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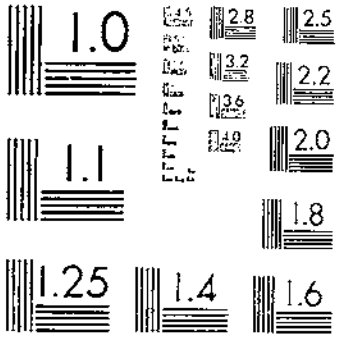
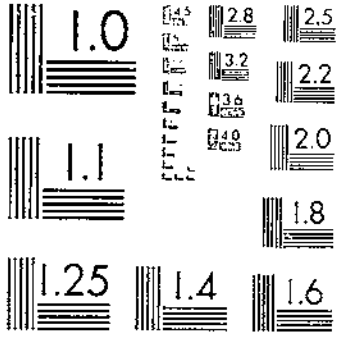


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

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EXPERIMENTS WITH NITROGEN FERTILIZERS ON COTTON SOILS

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CONTENTS

INTRODUCTION

Yields of cotton on many soils in the southeastern Cotton Belt are determined more by the available nitrogen supply than by any other controllable soil-fertility factor. In this region the yield of cotton may be at least doubled and sometimes tripled through the application of large quantities of commercial nitrogen with mineral fertilizers. The predominant need for nitrogen in this territory may be better understood when it is considered that practically all virgin soils in this region have a low nitrogen content. The nitrogen content of many of these soils is rapidly reduced through cultivation, the climatic conditions favoring a rapid loss of nitrogen. Most of the soils of the coastal plains, which comprise a large section of the southeastern Cotton Belt, are of such texture that the aeration is good even when they are uncultivated. The result is a very rapid decomposition of organic matter, initially in the soil, or added through green-manuring crops, and a depletion of the soil's store of nitrogen. To meet this diminishing supply of available nitrogen, especially on soils where cotton is grown year after year, and on soils where but little organic matter from soil-improving crops is obtained, it becomes necessary to use large quantities of fertilizers containing commercial nitrogen.

Since the decrease of the available supply of organic nitrogen [1] from vegetable and animal byproducts for fertilizers, the introduction of synthetic nitrogen salts, and the manufacture of cheaper mineral

[1] The term "organic nitrogen" is used in this bulletin to define organic nitrogen of vegetable or animal waste origin, such as cottonseed meal, tankage, dried blood, fish scrap, etc.

70266°—34——1

nitrogen, considerable experimentation has been in progress to study the effects of various carriers, and mixtures of different carriers of nitrogen on southern soils and how to use them to best advantage in mixtures with phosphoric acid and potash. Results of such work conducted by the State experiment stations of the Cotton Belt and

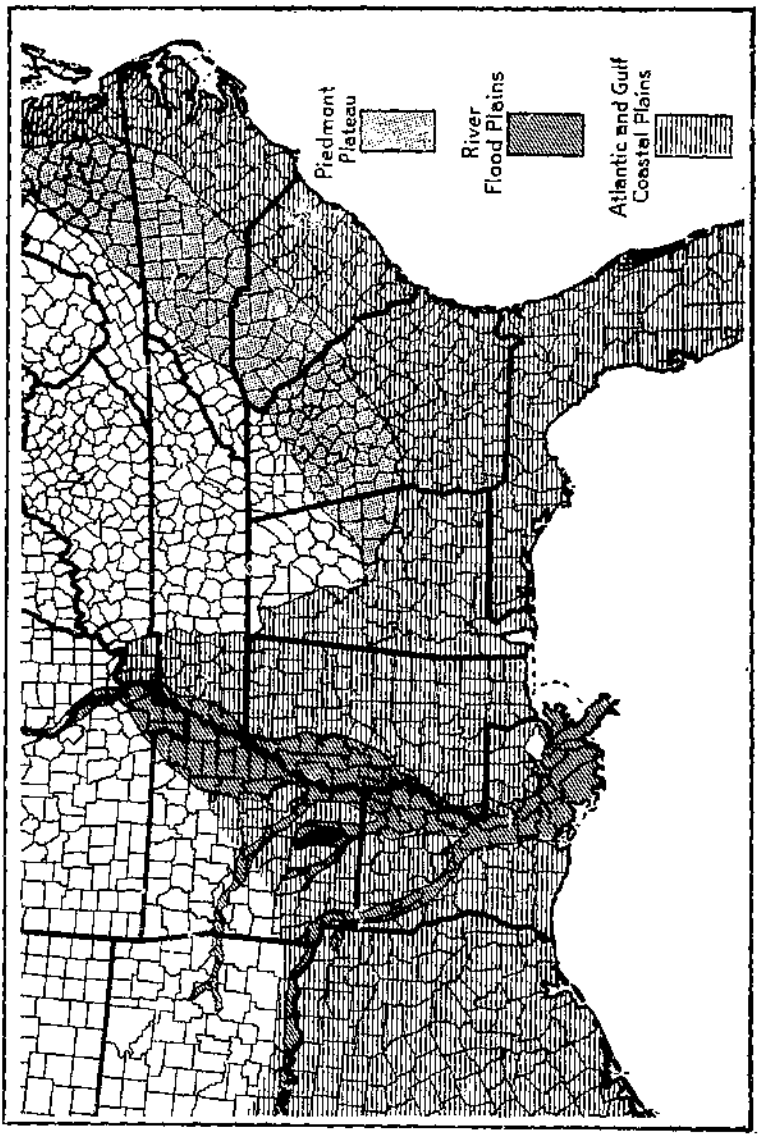

FIGURE 1.—Map of the southeastern Cotton Belt, showing the soils of the Atlantic and Gulf Coastal Plains and the Piedmont, where the results of the experiments with cotton apply.

the United States Department of Agriculture have been reported from time to time. The relative effects of nitrogen sources on yield of cotton have been studied in North Carolina, South Carolina, Georgia, Alabama, Mississippi, Arkansas, and other States, and reported on from time to time. A general soil map of the southeastern Cotton Belt, where these results apply, is given in figure 1. The nitrogen

sources in fertilizers with phosphoric acid and potash, giving best yields, have varied with climatic and soil conditions where commonly used materials, as sodium nitrate, ammonium sulphate, urea, Leunasalpeter, cottonseed meal, dried blood, tankage, fish scrap, etc., have been used.

On prairie soils of Mississippi (*1, 5*),[2] in experiments using mineral and synthetic sources of nitrogen in mixtures with phosphoric acid and potash, the variations in yield from sodium nitrate, ammonium sulphate, Leunasalpeter, calcium nitrate, and urea, each used as the entire source of nitrogen, were not great. Sodium nitrate and Leunasalpeter gave slightly higher yields on many of these prairie soils. On soils in south Mississippi (*4*), very little differences were noted in yield of cotton from the various inorganic and synthetic sources of nitrogen.

In experiments in North Carolina (*16*) on Norfolk sandy loam at the Upper Coastal Branch Station, Rocky Mount; on Cecil sandy loam at the Central Experiment Station farm, Raleigh; and on Cecil clay loam at the Piedmont Branch Station, Statesville, inorganic sources of nitrogen, sodium nitrate and ammonium sulphate, each used as the entire source of nitrogen with phosphoric acid and potash, gave larger yields of cotton than organic sources, such as cottonseed meal and dried blood. The yields produced by various inorganic and synthetic sources of nitrogen on these soils did not vary widely, except in the case of sodium nitrate, which generally gave larger yields.

On Tifton sandy loam in Georgia (*13*), sodium nitrate gave slightly larger yields than did other sources of nitrogen in complete fertilizers for cotton. Cottonseed meal, dried blood, and tankage, as the entire source of nitrogen, did not give as large yields as did inorganic or synthetic nitrogen. Mixtures of inorganic nitrogen and organic nitrogen were not used.

On Cecil sandy clay loam in Georgia (*3, 14*), sodium nitrate, followed by ammonium sulphate, gave best results when compared with synthetic nitrogen and tankage. In other experiments made for 7 years, there was not a wide variation in yield of cotton from different inorganic, synthetic, or organic nitrogen sources.

In a number of experiments made for several years in Alabama (*15*) in which sodium nitrate, ammonium sulphate, ammonium phosphate, Leunasalpeter, urea, and cottonseed meal were used, each as the entire source of nitrogen for cotton with phosphoric acid and potash, good results were generally secured from each. On the Clarksville and Holston soil series, sodium nitrate was the most effective source of nitrogen. On the Decatur soil series, sodium nitrate and urea were the leading sources. On the Hartsells and Cecil soil groups, sodium nitrate and ammonium sulphate produced equal increases in pounds of cotton per acre. On the Oktibbeha soil group of the Black Belt, ammonium phosphate and sodium nitrate gave greatest increases.

Sodium nitrate and ammonium sulphate were of approximately equal value for cotton on the Greenville soil group of the coastal plain. Sodium nitrate was most effective on Norfolk and Ruston soils.

[2] Italic numbers in parentheses refer to Literature Cited, p. 28.

On heavy soils in Arkansas (*6, 7*), yields of cotton from various sources of inorganic and synthetic nitrogen did not vary widely. Sodium nitrate generally gave slightly larger yields.

INORGANIC, ORGANIC, AND SYNTHETIC NITROGEN EXPERIMENTS

EXPERIMENTS IN NORTH CAROLINA

Experiments were made on nine soil types in North Carolina[3] to study the effects of inorganic and synthetic sources of nitrogen in mixtures with phosphoric acid and potash for cotton. The detailed results of this cooperative work are published in Bulletin No. 266 of the North Carolina Agricultural Experiment Station (*11*). A summary of the data, including the average yield of all the experiments on the various soil types in North Carolina, is given in table 1.

