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THE return received from the use of commercial fertilizer upon any crop is dependent on a number of factors. The more important of these factors are the kind of fertilizer, the fertility of the soil, the ratio of the different fertilizer constituents to each other, and the method and time of application of the fertilizer to the crop. For the solution of some of our fertilizer problems it is essential that the above factors be recognized and experiments planned to study as far as possible only one factor at a time. With this principle in mind, experiments were outlined for the purpose of studying some of the problems relating to the fertilization of corn.

Three of the most important problems relating to the use of fertilizer for corn in Alabama are:

(a) **The importance of nitrogen, phosphorus, and potash on the soils of the different soil divisions of the State.**
(b) **The relative value of cottonseed meal and nitrate of soda as sources of nitrogen.**
(c) **The best time for applying nitrate of soda to the crop.**

The present study was undertaken in an effort to secure data that would solve these problems. The results of the investigation are given in this publication.

Methods.—All of the experiments reported were conducted cooperatively with farmers in the several counties of Alabama. In each case a representative from the experiment station selected the land and measured the plots. Fertilizers for each plot and instructions concerning their application were sent from the experiment station to each cooperator. In the case of the experiments on the time of application of nitrate to corn, all fertilizers were applied by the representative of the experiment station. Each experiment was inspected one or more times during the growing season. All fertilizers except nitrate of soda were applied in the drill before planting. The nitrate of soda in the experiments on the relative value of nitrogen, phosphorus, and potash was applied when the plants were two to three feet high.

EXPERIMENTS ON THE RELATIVE VALUE OF NITROGEN, PHOSPHORUS, AND POTASH

Series 1

During the period 1911 to 1921 a large number of corn fertilizer experiments were conducted on the different soil divisions

of the State but the results of most of these experiments were lost by fire in 1920. However, the results of 56 of these tests were saved and are reported in Tables 1 and 2, pages 8, 9, and 10.

Table 1 gives the average yield of corn, the increased yield due to fertilization, and the average profit from the use of fertilizers as determined by the experiments on the several soil divisions of the State. The increase in yield due to fertilizer on a given plot is calculated by subtracting the average yield of the unfertilized plots from the yield of the plot receiving fertilizer.

In calculating the profit from the use of fertilizer the following prices for fertilizer and for corn have been used throughout this bulletin.

Acid phosphate	$18.00 per ton
Nitrate of soda	60.00 per ton
Cottonseed meal	38.00 per ton
Kainit	14.00 per ton
Muriate of potash	50.00 per ton
Corn	1.00 per bushel

With the exception of the price of kainit and muriate, these prices are believed to be near the average for these fertilizing materials and for corn from 1911 to 1927. During the war period, unmixed kainit and muriate were practically unobtainable by farmers.

The price used for corn is an arbitrary one since the price farmers receive is very different from the price paid for corn after it has been shucked, shelled, graded, stored, and handled by elevators, railroads, and merchants. The profit calculations are on the basis of corn standing ready to harvest in the field. No charge has been made for hauling and applying the fertilizers, interest, or any other expenses incurred from the use of fertilizers.

The results in Table 1 show that there has been no consistent profit from the use of phosphate, potash, or cottonseed meal singly or in combinations. The most consistently profitable fertilizer was the complete fertilizer containing nitrate of soda as the source of nitrogen. This, however, failed to give a profit on the soils of the Greenville-Orangeburg group. A comparison of the profit obtained from the fertilizer on Plots 10 and 12 shows that in all cases the greatest profit was obtained on Plot 12 indicating the decided advantage of using nitrate of soda as a source of nitrogen instead of cottonseed meal.

In order to evaluate better the influences of the various fertilizer constituents, the data in Table 2 have been calculated. Table 2 gives the increase per acre and the return per dollar invested for the various fertilizer materials when used in a complete fertilizer. The method of obtaining the yields of fertilizer materials when used in a complete fertilizer is as follows:

The increase due to acid phosphate is obtained by subtracting the yield of Plot 6 from that of Plot 9; the value of 100 pounds of kainit is obtained by subtracting the yield of Plot 5 from that of Plot 10; the value of cottonseed meal is obtained by subtracting the yield of Plot 8 from the yield of Plot 9. To find the value of nitrate of soda, the yield of Plot 10 is subtracted from that of Plot 12, the figure thus obtained is added to or substracted from the value of cottonseed meal which was obtained as explained above.

