland Rim and the Appalachian Plateau. The lowest returns from this application were obtained on the Houston soils group of the Black Belt.

The largest increase due to an additional quantity of a particular fertilizing ingredient over that used on the base plot was usually obtained when the ingredient was used in the presence of additional quantities of the other two necessary ingredients. Additional nitrogen over that used on the base plot gave the greatest increases on the soils of the Appalachian Plateau, the Oktibbeha group of the Black Belt, and the Limestone Valleys; additional phosphoric acid gave largest returns on the soils of the Highland Rim and the Oktibbeha group of the Black Belt; and additional potash gave largest returns on the Norfolk soils of the Coastal Plain and on the Highland and Rim soils.

The increase due to fertilizers was not consistently influenced by the fertility of the soil.