TABLE 1.—*Summary of yields per acre of seed cotton secured in experiments on nine soil types in North Carolina with various sources of nitrogen*

Source of nitrogen in 6–8–4 fertilizer applied at rate of 900 pounds an acre [1]	Portsmouth sandy loam, New Bern, average 2 years, 1921–22	Cecil sandy loam, Shelby, average 2 years, 1924–25	Greenville sandy loam, Weldon, average 2 years, 1926–27	Davidson clay, Lexington, average 2 years, 1926–27	Marlboro sandy loam, Wilson, average 2 years, 1926–27	Marlboro fine sandy loam, Seaboard, 1925	Appling sandy loam, Kings Mountain, 1924	Dunbar fine sandy loam, New Bern, 1920	Coxville sandy loam, New Bern, 1920	Average	Relative rating
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Pct.*
Sodium nitrate	1,270	1,051	1,695	1,450	1,620	1,495	1,313	834	642	1,203	100.0
Ammonium sulphate	1,200	993	2,040	1,418	1,573	1,288	1,075	1,052	692	1,269	100.4
Ammonium nitrate	1,172	957	2,015	1,357	1,428	1,403	1,103	930	700	1,236	97.8
Ammonium chloride	1,017	905	1,415	1,360	1,423	1,472	1,088	1,152	786	1,180	93.4
Ammonium chloride [2]	905	964	1,245	1,185	1,407	1,242	938	950	708	1,061	84.0
Ammonium phosphate [3]	1,115	935	1,850	1,525	1,486	1,310	1,238	820	676	1,217	96.4
Urea	1,025	950	1,905	1,430	1,457	1,311	1,203	810	640	1,190	94.3
Leunasalpeter	1,187	877	1,885	1,390	1,867						
No fertilizer	368	465	700	530	805	750	425	445	151	515	40.7

[1] Superphosphate source of phosphoric acid in fertilizer mixtures, potassium sulphate source of potash, except where noted.

[2] Potash from potassium chloride.

[3] *Ammonium phosphate containing 48 percent phosphoric acid and 12 percent ammonia source of phosphoric acid in this fertilizer.* In order to prepare a 6-percent ammonia fertilizer from this salt more than 8 percent of phosphoric acid was included in this fertilizer.

These soils represent some of the principal types on which cotton is grown in the Southeast. They are classified as Marlboro fine sandy loam and Marlboro sandy loam, Portsmouth sandy loam, Cecil sandy loam, Davidson clay, Greenville sandy loam, Appling sandy loam, Dunbar fine sandy loam, and Coxville sandy loam. Three of these are of the Piedmont and six of the coastal plain Cotton Belt. The effect of the air-derived nitrogen salts studied, when used in mixed fertilizer with superphosphate and potash, has generally been good.

In this work, each nitrogen salt was used as the entire source of nitrogen in a 6–8–4 [4] fertilizer applied before cottonseed was planted, at the rate of 900 pounds an acre. Superphosphate was the source

[3] Acknowledgment is made for the assistance of and cooperation by T. C. Black, Kings Mountain; C. D. Bradham, New Bern; S. C. Lattimore, Shelby; J. W. Holoman, Weldon; J. W. Meadows, New Bern; J. P. Lucas, Wilson; M. R. Stevenson, Seaboard; and E. C. Stokes, Lexington, cooperating farmers, who furnished land for the experiments in North Carolina and labor required for planting and cultivating the crop; and to R. P. Gulledge, county agent of Northampton County, and E. C. Sheffield, county agent of Davidson County, for general assistance in the work.

[4] Fertilizer analyses are given in this bulletin in the order of ammonia, phosphoric acid, and potash. *The fertilizers were prepared on the ammonia rather than the nitrogen basis as this was the custom when these experiments were made.*

of phosphoric acid and potassium sulphate the source of potash, except in one plot with ammonium chloride. In this case potassium chloride was the source of potash, which was added to study the effect of fertilizers containing two chloride salts. When ammonium phosphate was used, this was the source of phosphoric acid as well as the source of nitrogen.

On Portsmouth sandy loam, in a 2-year test near New Bern, the average acre yields of seed cotton ranged from 1,290 to 905 pounds. Ammonium sulphate gave the highest yield and ammonium chloride the lowest.

On Cecil sandy loam, in a 2-year test near Shelby, the average yields ranged from 1,051 to 877 pounds; the highest was from sodium nitrate and the lowest from Leunasalpeter.

On Greenville sandy loam in a 2-year test near Weldon, the average yields ranged from 2,040 to 1,245 pounds. Ammonium sulphate gave the highest yield and ammonium chloride the lowest.

On Davidson clay in a 2-year test at Lexington, the yields ranged from 1,525 to 1,185 pounds, the highest being from ammonium phosphate and the lowest from ammonium chloride.

On Marlboro sandy loam in a 2-year test near Wilson, the average yields ranged from 1,620 to 1,407 pounds, the highest being from sodium nitrate and the lowest from ammonium chloride.

On Marlboro fine sandy loam, in a single-year test at Seaboard, the yields ranged from 1,495 to 1,242 pounds per acre, the highest being from sodium nitrate and the lowest from ammonium chloride.

On Appling sandy loam in a single-year test near Kings Mountain, the yields for the various salts ranged from 1,313 to 938 pounds. The crop grown with sodium nitrate gave the best returns and with ammonium chloride the lowest.

On Dunbar fine sandy loam in a single-year test at New Bern, the yields ranged from 1,152 to 810 pounds. The highest yield was from ammonium chloride and the lowest from urea.

On Coxville sandy loam in a single-year test at New Bern, the yields ranged from 786 to 640 pounds. The highest yield was from ammonium chloride and the lowest from urea.

The average yields of all the experiments range from 1,269 to 1,061 pounds of seed cotton per acre. The highest yield is for ammonium sulphate and the lowest for ammonium chloride.

The results of these experiments with cotton on the various soil types show the average yields of seed cotton per acre, produced by fertilizers containing different nitrogen salts, are as follows: Ammonium sulphate, 1,269 pounds an acre; sodium nitrate, 1,263 pounds; ammonium nitrate, 1,236 pounds; ammonium phosphate, 1,217 pounds; urea, 1,199 pounds; ammonium chloride (used in mixtures with potassium sulphate), 1,180 pounds; and ammonium chloride (used in mixtures with potassium chloride), 1,061 pounds per acre.

In these experiments, ammonium nitrate, ammonium phosphate, and urea, have proved to be good forms of plant food for cotton and have produced larger yields than did ammonium chloride. The use of these air-derived nitrogen salts, containing relatively high concentrations of nitrogen, when applied in mixed fertilizer of the analysis used, has not produced any appreciably injurious effect on germination of cotton or on the plants in the early stages of growth.

Neither has there been any indication of unusual leaching of them from the soil in this work.

Ammonium chloride used in fertilizer with potassium chloride as the source of potash gave smaller yields than in mixtures with potassium sulphate as the source of potash. The plants did not develop normally, nor did they make as good growth. A 6–8–4 fertilizer applied at the rate of 900 pounds an acre, using the two chlorine salts, adds 141 pounds of chlorine per acre, compared to 112 pounds of chlorine added in the mixture containing ammonium chloride and potassium sulphate. Apparently, the chlorine content of the fertilizer containing the two chlorine salts is the cause of the depressed yields. (*9*)

In earlier cooperative work (*8*) with nitrogen sources on cotton soils of North Carolina, somewhat larger yields of cotton were secured on some of the soil types used in the experiments discussed above when the nitrogen was derived in part from inorganic sources and in part from organic sources, such as cottonseed meal, fish scrap, dried blood, or tankage, while other soils gave as large yields from fertilizers containing a single inorganic source of nitrogen.

EXPERIMENTS IN SOUTH CAROLINA

In South Carolina, experiments[5] were made on three soil types, with inorganic and synthetic sources of nitrogen in fertilizers for cotton, the details of which were reported, together with other nitrogen experiments made in that State (*10*). The experiments were made for 5 years on Norfolk fine sandy loam at the Pee Dee Experiment Station of Clemson College, at Florence, 1 year on Norfolk sandy loam at Hartsville, and 2 years on Marlboro sandy loam at Bennettsville. A summary of the data is given in table 2.

TABLE 2.—*Summary of yields per acre of seed cotton secured in experiments on three soil types in South Carolina with various sources of nitrogen*

Source of nitrogen in 6–8–4 fertilizer [1] applied at rate of 900 pounds an acre	Norfolk very fine sandy loam, Pee Dee Experiment Station, average 5 years, 1921–25	Norfolk sandy loam, Hartsville, 1924	Marlboro sandy loam, Bennettsville, average for 3 years 1921–23	Average	Relative rating
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Percent*
Sodium nitrate	1,091	1,100	1,330	1,174	100
Ammonium sulphate	1,008	1,120	1,337	1,155	98
Ammonium nitrate	1,054	1,140	1,447	1,214	103
Ammonium chloride	924	1,080	1,327	1,110	95
Ammonium phosphate [2]	1,007	980	1,450	1,146	98
Urea	1,047	1,020	1,340	1,136	97
No fertilizer	756	600	907	754	

[1] Superphosphate source of phosphoric acid in fertilizer mixtures, potassium sulphate source of potash.

[2] *Ammonium phosphate (containing 48 percent phosphoric acid and 12 percent ammonium)* supplied, phosphoric acid exceeding 8 percent in this fertilizer.

[5] Acknowledgment is made for the assistance of and cooperation by J. A. Adams, Bennettsville; Alex. Brunson, Florence; R. E. Currin, Pee Dee Experiment Station, Florence; B. D. Dargan, Darlington; R. P. Gillespie, Hartsville; and E. E. McGill, Darlington, cooperating farmers, who contributed land for the experiments in South Carolina, and labor required for planting and cultivating the crops; and to A. H. Ward, former county agent of Darlington County, for general assistance in the work.