These data show that on the Decatur and Colbert soils, acid phosphate, kainit, and cottonseed meal gave no profit, the return per dollar invested in each case being less than $1.00. Nitrate of soda in a complete fertilizer gave a small net return on the investment. On the DeKalb soils acid phosphate and kainit gave a small return on the investment. Cottonseed meal, on the other hand, returned only 74 cents for each dollar invested. Nitrate of soda gave a larger net return than any other fertilizer material used on the DeKalb soils. The results obtained on the Cecil and the Louisa soils of the Piedmont division are similar to those obtained on the DeKalb soils in that there is a profit from the use of acid phosphate and kainit in a complete fertilizer. Likewise, the greatest profit was obtained from the use of nitrate of soda.

The Black Belt soils—Houston, Sumter, and Oktibbeha—were the only soils on which cottonseed meal returned a profit. Acid phosphate also returned a profit on these soils while the results obtained from kainit were conflicting. One hundred pounds of kainit apparently gave a large profit while 200 pounds was unprofitable.

There are two groups of soils in the Coastal Plain division—the Norfolk-Ruston group and the Greenville-Orangeburg group. None of these soils gave a pofit from the use of phosphate, kainit, or cottonseed meal. The soils in the Norfolk-Ruston group returned a good profit from the use of nitrate of soda in the complete fertilizer, while the soils of the Greenville-Orangeburg group showed only a very small profit from the use of nitrate.

Series 2

During the years 1925-1926 additional experiments were conducted to determine the value of phosphate, potash, and nitrogen for corn. In these experiments 100, 200, and 300 pounds of nitrate of soda were used with and without the addition of 200 pounds of acid phosphate and 25 pounds of muriate of potash. The results of these experiments are given in Table 3, page 11.

The figures in Table 3 show that on the soils of the Norfolk-Ruston group phosphorus and potash produced a slight increase in yield when used with 100 or 200 pounds of nitrate of soda. The increase was not great enough to be considered profitable. When used with 300 pounds nitrate of soda, however, the phos-

phate and potash gave a profit of $2.05 per acre. On the Dekalb soils phosphate and potash alone and nitrate of soda alone failed to give a profit. The use of a complete fertilizer, however, was slightly profitable but in no instance was the profit nearly so great as was obtained on the Norfolk-Ruston soils.

The Hagerstown and Decatur soils differ from the other soils used in these experiments in that they are considerably more fertile. This is indicated by a comparison of the yields obtained on the check plots. As might be expected, the return from the use of fertilizer on land producing an average of 31 bushels of corn per acre was small. On these soils the greatest profit was secured when phosphate and potash were used with 200 pounds of nitrate of soda per acre. The differences, however, were so small that any conclusions drawn are subject to question.

EXPERIMENTS ON THE TIME OF APPLYING NITRATE

Fourteen experiments were conducted in different parts of the State in the years 1923-1924 to determine the effect of time of application of nitrate on the yield of corn. The general procedure in each experiment was to fertilize 12 one-twentieth-acre plots with the same amounts of acid phosphate and muriate of potash, and all except the check plots with equal amounts of nitrate of soda. Acid phosphate and muriate of potash were used at the rate of 200 pounds and 25 pounds per acre, respectively. These materials were applied in the drill just before planting. Nitrate of soda at the rate of 200 pounds per acre was applied as indicated in Table 4, page 12.

On the light or sandy soils—excepting the plot receiving the broadcast application of nitrate—the increase due to the application of 200 pounds of nitrate varied from 12.9 bushels to 16.2 bushels. The highest yield was secured from the plot receiving all of the nitrate 35 days after planting. It is apparent, however, that the time of application of nitrate does not influence the corn yield as much as the yield of cotton.

The experiments on heavy soils—mostly silt loams and clay loams—show about the same order of results as the experiments on the sandy soils. The small differences obtained as a result of applying nitrate at different times are probably not very significant. The results, however, show that there is little or no advantage in making two applications of nitrate to corn. Apparently the best practice would be to make one application of nitrate 30 or 40 days after planting.