When all the cotton experiments are considered, the yields of cotton from ammonium phosphate, ammonium nitrate, and urea did not vary widely from those produced by sodium nitrate and ammonium sulphate. Ammonium chloride produced a slightly smaller average yield than other inorganic nitrogen carriers in the 5-year experiment on Norfolk very fine sandy loam. In the first 2 years of the experiment on this soil, ammonium chloride gave larger yields than did sodium nitrate and ammonium sulphate, but in the last 3 years the yields from the ammonium chloride plots were considerably smaller, the difference in yield increasing each year.

In other experiments by the same workers, sodium nitrate and ammonium sulphate were used as single sources of nitrogen in complete fertilizers (with superphosphate and potash), combined in different proportions, and together with (1) dried blood, (2) cottonseed meal, (3) fish scrap, and (4) tankage. In the experiments, which included organic materials, 50 percent of the nitrogen in the fertilizer was from inorganic sources and 50 percent from organic sources. The experiments were made on five soil types which represent the principal soils used for cotton in the south Atlantic Coastal Plain. A summary of the data secured is given in table 3.

TABLE 3.—*Effect of various sources of nitrogen in fertilizers on yield of cotton on several soil types in South Carolina*

Sources of nitrogen in 6-6-3 fertilizer[1] applied at rate of 900 pounds per acre	Norfolk fine sandy loam, Florence		Ruston coarse sandy loam, Darlington		Norfolk sandy loam, Darlington		Norfolk sandy loam, Hartsville				Marlboro sandy loam, Bennettsville						Average yield	Relative yield
	1920		1920		1921		1923		1924		1921		1922		1923			
	Yield per acre	Cotton open Sept. 27	Yield per acre	Cotton open Sept. 23	Yield per acre	Cotton open Sept. 18	Yield per acre	Cotton open Sept. 18	Yield per acre	Cotton open Sept. 19	Yield per acre	Cotton open Sept. 26	Yield per acre	Cotton open Sept. 22	Yield per acre	Cotton open Sept. 19		
	Lbs.	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*
Sodium nitrate	1,300	69	1,340	39	1,136	51	1,180	58	1,100	27	1,700	64	1,050	91	1,240	65	1,255.7	100
Ammonium sulphate	780	67	1,580	42	1,486	65	1,060	60	1,120	48	1,700	64	1,050	94	1,260	70	1,254.5	100
33 percent from sodium nitrate 67 percent from ammonium sulphate	1,360	62	1,640	45	1,597	63	1,060	57	1,020	41	1,720	59	1,010	93	1,460	70	1,358.4	108
67 percent from sodium nitrate 33 percent from ammonium sulphate	1,700	69	1,580	42	1,527	58	1,140	58	940	45	1,840	70	1,120	93	1,240	73	1,385.9	110
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from dried blood	1,760	68	1,520	38	1,790	61	1,140	65	960	52	1,840	70	1,020	90	1,280	77	1,413.7	112
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from cottonseed meal	1,740	71	1,540	45	1,897	64	1,060	70	880	55	1,820	70	970	91	1,380	77	1,410.9	112
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from fish scrap	1,880	62	1,580	44	1,836	67	1,100	58	900	62	1,880	70	980	90	1,320	64	1,434.5	114
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from tankage	1,560	67	1,520	53	1,832	65	1,220	69	1,020	59	1,760	81	920	90	1,400	70	1,404.0	111
No fertilizer	780	77	620	35	903	70	680	71	600	17	1,080	70	520	92	1,120	61	787.9	62

[1] Superphosphate source of phosphoric acid in fertilizer mixtures, potassium sulphate source of potash.

The comparative yields from sodium nitrate and ammonium sulphate varied with the soil. Larger yields were produced by sodium nitrate on Norfolk fine sandy loam at Florence, and larger yields from ammonium sulphate on Ruston coarse sandy loam and Norfolk sandy loam at Darlington. There was but little variation in yields from these two nitrogen sources on the other soil types. The averages of all the experiments were practically the same.

Two sources of inorganic nitrogen proved to be better than a single source in some of the experiments, and nitrogen one-half from the two inorganic sources and one-half from organic sources proved better than did single inorganic sources on some soils. The average yields of all the experiments favor slightly the mixtures (1) of two sources of inorganic, and (2) mixtures of inorganic and organic nitrogen. There was no consistent or appreciable difference in earliness of cotton produced by the inorganic sources of nitrogen or mixtures of inorganic and organic nitrogen.

In a 6-year experiment on Norfolk very fine sandy loam, conducted at the Pee Dee Experiment Station, Florence, where cotton was grown in rotation with corn interplanted with cowpeas, sodium nitrate gave somewhat larger yields of cotton than did ammonium sulphate for 4 years and a larger average yield for 6 years. Mixtures of inorganic and organic nitrogen gave slightly larger average yields for 6 years than did single inorganic nitrogen sources. These data are given in table 4. The detailed results with both cotton and corn are given by Skinner and Buie (*10*). There was no consistent or appreciable difference in the earliness of cotton as influenced by nitrogen sources or combination of several sources.

70266°—34——2

TABLE 4.—*Effect of various sources of nitrogen in mixed fertilizers on yield of cotton on Norfolk very fine sandy loam at Pee Dee Experiment Station, Florence, S.C.*

Source of nitrogen in 6–8–4 fertilizers [1] applied at rate of 900 pounds per acre	1920		1921		1922		1923		1924		1925		Average yield	Relative yield
	Yield per acre	Cotton open Sept. 28	Yield per acre	Cotton open Sept. 26	Yield per acre	Cotton open Sept. 6	Yield per acre	Cotton open Sept. 13	Yield per acre	Cotton open Sept. 6	Yield per acre	Cotton open Aug. 27		
	Pounds	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*
Sodium nitrate	1,764	45	1,020	35	460	70	1,430	67	810	42	1,734	58	1,203.0	100
Ammonium sulphate	1,316	33	1,220	25	420	56	1,260	70	810	53	1,330	44	1,059.3	88
33 percent from sodium nitrate 67 percent from ammonium sulphate	1,640	24	1,260	26	380	32	1,220	62	700	51	1,440	47	1,106.6	92
67 percent from sodium nitrate 33 percent from ammonium sulphate	1,816	35	1,400	21	680	50	1,380	65	800	44	1,560	49	1,272.6	106
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from dried blood	1,820	42	1,240	22	740	54	1,230	64	870	44	1,600	51	1,250.0	104
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from cottonseed meal	1,920	51	1,180	14	720	61	1,490	72	750	41	1,470	59	1,255.0	104
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from fish scrap	2,060	47	1,140	21	760	63	1,390	70	710	45	1,530	58	1,265.0	105
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from tankage	2,076	46	1,020	10	720	67	1,350	68	750	39	1,610	61	1,254.3	104
No fertilizer	1,256	48	1,100	32	220	73	1,080	78	400	48	1,212	61	878.0	----

[1] Superphosphate source of phosphoric acid and potassium sulphate source of potash in fertilizer mixtures.

EXPERIMENTS IN GEORGIA

An experiment made on Cecil sandy clay in Georgia for 6 years gives further data to show the slight superiority of fertilizers containing both inorganic and organic nitrogen over fertilizers containing only quickly available inorganic nitrogen on cotton. This experiment was made on land on which cotton and corn were grown in rotation on two tiers of plots. The corn received no fertilizer. The experiment was made in cooperation with the agronomy division of the Georgia State College of Agriculture[9] and is part of a general fertilizer experiment with fertilizer ratios and sources of potash and nitrogen. The data are given in table 5 for the years 1920 to 1926, except 1925 when the crop failed owing to abnormal weather conditions.

The data show greater returns from a mixture of sodium nitrate and ammonium sulphate than from either of these inorganic sources singly, and still greater returns from fertilizers having nitrogen derived in part from inorganic sources and in part from organic materials, such as cottonseed meal, dried blood, fish scrap, and tankage. There was more cotton picked early on plots receiving fertilizers containing both inorganic and organic nitrogen than from plots fertilized only with inorganic nitrogen.

TABLE 5.—*Effect of various sources of nitrogen in fertilizer on yield of cotton on Cecil sandy clay, Athens, Ga.*

Source of nitrogen in 6-8-4 fertilizer applied at rate of 600 pounds per acre	1920		1921		1923		1924		1926		Average yield per acre	Relative rating
	Yield per acre	Cotton open first picking	Yield per acre	Cotton open first picking	Yield per acre	Cotton open first picking	Yield per acre	Cotton open first picking	Yield per acre	Cotton open first picking		
	Lbs.	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*	*Lbs*	*Pct.*	*Lbs.*	*Pct.*	*Lbs.*	*Pct.*
Sodium nitrate	1,522	28	996	48	780	41	620	52	562	27	896	100
Ammonium sulphate	1,432	36	802	55	800	40	710	46	550	20	877	98
33 percent from sodium nitrate 67 percent from ammonium sulphate	1,640	31	834	57	860	49	740	42	650	34	945	105
67 percent from sodium nitrate 33 percent from ammonium sulphate	1,816	30	840	57	740	46	750	47	760	32	979	109
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from dried blood	1,804	33	1,080	59	740	49	790	43	700	31	1,023	114
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from cottonseed meal	1,710	29	1,054	56	780	50	770	54	775	27	1,019	114
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from fish scrap	1,818	28	1,022	63	740	49	710	45	762	33	1,010	113
25 percent from sodium nitrate 25 percent from ammonium sulphate 50 percent from tankage	1,830	25	944	64	800	55	690	45	760	29	1,004	112
No fertilizer	884	40	600	60	500	36	340	35	237	4	624	68

RATIO OF INORGANIC AND SYNTHETIC TO ORGANIC NITROGEN

In 1927, experiments to study the best ratio of inorganic and synthetic to organic nitrogen in fertilizer mixtures with phosphoric acid and potash were planned by representatives of experiment stations of the Southeastern States and of the United States Department of

[9] Credit is due J. R. Fain, head of the agronomy division of the Georgia State College of Agriculture, for cooperation in conducting this work and to A. P. Winston, superintendent of the dairy farm, for assistance in details of conducting this experiment.

Agriculture. The experiments were inaugurated on a wide range of soils including the principal soil types used for cotton production in the Southeastern States. In this work, nitrogen, phosphoric acid, and potash were used in mixtures, the source of nitrogen varying. The plan of the experiment included sodium nitrate as the entire source of nitrogen, and nitrogen from mixtures of sodium nitrate and cottonseed meal in the following proportions, respectively: 90:10, 80:20, 65:35, 50:50, and 25:75. Ammonium sulphate was likewise used as the entire source of nitrogen and in varying proportions with cottonseed meal. Urea and Leunasalpeter as types of synthetic nitrogen were also used as the single sources of nitrogen and with cottonseed meal in varying proportions. Plots fertilized with phosphoric acid and potash, without nitrogen, were included and served as checks.

The results of experiments on several soil types in which this plan was used are as follows:

On Norfolk sandy loam better results were secured with fertilizers containing approximately equal proportions of nitrogen from inorganic salts, sodium nitrate or ammonium sulphate, and cottonseed meal than from fertilizers containing nitrogen from larger percentages of inorganic nitrogen in the first 4 years of an experiment at Holland, Va., reported by Batten and Hutcheson (*2*). A similar result was secured with nitrogen derived from Leunasalpeter and cottonseed meal.

On Greenville sandy loam and Decatur clay loam, better results were secured with fertilizers containing nitrogen derived entirely from sodium nitrate, or 80 percent or more from sodium nitrate, and a small proportion from cottonseed meal than from fertilizers containing nitrogen from small percentages of sodium nitrate and large percentages of cottonseed meal in 3-year experiments in Alabama, reported by Tidmore and Williamson (*15*).

On Cecil sandy loam, better results were secured from fertilizers containing nitrogen derived 90 percent from sodium nitrate and 10 percent from cottonseed meal, at Experiment, Ga., in 1930, reported by Bledsoe (*3*, *14*), though in previous years fertilizers containing nitrogen from smaller percentages of sodium nitrate and larger percentages of cottonseed meal than this are reported to have given best results. The 65 : 35 and 80 : 20 ratios, respectively, of sodium nitrate and cottonseed meal produced largest yields.

On Tifton sandy loam at Tifton, Ga., it is reported (*12*) that work in progress with nitrogen appears to show that fertilizers for cotton on this soil gave best results when the nitrogen was derived 75 to 80 percent from sodium nitrate or ammonium sulphate and 25 to 20 percent from organic material, such as cottonseed meal.

In experiments on a heavy soil in Arkansas (*6*, *7*), with fertilizers containing organic nitrogen in the form of cottonseed meal in varying proportions with (1) sodium nitrate, (2) ammonium sulphate, and (3) Leunasalpeter, there was a marked tendency the first 2 years of the experiments for the yields of cotton to increase as the ratio of organic nitrogen was reduced until the low rate of 30 percent or less of organic nitrogen was reached when the yields differed but little. These results, however, varied from year to year, possibly owing to weather conditions. After 3 years, best results were secured with higher ratios of organic nitrogen. From the results as a whole it

appears that the best ratio of inorganic to organic nitrogen is 70 to 80 percent of the former and 30 to 20 percent of the latter.

Experiments conducted by the South Carolina Agricultural Experiment Station,[7] to determine the best ratio of inorganic or synthetic nitrogen and cottonseed meal for cotton soils in South Carolina, have been in progress several years on Cecil clay loam, Norfolk sandy loam, and other soil types. The data are helpful and in harmony with those already reported in other States, but are not very conclusive as to the exact ratio of inorganic to organic nitrogen for cotton fertilizers.

EXPERIMENTS ON CECIL CLAY LOAM

The results of a 6-year experiment on Cecil clay loam at Youngsville,[8] N.C., are given in table 6 and shown graphically in figure 2.

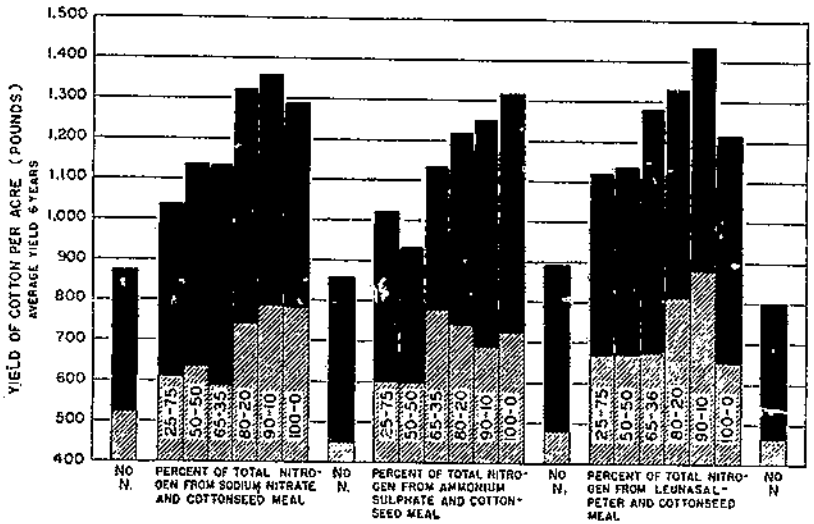

FIGURE 2.—Average yield of cotton for 6 years on Cecil clay loam, Youngsville, N.C., from 800 pounds per acre of 6–10–4 fertilizer containing nitrogen from various proportions of inorganic or synthetic sources and cottonseed meal. Hachured section of column represents yield from first picking; entire height of column represents total yield.

In this experiment a 6–10–4 fertilizer was applied annually at the rate of 800 pounds an acre in the furrow by hand 8 to 10 days before planting. It was mixed in the soil and bedded on. The beds were settled at time of planting the seed, and generally good stands were obtained.

Considering first the sodium nitrate series, the three fertilizers giving largest average yields over the 6-year period are those having nitrogen derived 90 percent from sodium nitrate and 10 percent from cottonseed meal, 80 percent from sodium nitrate and 20 percent from cottonseed meal, and nitrogen derived all from sodium nitrate. Largest yields were obtained for 3 years from the 90:10 ratio, for 2 years from the 80:20 ratio, and for 1 year from the fertilizer having nitrogen entirely from sodium nitrate. The yields from these three

[7] Private communications by T. S. Bule and H. P. Cooper of the South Carolina Agricultural Experiment Station.

[8] Acknowledgment is made for the assistance of and cooperation by W. T. Moss, Youngsville, N.C., who furnished land for these experiments and labor required for planting and cultivating the crop.

fertilizers did not vary widely, except the last year of the experiment when the fertilizer containing all of the nitrogen from sodium nitrate yielded 200 pounds of cotton less than the 80:20 mixture.

There was a substantial increase in yield of cotton from the fertilizer containing nitrogen over those containing phosphate and potash and no nitrogen.

In the 6-year average, the yields with two exceptions increased as the nitrogen from sodium nitrate increased and that from cottonseed meal decreased to the 90:10 ratio. The lowest average yield, 1,027 pounds of cotton per acre, was from the 25:75 ratio, and the largest average yield, 1,356 pounds per acre, from the 90:10 ratio. The fertilizer having nitrogen entirely from sodium nitrate gave an average yield of 1,284 pounds per acre.

TABLE 6.—*Yields of cotton 1928–33 on Cecil clay loam, Youngsville, N.C., from fertilizer containing nitrogen from different sources and in different percentages from mineral or synthetic nitrogen and organic nitrogen*

[Fertilizer applied annually at rate of 800 pounds per acre before planting; source of fertilizer ingredients: Nitrogen as note 1, phosphoric acid from superphosphate, potash from potassium sulphate]