Discussion.—The foregoing results show that when used as direct fertilizer to corn no material profits were secured from the use of phosphate, kainit, or cottonseed meal on the soils of the Limestone Valleys and the Coastal Plains. While there were

some cases where these materials paid their cost and some interest on the investment on the soils of the Appalachian Plateau, Piedmont Plateau, and Black Belt, the small margin of profits on these soils usually made their use of questionable value.

There is nothing in these results, however, which indicates that the quantity of acid phosphate and potash per acre or per farm should be reduced. The data presented show only the value of these materials when applied directly to corn. Cotton and some other crops that are commonly used in rotation with corn on the soils represented by these experiments respond quite readily to acid phosphate and potash. The residual effect of these materials when applied to crops other than corn in the rotation is often sufficient to take the place of the direct application to corn. No doubt a complete history of the soils on which these experiments were conducted would reveal that in many cases considerable phosphate and potash had been applied to the preceding crops.

In almost all the experiments reported, the use of nitrogen in the form of cottonseed meal or nitrate of soda gave larger increases than did the use of phosphate or potash. In a number of the experiments the use of nitrate of soda was very profitable. In general the results indicate that corn should not receive phosphate and potash but should be fertilized with nitrate of soda.

While nitrate of soda was the only source of inorganic nitrogen used in these experiments, it is probable that similar results would have been secured with other readily available basic nitrogenous fertilizers. Acid-forming nitrogenous fertilizers probably would have given similar results in these short-time tests. Their regular use is not to be recommended, however, unless lime is added to correct the resulting acidity.

A comparison with the results obtained on Plots 10 and 12 of Series 1 shows that a given amount of nitrogen in nitrate of soda produced larger increases than an equivalent amount of nitrogen in cottonseed meal. Not only is the nitrogen in nitrate of soda more efficient for the production of corn, but it is usually less expensive per unit than is the nitrogen in cottonseed meal.

The results reported in this bulletin on the time of applying nitrate of soda to corn agree with the results obtained and reported in Alabama Experiment Station Bulletin No. 210. They show that nitrate of soda should be applied to corn five or six weeks after planting. They also show that there is little or no advantage in making two applications of nitrate of soda instead of one.

The losses, or very small profits, due to the use of fertilizers to corn as compared with the profit usually secured from the applications of fertilizer to other crops can be explained by noting that—with the possible exception of oats—the unit value of corn is lower than the unit value of any other common farm crop. The value of a pound of corn to the farmer is usually between 1

and 2 cents in comparison with the value of 6 to 8 cents for a pound of seed cotton.

The increases in pounds of corn per acre have been slightly larger on the average than the increase in pounds of seed cotton obtained by this station on these soil regions from the use of the same kinds and quantity of fertilizing materials. However, the profit due to fertilizers on corn is usually small while on cotton good fertilization is nearly always profitable. These considerations lead to the conclusion that the best farm practice would be to apply all of the phosphate and potash to cotton. Corn following cotton that has been well fertilized should not receive phosphate and potash but should be fertilized with nitrate of soda.

SUMMARY

A. Fifty-six corn fertilizer experiments conducted from 1911 to 1921 show:

(1) **That fertilization of corn with acid phosphate or kainit was unprofitable except on soils of the Appalachian and Piedmont Plateaus.**

(2) **That cottonseed meal seldom returned a profit but that nitrate of soda gave a profit on all the soils studied.**

(3) **The profit from nitrate of soda was largest on soils of the Appalachian and Piedmont Plateaus and smallest on the Greenville-Orangeburg soils of the Coastal Plain.**

B. Eleven experiments were conducted in 1925 and 1926 on the value of phosphate and potash for corn with varying amounts of nitrate of soda. The results indicate that corn seldom returns a profit from the use of phosphate and potash.

C. The results of experiments on time of applying nitrate of soda to corn show that the best time of application is about six weeks after planting. There is no advantage in applying the nitrate in two applications instead of one.