Source of nitrogen in 6-10-4 fertilizer	1928		1929		1930		1931		1932		1933		Average yield
	Yield per acre	Cotton picked first picking	Yield per acre	Cotton picked first picking	Yield per acre	Cotton picked first picking	Yield per acre	Cotton picked first picking	Yield per acre	Cotton picked first picking	Yield per acre	Cotton picked first picking	
	Pounds	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*
No nitrogen	516	81	684	34	600	58	1,371	62	705	44	1,368	68	874
25 percent from sodium nitrate, 75 percent from cottonseed meal	840	76	1,092	40	555	60	1,208	58	702	40	1,704	79	1,027
50 percent from sodium nitrate, 50 percent from cottonseed meal	972	76	1,026	41	661	56	1,568	56	694	36	1,896	61	1,136
65 percent from sodium nitrate, 35 percent from cottonseed meal	972	70	1,026	33	673	50	1,609	54	638	32	1,874	60	1,132
No nitrogen	756	81	912	42	654	62	1,335	60	673	50	1,372	72	950
80 percent from sodium nitrate, 20 percent from cottonseed meal	984	76	1,108	39	952	58	1,731	54	870	50	2,304	59	1,325
90 percent from sodium nitrate, 10 percent from cottonseed meal	1,000	76	1,074	42	1,226	56	1,737	60	960	51	2,136	62	1,356
100 percent from sodium nitrate, 0 percent from cottonseed meal	936	77	1,024	46	1,044	61	1,793	61	819	65	2,088	55	1,284
No nitrogen	672	68	636	35	501	49	1,161	53	634	36	1,412	64	851
No nitrogen	576	75	642	39	515	62	1,295	60	849	70	1,272	60	858
25 percent from ammonium sulphate, 75 percent from cottonseed meal	816	75	774	39	500	59	1,668	59	934	63	1,436	61	1,021
50 percent from ammonium sulphate, 50 percent from cottonseed meal	840	77	756	39	480	60	1,200	68	944	64	1,368	75	931
65 percent from ammonium sulphate, 35 percent from cottonseed meal	888	78	816	39	756	67	1,468	69	1,149	71	1,728	80	1,134
No nitrogen	648	79	546	41	447	65	1,159	65	905	64	1,368	74	846
80 percent from ammonium sulphate, 20 percent from cottonseed meal	936	70	780	41	1,080	59	1,629	63	1,404	69	1,486	68	1,219
90 percent from ammonium sulphate, 10 percent from cottonseed meal	996	73	801	35	1,023	62	1,818	60	1,397	83	1,464	55	1,253
100 percent from ammonium sulphate, 0 percent from cottonseed meal	1,080	71	1,116	40	1,184	50	1,645	60	1,340	78	1,531	70	1,316
No nitrogen	664	73	672	38	567	56	1,237	52	897	75	1,316	40	892
No nitrogen	672	75	672	47	492	59	1,213	59	800	48	1,324	66	862
25 percent from Leunasalpeter, 75 percent from cottonseed meal	846	82	900	45	680	60	1,561	60	1,125	54	1,608	60	1,120
50 percent from Leunasalpeter, 50 percent from cottonseed meal	948	78	924	47	668	62	1,528	58	993	60	1,752	55	1,136
65 percent from Leunasalpeter, 35 percent from cottonseed meal	1,034	65	1,032	33	987	54	1,528	58	926	60	2,184	51	1,282
No nitrogen	748	76	972	35	484	60	1,273	60	759	65	1,420	62	943
80 percent from Leunasalpeter, 20 percent from cottonseed meal	1,056	77	924	42	1,123	60	1,616	62	1,301	63	1,968	61	1,331
90 percent from Leunasalpeter, 10 percent from cottonseed meal	1,032	77	1,068	36	1,068	58	2,142	64	1,351	73	1,946	59	1,435
100 percent from Leunasalpeter, 0 percent from cottonseed meal	960	63	900	37	850	54	1,882	56	769	69	1,944	53	1,218
No nitrogen	672	68	504	33	396	55	1,136	55	765	51	1,348	70	804
Average of nitrogen plots in sodium nitrate series	951	------	1,058	------	852	------	1,618	------	781	------	2,000	------	------
Average of nitrogen plots in ammonium sulphate series	926	------	841	------	840	------	1,571	------	1,195	------	1,502	------	------
Average of nitrogen plots in Leunasalpeter series	979	------	958	------	890	------	1,710	------	1,078	------	1,900	------	------
Average of no nitrogen plots	658	------	693	------	527	------	1,242	------	776	------	1,356	------	------

In the ammonium sulphate series, the 80:20, 90:10, and 100:0 nitrogen ratios were likewise the three highest yielding fertilizers during the 6 years of the experiment. For 3 years the fertilizer having nitrogen entirely from ammonium sulphate gave largest yields, for 1 year the 90:10, for 1 year the 80:20, and for 1 year the 65:35 gave largest yields. The average yields from the 6-year experiment were 1,316 pounds per acre for the fertilizer having nitrogen entirely from ammonium sulphate, 1,253 pounds for the 90:10 ratio mixture, and 1,219 pounds from the 80:20 ratio mixture. The smallest yields were from the mixture having nitrogen derived 25 percent from ammonium sulphate and 75 percent from cottonseed meal and from the mixture having nitrogen from equal proportions of the two materials.

In the Leunasalpeter series, the largest yields of cotton were from the 90:10, 80:20, and 65:35 ratios. For 3 years the 90:10 ratio gave largest yields, for 2 years the 80:20 gave largest yields, and for 1 year the 65:35 gave largest yields. An average of the 6 years' results was 1,120 pounds for the 25:75 ratio, 1,136 pounds for the 50:50 ratio, 1,282 pounds for the 65:35 ratio, 1,331 pounds for the 80:20 ratio, 1,435 pounds for the 90:10 ratio, and 1,218 pounds for the fertilizer with all the nitrogen derived from Leunasalpeter.

The relative effects of sodium nitrate, ammonium sulphate, and Leunasalpeter as single sources of nitrogen in fertilizer with phosphoric acid and potash on this soil are compared in table 7. For 4 years ammonium sulphate took the lead, for 1 year sodium nitrate was higher, and for 1 year Leunasalpeter gave largest yields. The highest average yield of the 6 years was from ammonium sulphate.

TABLE 7.—*Yields of cotton on Cecil clay loam, Youngsville, N.C., from sodium nitrate, ammonium sulphate, and Leunasalpeter as sources of nitrogen in 6-10-4 fertilizer*

Year	Yield of seed cotton per acre from—			Year	Yield of seed cotton per acre from—		
	Sodium nitrate	Ammonium sulphate	Leunasalpeter		Sodium nitrate	Ammonium sulphate	Leunasalpeter
	Pounds	*Pounds*	*Pounds*		*Pounds*	*Pounds*	*Pounds*
1928	936	1,080	960	1932	819	1,340	769
1929	1,024	1,116	900	1933	2,088	1,531	1,944
1930	1,044	1,184	850				
1931	1,793	1,045	1,882	Average	1,284	1,316	1,218

There was not a wide variation in yield from fertilizers containing sodium nitrate, ammonium sulphate, or Leunasalpeter, when part of the nitrogen in the mixture was derived from the inorganic or synthetic source and part from cottonseed meal As shown in table 6, for 2 years, 1928 and 1930, the yields were practically the same; the sodium nitrate series gave largest yields for 2 years, the ammonium sulphate series for 1 year, and the Leunasalpeter series for 1 year.

Fertilizers giving largest total yields generally gave largest yields of cotton at the first picking, as shown in figure 2, indicating the ratio of quickly available inorganic nitrogen to slowly available nitrogen from cottonseed meal which gives largest yields on this soil; also gives the earliest cotton.

EXPERIMENTS ON NORFOLK FINE SAND

A nitrogen-ratio experiment was made for a single year on Norfolk fine sand at the Sandhill Experiment Station of Clemson College, near Columbia, S.C. This soil is typical of that occurring in the sandhill section of North Carolina, South Carolina, and Georgia, shown in figure 3. Much of this area is devoted to cotton production,

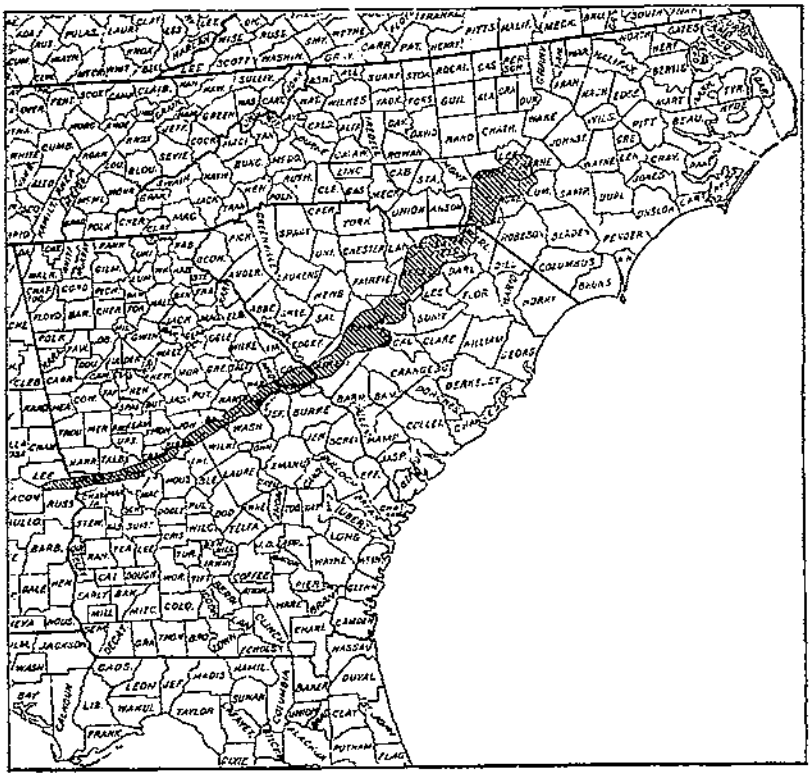

FIGURE 3.—Sand-hill section of North Carolina, South Carolina, and Georgia, lying between the Piedmont and Atlantic Coastal Plains belts, where Norfolk fine sand occurs in large areas. Shaded section is the sand-hill section.

although some of this soil is naturally unproductive and may be expected to give small yields of cotton unless large applications of fertilizer are used. Commercial fertilizers are necessary for cotton on this soil and usually two applications each season are made. The fertilizers used in the nitrogen-ratio experiments were applied in two applications, 400 pounds an acre a few days before planting and 400 pounds as a side dressing 4 weeks after the plants came up. The results are given in table 8.