Table 1.—Results of Fertilizer Experiments with Corn on the Principal Soil Types of Alabama

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Decatur and Colbert Soils*			DeKalb Soils**			Cecil and Louisa Soils***		
			Average yield corn per acre	Increase over unfertilized plots	Average profit per acre from fertilizers	Average yield corn per acre	Increase over unfertilized plots	Average profit per acre from fertilizers	Average yield corn per acre	Increase over unfertilized plots	Average profit per acre from fertilizers
	Lbs.		Bus.	Bus.	Dollars	Bus.	Bus.	Dollars	Bus.	Bus.	Dollars
1	200	Cottonseed meal	26.8	3.1	—0.70	13.3	2.0	—1.80	19.4	1.6	—2.20
2	240	Acid phosphate	26.1	2.4	0.24	14.7	3.4	1.24	18.1	0.3	—1.86
3	---	No fertilizer	23.3	—	———	10.5	—	———	16.6	—	———
4	200	Kainit	24.3	0.6	—0.80	10.9	—0.4	—1.80	16.8	—1.0	—2.40
5	200 240	Cottonseed meal Acid phosphate	29.5	5.8	—0.16	13.7	2.4	—3.56	20.0	2.2	—3.76
6	200 200	Cottonseed meal Kainit	29.1	5.4	0.20	14.6	3.3	—1.90	18.5	0.7	—4.50
7	---	No fertilizer	23.8	—	———	11.7	—	———	18.1	—	———
8	240 200	Acid phosphate Kainit	27.9	4.2	0.64	14.6	3.3	—0.26	18.9	1.1	—2.46
9	200 240 200	Cottonseed meal Acid phosphate Kainit	30.3	6.6	—0.76	17.4	6.1	—1.26	22.2	4.4	—2.96
10	200 240 100	Cottonseed meal Acid phosphate Kainit	29.7	6.0	—0.66	14.3	3.0	—3.66	22.5	4.7	—1.96
11	---	No fertilizer	23.9	—	———	11.8	—	———	18.6	—	———
12	100 240 100	Nitrate of soda Acid phosphate Kainit	30.9	7.2	1.34	21.1	9.8	3.94	27.6	9.8	3.94

* 11 experiments, ** 4 experiments, *** 5 experiments.

Table 1 (continued).—Results of Fertilizer Experiments with Corn on the Principal Soil Types of Alabama

Plot No.	Amt. fertilizer per acre	Kind of Fertilizer	Houston, Sumter, and Oktibbeha Soils*			Norfolk Soil Group**			Greenville Soil Group***		
			Average yield corn per acre	Increase over unfertilized plots	Average profit per acre from fertilizers	Average yield corn per acre	Increase over unfertilized plots	Average profit per acre from fertilizers	Average yield corn per acre	Increase over unfertilized plots	Average profit per acre from fertilizers
	Lbs.		Bus.	Bus.	Dollars	Bus.	Bus.	Dollars	Bus.	Bus.	Dollars
1	200	Cottonseed meal	31.8	8.8	5.00	21.8	4.9	1.10	19.1	2.5	1.30
2	240	Acid phosphate	26.1	3.1	0.94	18.4	1.5	—0.66	17.0	0.4	—1.76
3	---	No fertilizer	22.2	—	——	17.5	—	——	16.3	—	——
4	200	Kainit	23.8	0.8	—0.60	18.0	1.1	—0.30	16.8	0.2	—1.20
5	200 240	Cottonseed meal Acid phosphate	31.9	8.9	2.94	22.7	5.8	—0.16	19.2	2.6	—3.36
6	200 200	Cottonseed meal Kainit	28.4	5.4	0.20	21.4	4.5	—0.70	18.6	2.0	—3.20
7	---	No fertilizer	23.6	—	——	16.7	—	——	17.2	—	——
8	240 200	Acid phosphate Kainit	25.6	2.6	—0.96	18.0	1.1	—2.46	17.9	1.3	—2.26
9	200 240 200	Cottonseed meal Acid phosphate Kainit	32.5	9.5	2.14	21.5	4.6	—2.76	19.5	2.9	—4.46
10	200 240 100	Cottonseed meal Acid phosphate Kainit	32.1	9.1	2.44	20.7	3.8	—2.86	19.8	3.2	—3.46
11	---	No fertilizer	23.3	—	——	16.5	—	——	16.2	—	——
12	100 240 100	Nitrate of soda Acid phosphate Kainit				23.7	6.8	0.94	21.4	4.8	—1.06

* 4 experiments, ** 14 experiments, *** 18 experiments.