TABLE 8.—*Yields of cotton on Norfolk fine sand from fertilizer containing different sources of nitrogen and different proportions of nitrogen from inorganic or synthetic and organic nitrogen, Sandhill Experiment Station, Columbia, S.C.*

[Fertilizer applied at rate of 800 pounds per acre, one-half before planting and one-half 4 weeks after cotton came up]

Source of nitrogen in 6-8-4 fertilizer [1]	Yield of cotton per acre	Cotton open first picking
	Pounds	*Percent*
No nitrogen	220	90
25 percent from sodium nitrate, 75 percent from cottonseed meal	504	89
50 percent from sodium nitrate, 50 percent from cottonseed meal	587	72
65 percent from sodium nitrate, 35 percent from cottonseed meal	507	81
80 percent from sodium nitrate, 20 percent from cottonseed meal	513	80
90 percent from sodium nitrate, 10 percent from cottonseed meal	403	81
100 percent from sodium nitrate, 0 percent from cottonseed meal	409	71
No nitrogen	205	70
Do	230	92
25 percent from ammonium sulphate, 75 percent from cottonseed meal	615	86
50 percent from ammonium sulphate, 50 percent from cottonseed meal	543	80
65 percent from ammonium sulphate, 35 percent from cottonseed meal	533	88
80 percent from ammonium sulphate, 20 percent from cottonseed meal	440	86
90 percent from ammonium sulphate, 10 percent from cottonseed meal	445	91
100 percent from ammonium sulphate, 0 percent from cottonseed meal	407	90
No nitrogen	240	92
Do	198	93
25 percent from Leunasalpeter, 75 percent from cottonseed meal	480	95
50 percent from Leunasalpeter, 50 percent from cottonseed meal	531	89
65 percent from Leunasalpeter, 35 percent from cottonseed meal	500	96
80 percent from Leunasalpeter, 20 percent from cottonseed meal	580	89
90 percent from Leunasalpeter, 10 percent from cottonseed meal	464	----
100 percent from Leunasalpeter, 0 percent from cottonseed meal	371	89
No nitrogen	234	83

[1] Source of fertilizer ingredients, nitrogen as noted, phosphoric acid from superphosphate, potash from potassium sulphate.

In this experiment the fertilizers containing nitrogen derived from the higher percentages of cottonseed meal gave highest yields. In the sodium nitrate and ammonium sulphate series mixtures containing from 35 to 75 percent of the nitrogen from cottonseed meal and the remainder from sodium nitrate or ammonium sulphate were best. Fertilizer containing nitrogen from mixtures of Leunasalpeter and cottonseed meal gave best results when the nitrogen was derived 20 to 50 percent from the latter. It would seem that for best results with cotton on this sandy soil the nitrogen in the fertilizer should contain more of the slowly available form than for cotton on a sandy loam or a heavy clay soil.

There was a marked increase in yield of early cotton from fertilizers containing the higher percentages of slowly available nitrogen compared with those containing principally quickly available nitrogen

EXPERIMENTS ON RUSTON SANDY LOAM

NITROGEN RATIOS

An experiment was made on Ruston sandy loam at Fayetteville N.C.,[9] for 3 years. Preceding the inauguration of the experiment the field had grown cotton in rotation with corn interplanted with soybeans. The vegetation produced by the soybeans was plowed under in the fall for green manure. By this practice the soil had been maintained at a high level of fertility, and large yields of cotton were

[9] Land for the experiments on Ruston sandy loam, at Fayetteville, N.C., was contributed by T. J. Purdie. His helpful assistance and cooperation is acknowledged and that of S. P. Guy, who contributed labor for planting and cultivating the crop. The general assistance of N. B. Stevens, county agent of Cumberland County, is appreciated.

secured. The year preceding the inauguration of the experiment, the field was in corn and soybeans and a mass of vegetation from the soybean vines was turned under late in the fall. Cotton was grown continuously in the experiment for 3 years, each plot receiving identical fertilizer treatments each year, and no vegetation except cotton stalks was grown or turned under during the 3-year period. In this experiment 800 pounds an acre of a 6–8–8 or 0–8–8 fertilizer were used and applied before planting. The results secured in 1931, 1932, and 1933 are given in figure 4 and in table 9.

TABLE 9.—*Yields of cotton on Ruston sandy loam, Fayetteville, N.C., from fertilizer containing nitrogen from different sources and varying percentages of mineral, synthetic, and organic nitrogen*

[Fertilizer applied at rate of 800 pounds per acre; source of fertilizer ingredients: Nitrogen as noted, phosphoric acid from superphosphate, potash from potassium chloride]

Source of nitrogen in 0–8–8 fertilizer	1931		1932		1933		Average yield
	Yield per acre	Cotton open first picking	Yield per acre	Cotton open first picking	Yield per acre	Cotton open first picking	
	Pounds	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*	*Pounds*
No nitrogen	2,370	78	1,325	60	1,425	91	1,707
25 percent from sodium nitrate, 75 percent from cottonseed meal	2,100	84	1,350	53	2,001	85	1,817
50 percent from sodium nitrate, 50 percent from cottonseed meal	2,100	71	1,387	50	2,050	80	1,846
65 percent from sodium nitrate, 35 percent from cottonseed meal	2,025	70	1,538	49	2,125	78	1,896
80 percent from sodium nitrate, 20 percent from cottonseed meal	2,225	73	1,540	51	2,210	81	1,995
90 percent from sodium nitrate, 10 percent from cottonseed meal	2,000	74	1,537	45	2,100	74	1,909
100 percent from sodium nitrate, 0 percent from cottonseed meal	2,100	74	1,437	55	2,150	81	1,896
Average of sodium nitrate series	2,107		1,465		2,108		
No nitrogen	2,325	82	1,362	58	1,400	96	1,696
25 percent from ammonium sulphate, 75 percent from cottonseed meal	2,100	80	1,412	50	1,802	84	1,771
50 percent from ammonium sulphate, 50 percent from cottonseed meal	2,100	81	1,387	58	1,891	85	1,826
65 percent from ammonium sulphate, 35 percent from cottonseed meal	2,075	75	1,537	54	1,862	82	1,825
80 percent from ammonium sulphate, 20 percent from cottonseed meal	2,175	71	1,502	53	1,962	81	1,900
90 percent from ammonium sulphate, 10 percent from cottonseed meal	2,110	76	1,537	50	1,825	80	1,824
100 percent from ammonium sulphate, 0 percent from cottonseed meal	1,975	76	1,387	54	1,738	84	1,717
Average of ammonium sulphate series	2,089		1,487		1,855		
No nitrogen	2,240	83	1,325	47	1,438	90	1,668
25 percent from urea, 75 percent from cottonseed meal	2,000	90	1,537	58	1,895	88	1,777
50 percent from urea, 50 percent from cottonseed meal	1,925	75	1,524	55	1,987	89	1,812
65 percent from urea, 35 percent from cottonseed meal	2,135	76	1,335	54	2,012	87	1,827
80 percent from urea, 20 percent from cottonseed meal	2,060	75	1,362	50	1,875	86	1,766
90 percent from urea, 10 percent from cottonseed meal	2,025	75	1,500	57	1,880	84	1,802
100 percent from urea, 0 percent from cottonseed meal	1,975	76	1,437	54	1,762	88	1,725
Average of urea series	2,019		1,403		1,902		
No nitrogen	2,350	84	1,300	58	1,425	95	
Average of no-nitrogen plots	2,321		1,328		1,422		

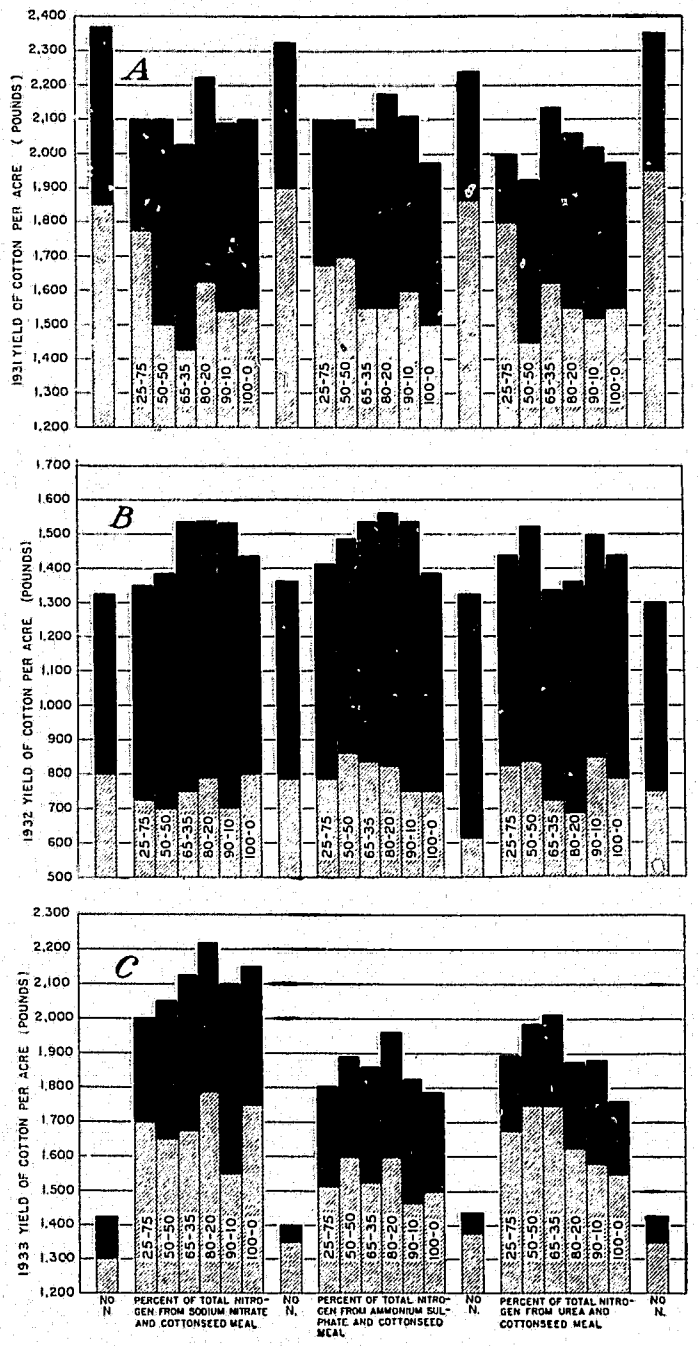

FIGURE 4.—Yields of cotton on Ruston sandy loam, Fayetteville, N.C., from 800 pounds per acre of 6-8-8 fertilizer containing nitrogen from various proportions of inorganic or synthetic sources and cottonseed meal. Hachured section represents yield from first picking; entire column represents total yield: *A*, yields in 1931; *B*, yields in 1932; *C*, yields in 1933. In 1931 cotton followed corn interplanted with soy beans for green manure, and cotton followed cotton in 1932 and 1933.