Table 2.—Average Return from the Use of Acid Phosphate, Kainit, Cottonseed Meal, and Nitrate of Soda in a Complete Fertilizer for Corn

Soil Types	Acid phosphate (240 lbs.)		Kainit (200 lbs.)		Kainit (100 lbs.)		Cottonseed meal (200 lbs.)		Nitrate of soda (100 lbs.)	
	Bus. per acre	Per dollar invested	Bus. per acre	Per dollar invested	Bus. per acre	Per dollar invested	Bus. per acre	Per dollar invested	Bus. per acre	Per dollar invested
	Bus.	Dollars	Bus.	Dollars	Bus.	Dollars	Bus.	Dollars	Bus.	Dollars
Decatur Colbert	1.2	0.56	0.8	0.57	0.2	0.29	2.4	0.63	3.6	1.20
DeKalb	2.8	1.29	3.7	2.64	0.6	0.86	2.8	0.74	9.6	3.20
Cecil Louisa	3.7	1.71	2.2	1.57	2.5	3.57	3.3	0.87	8.4	2.80
Houston, Sumter Oktibbeha	4.1	1.89	0.6	0.43	0.2	4.00	6.9	1.82	—	—
Norfolk Ruston	0.1	0.04	—1.2	—1.86	—2.0	—3.86	3.5	0.92	6.5	2.17
Greenville Orangeburg	0.9	0.42	0.3	0.21	0.6	0.86	1.6	0.42	3.2	1.07

Table 3.—The Relative Value of Nitrate of Soda and of Acid Phosphate and Muriate of Potash for Corn on Different Soil Types

Plot No.	Fertilizer Treatment	Norfolk and Ruston (4 experiments)			DeKalb (3 experiments)			Hagerstown and Decatur (4 experiments)		
		Yield per acre	Increase per acre	Profit per acre	Yield per acre	Increase per acre	Profit per acre	Yield per acre	Increase per acre	Profit per acre
		Bus.	Bus.	Dollars	Bus.	Bus.	Dollars	Bus.	Bus.	Dollars
1	O	13.59	——	——	19.86	——	——	30.79	——	——
2	P K	17.75	2.60	0.18	20.67	0.69	—1.73	35.66	4.32	1.90
3	N	24.53	9.38	6.38	22.44	2.46	—0.54	34.99	3.65	0.65
4	N P K	25.86	10.71	5.29	26.09	6.11	0.69	35.99	4.65	—0.77
5	O	15.73	——	——	19.42	——	——	31.26	——	——
6	2N	32.06	16.91	10.91	23.77	3.79	—2.21	37.99	6.65	0.65
7	2N 1P 1K	34.13	18.98	10.56	30.09	10.11	1.69	42.53	11.19	2.77
8	3N	33.99	18.84	9.84	26.00	6.02	—2.98	40.93	9.59	0.59
9	3N 1P 1K	38.46	23.31	11.89	32.13	12.15	0.73	42.00	10.66	—0.76
10	O	16.13	——	——	20.66	——	——	31.99	——	——

N—100 lbs. nitrate of soda, P—200 lbs. acid phosphate, K—25 lbs. muriate of potash.

Table 4.—Average Results Obtained from Applying Nitrate of Soda to Corn at Different Stages of Growth

Plot No.	Amt. per acre	Nitrate Fertilization: Time of application	Sandy soils (8 experiments): Yield per acre	Sandy soils (8 experiments): Increase per acre	Heavy soils (6 experiments): Yield per acre	Heavy soils (6 experiments): Increase per acre
	Lbs.		Bus.	Bus.	Bus.	Bus.
1	0	----------	17.8	---	14.8	---
2	200	At planting (Bdc.)	28.0	11.3	25.0	9.6
3	200	At planting (Drill)	31.3	14.6	28.0	12.6
4	0	----------	16.8	---	17.6	---
5	200	35 days after planting	32.9	16.2	28.6	13.2
6	200	65 days after planting	30.1	13.4	27.9	12.5
	100	35 days after planting				
7	100	65 days after planting	31.8	15.1	29.8	14.4
8	0	----------	15.4	---	16.0	---
	100	At planting				
9	100	35 days after planting	29.6	12.9	27.2	11.8
	100	At planting				
10	100	65 days after planting	30.3	13.6	28.1	12.7
	67	At planting				
	67	35 days after planting				
11	67	65 days after planting	31.0	14.3	25.6	10.2
12	0	----------	16.9	---	13.2	---