In 1931, when cotton followed corn and soybeans, the no-nitrogen fertilizers gave larger yields than did any of the fertilizer mixtures containing nitrogen, regardless of the source of nitrogen. In 1932, the second year after corn and soybeans were grown, the yields from the fertilizers containing nitrogen were greater than from the no-nitrogen fertilizers, but the differences were not wide. In 1933, after cotton had grown 2 years in succession without turning under green-manure crops, there was a decidedly increased yield from the nitrogen fertilizer over the no-nitrogen fertilizers.

Considering first the sodium nitrate series, the largest average yield for the 3 years, 1,995 pounds of seed cotton per acre, was obtained from the mixture having its nitrogen derived 80 percent from sodium nitrate and 20 percent from cottonseed meal. The 90:10 and 65:35 ratios produced yields very near those of the 80:20 ratio. Fertilizer having its nitrogen derived entirely from sodium nitrate gave an average yield of 1,896 pounds an acre, and the mixture having its nitrogen 50 percent from the inorganic source and 50 percent from the organic source gave an average yield of 1,846 pounds an acre. Though there was no increased yield from nitrogen the first year of the experiment, the largest yield from fertilizers containing nitrogen was from the 80:20 ratio this year as well as the second and third years of the experiment.

In the ammonium sulphate series, the largest average yield, 1,900 pounds per acre, was also from the fertilizer having the nitrogen derived 80 percent from ammonium sulphate and 20 percent from cottonseed meal. The 90:10, 65:35, and 50:50 ratios gave about the same average yield over the 3-year period. The largest yield each year was from the 80:20 ratio.

The results in the urea series were not so uniform. The highest average yield of 1,827 pounds was from the 65:35 ratio. However, this did not vary widely from the yield produced by the 90:10 and 50:50 ratio. The 65:35 ratio gave the highest yield in 2 of the 3 years.

The lack of response to nitrogen the first year of the experiment may be attributed to the growing and incorporation of soybean vines with the soil the preceding year. It has been noted that added nitrogen produced a slight increase the second year and a marked increase the third year, indicating a decrease of nitrogen supplied from the legume green-manure crop the second year and possibly a depletion of this nitrogen the third year.

When the experiment was started in the spring of 1931, the soil contained 1.02 percent of carbon and 0.065 percent of total nitrogen. At the end of the experiment in 1933 its organic carbon content was 0.86 percent and its total nitrogen content 0.053 percent. The pH of the soil of the different plots was practically the same, ranging from 5.0 to 5.3. The addition of the various nitrogen materials did not change the reaction of the soil appreciably during the 3 years.

Fertilizers giving largest total yields generally gave largest yields of early cotton as noted by yields secured at the first pickings shown in figures 2 and 4.

Fertilizer containing nitrogen, 80 percent from inorganic sources and 20 percent from organic, have given best results.

The use of large percentages of nitrogen from the more expensive organic sources of vegetable and animal waste origin would not seem justifiable, as indicated by the results secured on the Ruston sandy loam or the Cecil clay loam previously discussed. There is some

indication, however, that fertilizer for cotton on the lighter phases of Norfolk sandy soils should contain slightly more slowly available organic nitrogen than fertilizer for cotton on the heavier Cecil clay loam.

These results are in general harmony with the results of similar experiments on Greenville sandy loam and Decatur clay loam in Alabama, on Cecil sandy clay loam and Tifton sandy loam in Georgia, and on heavy soils in Arkansas.

Lighter and more sandy soils than these produced larger yields of cotton when the fertilizer containing nitrogen, phosphoric acid, and potash, applied before planting, had nitrogen derived approximately half from inorganic sources, as sodium nitrate or ammonium sulphate, and half from cottonseed meal, as shown by results of experiments on Norfolk fine sand in South Carolina, which is in general harmony with the results reported on Norfolk sandy loam in Virginia.

NITROGEN SOURCES AND TIME OF APPLICATION

The comparative effects of sodium nitrate, ammonium sulphate, and urea as sources of nitrogen in cotton fertilizers on Ruston sandy loam, when used as a single source or in mixtures, first, with cottonseed meal, and second, with ammonium phosphate, are given in table 10, together with data on effect of time of application of nitrogen on cotton yields.

TABLE 10.—*Comparative effects of sodium nitrate, ammonium sulphate, and urea, as sources of nitrogen, in mixtures with phosphate and potash for cotton on Ruston sandy loam*

[6-8-8 fertilizer applied at rate of 800 pounds per acre]

Fertilizer analysis (NH_3–P_2O_5–K_2O)	Composition of fertilizer in nitrogen	Delayed application of nitrogen	Form of fertilizer and time of application	Year	Yield of cotton per acre from—		
					Sodium nitrate	Ammonium sulphate	Urea
					Lbs.	*Lbs.*	*Lbs.*
6-8-8	Single source	None.	In mixture, all applied before planting.	1931	2,100	1,975	1,975
				1932	1,437	1,367	1,437
				1933	2,150	1,788	1,702
6-8-8	In various proportions of cottonseed meal, average 5 mixtures.	do	do	1931	2,108	2,112	2,028
				1932	1,471	1,507	1,432
				1933	2,099	1,868	1,930
3-8-8	Single source	24 pounds[1] NH_3	3-8-8 applied before planting, 24 pounds of nitrogen at chopping.	1931	1,975	1,743	1,906
				1932	1,300	1,299	1,318
				1933	1,675	1,580	1,572
2-8-8	Single source	32 pounds[2] NH_3	2-8-8 applied before planting, 16 pounds of nitrogen at chopping, 16 pounds of nitrogen 3 weeks after chopping.	1931	1,912	1,755	1,987
				1932	1,480	1,389	1,390
				1933	1,257	1,788	1,837
6-8-8	With ammonium phosphate.	None.	In mixture applied before planting.	1931	1,836	1,675	1,812
				1932	1,324	1,292	1,208
				1933	1,603	1,557	1,200
Average					1,755.5	1,647.6	1,650.9

[1] 800 pounds of 3-8-8 and 24 pounds of nitrogen equivalent in nitrogen to 800 pounds of 6-8-8.
[2] 800 pounds of 2-8-8 and 32 pounds of nitrogen equivalent in nitrogen to 800 pounds of 6-8-8.

The yields indicate that when the three are used, each as the entire source of nitrogen in fertilizer for preplanting applications, sodium nitrate is relatively more efficient, although in 1 year of the 3 urea gave as large a yield. Where each was used with cottonseed meal, there was not a marked difference in yield. The average of the 3 years, however, is in favor of sodium nitrate. Where each was used with ammonium phosphate, sodium nitrate was more efficient than ammonium sulphate or urea.

Sodium nitrate gave slightly better results than ammonium sulphate or urea, when part of the nitrogen was applied in mixtures with phosphoric acid and potash before planting and part later in the growing period. The data as a whole show that slightly better yields may be secured from sodium nitrate than from ammonium sulphate or urea. Although the former is a physiologically alkaline fertilizer and the latter two are physiologically acid fertilizers, any change in the reaction of the soil was not appreciable as the pH of the soil was practically the same at the end of the 3-year period. The more favorable results from sodium nitrate may be attributed to a number of factors, possibly to a temporary change in the reaction of the soil during the growing period or possibly because nitrate nitrogen is more favorable to cotton on this soil type.

The data are arranged in table 11 to show the effects of nitrogen, applied at different times, on the stand, yield, and earliness of cotton.

TABLE 11.—*Effect of time of application of nitrogen on stand, yield, and earliness of cotton on Ruston sandy loam, Fayetteville, N.C.*

Fertilizer analysis applied at planting, 800 pounds per acre (NH_3–P_2O_5–K_2O)	Source of nitrogen	Delayed applications	1931			1932			1933			Average yield per acre
			Area in which cotton did not come up	Yield per acre	Cotton open first picking	Area in which cotton did not come up	Yield per acre	Cotton open first picking	Area in which cotton did not come up	Yield per acre	Cotton open first picking	
			Percent	*Pounds*	*Percent*	*Percent*	*Pounds*	*Percent*	*Percent*	*Pounds*	*Percent*	*Pounds*
6–8–8	Sodium nitrate	None	10	2,100	74	10	1,437	55	20	2,150	81	1,896
3–8–8 [1]		24 pounds of nitrogen at chopping	5	1,975	80	14	1,306	52	20	1,675	82	1,652
2–8–8 [2]		16 pounds of nitrogen at chopping, 16 pounds 3 weeks later	3	1,912	83	14	1,480	58	20	1,857	85	1,750
6–8–8	Ammonium sulphate	None	10	1,975	76	16	1,387	54	20	1,788	84	1,717
3–8–8 [1]		24 pounds of nitrogen at chopping	5	1,743	82	16	1,299	56	20	1,589	87	1,541
2–8–8 [2]		16 pounds of nitrogen at chopping, 16 pounds 3 weeks later	2	1,755	81	16	1,389	59	16	1,788	88	1,644
6–8–8	Urea	None	10	1,975	78	14	1,437	54	20	1,762	88	1,725
3–8–8 [1]		24 pounds of nitrogen at chopping	3	1,906	79	12	1,318	56	20	1,572	88	1,599
2–8–8 [2]		16 pounds of nitrogen at chopping, 16 pounds 3 weeks later	2	1,987	81	14	1,300	53	18	1,837	91	1,708
	No fertilizer, average of 3 plots.		1	1,025	89	3	762	60	8	870	67	886

[1] 800 pounds of 3–8–8 and 24 pounds of nitrogen equivalent in nitrogen to 800 pounds of 6–8–8.
[2] 800 pounds of 2–8–8 and 32 pounds of nitrogen equivalent in nitrogen to 800 pounds of 6–8–8.

Fertilizer with a 6–8–8 analysis, containing sodium nitrate, when applied at the rate of 800 pounds an acre, before planting interfered slightly more with the germination of the cotton in 1931, than when one-half and two-thirds of the inorganic nitrogen was withheld for later applications. However, in the second and third years there was no difference in this respect. The yields from fertilizers containing the full amount of nitrogen applied before planting were larger in 2 years than when one-half and two-thirds of the nitrogen was withheld for later applications. The average for the 3 years is in favor of applying all the nitrogen with phosphoric acid and potash before planting. There is some evidence to show that withholding part of the nitrogen for later applications favors an earlier opening of a larger percentage of cotton, but this tendency is slight.

The fertilizer containing ammonium sulphate when applied before planting interfered more with the germination of the cotton, but gave larger yields than when one-half and two-thirds of the nitrogen was withheld for later applications the first year of the experiment. The average yield is but slightly in favor of application of all nitrogen with phosphoric acid and potash before planting. More cotton opened earlier when the nitrogen was applied in 2 or 3 applications.

Where urea was used as the source of nitrogen, the results are not clear as to the most favorable time for applying nitrogen. There was no marked or consistent difference in yield or time of maturing of cotton, resulting from the variation in time of applying the nitrogen. From the results of each of the series of experiments there seems no evidence to favor split or delayed applications of part of the nitrogen for cotton on the Ruston soil.

NITROGEN SOURCES IN CONCENTRATED FERTILIZERS

The experiments on Ruston sandy loam included a study of sodium nitrate, ammonium sulphate, and urea as sources of nitrogen in concentrated fertilizers with ammonium phosphate and potassium sulphate. Fertilizers were prepared in double strength, analyzing 12 percent of ammonia, 16 percent of phosphoric acid, and 16 percent of potash, and compared with a 6–8–8 fertilizer containing superphosphate, nitrogen, and potassium sulphate. The results are given in table 12. The double-strength fertilizer containing ammonium phosphate, sodium nitrate, and potash did not give as large yields of cotton as the single-strength fertilizer composed of superphosphate, sodium nitrate, and potash. The substitution of cottonseed meal as part of the nitrogen in the 6–8–8 fertilizer produced the same quantity of cotton as the fertilizer containing all its nitrogen from sodium nitrate.

Neither did the concentrated fertilizer composed of ammonium phosphate, ammonium sulphate, and potassium sulphate give as good returns as the 6–8–8 composed of superphosphate, ammonium sulphate, and potassium sulphate. The substitution of cottonseed meal for part of the ammonium sulphate made the fertilizer more efficient for cotton.

Likewise the concentrated fertilizer containing ammonium phosphate, urea, and potassium sulphate was less favorable to cotton than the single-strength fertilizer composed of superphosphate, urea, and potassium sulphate. The 6–8–8 fertilizer containing both urea and cottonseed meal as sources of nitrogen gave larger yields of cotton than

fertilizer containing only urea, in all but 1 year, and larger average yields for 3 years.

TABLE 12.—*Yields of cotton from ordinary-analysis fertilizer and concentrated fertilizer on Ruston sandy loam, Fayetteville, N.C.*

Fertilizer analysis (NH_3-P_2O_5-K_2O)	Rate per acre	Source of fertilizer materials	1931	1932	1933	Average
	Pounds		*Pounds*	*Pounds*	*Pounds*	*Pounds*
6-4-8	800	Superphosphate, sodium nitrate, and potassium sulphate.	2,100	1,437	2,160	1,896
6-8-8	800	Superphosphate, sodium nitrate, cottonseed meal, and potassium sulphate.[1]	2,025	1,538	2,125	1,896
12-16-16	400	Ammonium phosphate, sodium nitrate, and potassium sulphate.	1,836	1,324	1,603	1,588
6-8-8	800	Superphosphate, ammonium sulphate, and potassium sulphate.	1,975	1,387	1,788	1,717
6-8-8	800	Superphosphate, ammonium sulphate, cottonseed meal, and potassium sulphate.[2]	2,075	1,537	1,862	1,825
12-16-16	400	Ammonium phosphate, ammonium sulphate, and potassium sulphate.	1,675	1,202	1,557	1,508
6-8-8	800	Superphosphate, urea, and potassium sulphate	1,975	1,437	1,762	1,725
6-8-8	800	Superphosphate, urea, cottonseed meal, and potassium sulphate.[3]	2,125	1,535	2,012	1,827
12-16-16	400	Ammonium phosphate, urea, and potassium sulphate.	1,812	1,268	1,200	1,427
No fertilizer			1,025	762	870	886

[1] Nitrogen derived 65 percent from sodium nitrate and 35 percent from cottonseed meal.
[2] Nitrogen derived 65 percent from ammonium sulphate and 35 percent from cottonseed meal.
[3] Nitrogen derived 65 percent from urea and 35 percent from cottonseed meal.

SUMMARY

Results of experiments are reported showing the relative effects of various sources of inorganic, synthetic, and organic nitrogen in fertilizers for cotton on the principal soils of the southeastern Cotton Belt. On many soils there was not a wide variation in yield of cotton from fertilizers containing phosphoric acid and potash with different sources of nitrogen, such as sodium nitrate, ammonium sulphate, ammonium nitrate, urea, Leunasalpeter, and ammonium phosphate. In some of the experiments ammonium chloride gave slightly lower yields.

Fertilizers containing nitrogen derived partly from quickly available inorganic or synthetic nitrogen and partly from slowly available organic nitrogen of vegetable or animal-waste origin gave larger returns on some soils than fertilizers containing only quickly available inorganic or synthetic nitrogen, while on other soils quickly available nitrogen gave as good results as a mixture of the two types of nitrogen carriers.

In a 6-year experiment on Cecil clay loam in North Carolina a 6–8–4 fertilizer, applied at the rate of 800 pounds an acre in which nitrogen was derived from various proportions of sodium nitrate and cottonseed meal, gave larger average yields with the 90:10 ratio, followed closely by the 80 : 20 ratio. Fertilizers containing ammonium sulphate as the entire source of nitrogen gave larger average yields than those containing a mixture of ammonium sulphate and cottonseed meal. The next most effective in this series was the 90 : 10 ratio. When Leunasalpeter and cottonseed meal were used as the source of nitrogen, largest returns were from the 90:10 ratio.

The largest yields of cotton at the early pickings on the Cecil clay loam were generally from the fertilizers giving largest total

yields. However, in the ammonium sulphate-cottonseed meal mixtures there was a tendency for the early yields to increase as the nitrogen from cottonseed meal increased. Nitrogen, 65 percent from sodium nitrate and 35 percent from cottonseed meal, proved to be the most effective ratio.

On Norfolk fine sand in South Carolina, more favorable results were secured when the nitrogen was derived 35 to 75 percent from organic sources, such as cottonseed meal, and the remainder from quickly available inorganic sources. In these experiments the fertilizer giving largest yields generally produced most cotton at the first picking.

In a 3-year experiment on Ruston sandy loam in North Carolina, no increased yields of cotton were secured from the addition of commercial nitrogen the first year on soil on which corn and soybeans had grown the preceding year. The soil contained 1.02 percent of carbon and 0.065 percent of nitrogen at the beginning of the experiment. The second year a moderate response from added nitrogen was secured and the third year a marked response. The soil at the end of the 3-year period contained 0.86 percent of carbon and 0.053 percent of nitrogen.

The first year of the experiment fertilizers containing nitrogen in the proportion of 80:20 from sodium nitrate and cottonseed meal, respectively, gave largest returns. With mixtures of ammonium sulphate and cottonseed meal the 80:20 ratio was best, and with mixtures of urea and cottonseed meal the 65:35 ratio gave best results.

The second year fertilizers containing nitrogen in the proportion of 65:35, 80:20, and 90:10 from sodium nitrate and cottonseed meal, gave equally good results. Fertilizers containing nitrogen from ammonium sulphate and cottonseed meal were most effective when the nitrogen was 80 percent from the former and 20 percent from the latter. The 65:35 and 90:10 ratios gave almost as good results. The yields from mixtures of urea and cottonseed meal were not consistent.

The third year the 80:20 ratio of sodium nitrate and cottonseed meal, the 80:20 ratio of ammonium sulphate and cottonseed meal and the 65:35 ratio of urea and cottonseed meal were most profitable. The fertilizers giving largest total yields generally gave largest yields at the first picking.

Results of experiments with various proportions of inorganic and organic nitrogen previously reported by other workers show largest yields of cotton on Greenville sandy loam and Decatur clay loam in Alabama from fertilizer containing nitrogen principally from sodium nitrate or 80 to 90 percent from sodium nitrate and the remainder from cottonseed meal; on Norfolk sandy loam in Virginia from fertilizer containing approximately equal proportions of inorganic and organic nitrogen; on Cecil sandy clay in Georgia from fertilizers containing nitrogen in proportions of 90:10 from sodium nitrate and cottonseed meal, respectively; on Tifton sandy loam in Georgia, from fertilizers having nitrogen in an 80:20 ratio of inorganic and organic form; and on heavy soils in Arkansas from fertilizers containing nitrogen 70 to 80 percent from inorganic and 30 to 20 percent from organic materials.

Nitrogen applied in mixtures with phosphoric acid and potash before planting gave larger returns on Ruston sandy loam than

when part was applied after the cotton was up, regardless of the source of nitrogen.

Double-strength fertilizers containing ammonium phosphate and sodium nitrate, or ammonium phosphate and ammonium sulphate, or ammonium phosphate and urea, each with potash, gave smaller returns on Ruston sandy loam than single-strength fertilizers containing superphosphate, nitrogen, and potash.

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