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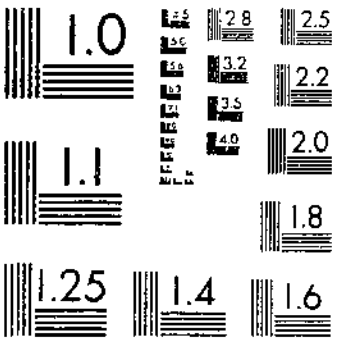

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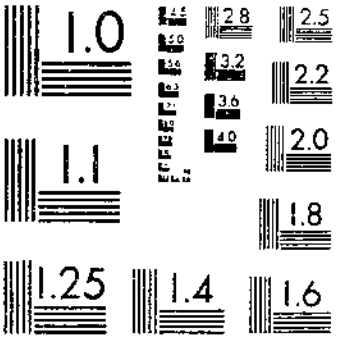

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

TECHNICAL BULLETIN No. 225 February 1931

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

RESULTS OF FERTILIZER EXPERIMENTS ON NORFOLK FINE SANDY LOAM AND ON NORFOLK SANDY LOAM

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CONTENTS

INTRODUCTION

The experiments reported in this bulletin were made at the Pee Dee Experiment Station of Clemson College, near Florence, Florence County, S. C., from 1919 to 1928, inclusive, on Norfolk fine sandy loam, and in Darlington County, S. C., from 1922 to 1924, inclusive, on Norfolk sandy loam. Cotton and corn interplanted with cowpeas were grown in rotation on two duplicate tiers of plots in the experiments at the Pee Dee station, both crops being grown each year, and cotton, preceded by corn, was grown in the Darlington County experiments.

The Norfolk soils are among the principal soils of the Atlantic coastal plain and are used extensively for the growing of cotton. The Norfolk fine sandy loam occurring at the Pee Dee Experiment Station is slightly heavier than the same soil type in the surrounding country in Florence (*1*)[2] and Darlington (*10*) Counties, S. C. The surface soil to a depth of 8 inches is light-brown or grayish-brown loamy fine sand. It is underlain, to a depth of about 18 inches, by similar-textured loamy fine sand of a dull yellowish-gray color. Below this depth, the subsoil is yellow and of fine sandy clay texture. This soil is typical of a large area of Norfolk fine sandy loam occurring in the coastal-plain area.

In Florence County 70,336 acres of Norfolk sandy loam and 44,800 acres of Norfolk fine sandy loam were mapped. In Darlington

[1] This report is the result of cooperative work carried on by the U. S. Department of Agriculture and the South Carolina Agricultural Experiment Station at its branch station at Florence, S. C. Assistance by R. E. Currin, superintendent, and E. E. Hall, agronomist of the branch station, who furnished technical aid and facilities for carrying out the details of the work, is acknowledged.

[2] Italic numbers in parentheses refer to Literature Cited, p. 21.

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County, the adjoining county, 65,024 acres of Norfolk sandy loam were mapped. In North Carolina, South Carolina, Georgia, and Alabama there had been mapped by the United States Department of Agriculture to December 30, 1924, 4,782,268 acres of Norfolk sandy loam and 3,799,300 acres of Norfolk fine sandy loam.

The triangle system of fertilizer experimentation (*12*) was used in the experiments to be described. This plan consists of using the fertilizer constituents, nitrogen (ammonia), phosphoric acid, and potash, singly, two together, and three together, the ratios varying in 3 per cent stages. This plan of fertilizer experimentation originated with a study of nutrient solutions (*11*) and has since been used extensively in aqueous culture investigations (*15*, *13*). Following the use of the triangle system in solution-culture work, it was used in field studies, first in a grass experiment at the Pennsylvania State College (*8*) and later with many crops in various sections of the United States in connection with fertilizer problems. The scheme has been found valuable as a basis for preparing fertilizer mixtures, charting data, and interpreting results. The triangle has been suggested as a basis for the simplification of the list of fertilizer analyses manufactured for the several regions of the United States (*3*). The system is explained in detail in the following pages.

PLAN OF THE EXPERIMENT AND FERTILIZER MIXTURES

At the Pee Dee Experiment Station, two tiers or series of plots were used in the fertilizer experiments under discussion. Each tier consisted of twenty-eight $\frac{1}{10}$-acre plots. Twenty-one plots received fertilizer applications and seven, or every third plot, received no fertilizer and served as checks. Cotton and corn were grown in rotation. Cowpeas were broadcast in the corn at its last cultivation to produce vegetation for plowing under. The two tiers of plots, with cotton and corn, are shown in Figure 1.

The experiment was planned and conducted to study the effect of different fertilizer ratios on the Norfolk fine sandy loam soil on cotton and corn. The plots received 21 different treatments of single fertilizer elements and combinations of the three elements. The composition of the 21 mixtures used is shown as bags of fertilizers in Figure 2. The bag at each extreme point represents a fertilizer containing 15 per cent ammonia (NH_3), 15 per cent phosphoric acid (P_2O_5), and 15 per cent potash (K_2O).[3]

In Figure 2 the bags on the line forming the base of the triangle represent mixtures containing no phosphoric acid, those on the line just above contain 3 per cent phosphoric acid, and those on the next line 6 per cent phosphoric acid. This progression continues, so that the extreme bag of the triangle contains 15 per cent phosphoric acid. In the same manner the bags on the two sides contain no potash and no ammonia, and those on the lines parallel to them contain from 3 to 15 per cent of these elements.

A gradual decrease in the percentage of phosphoric acid and a gradual increase in percentages of ammonia and potash in the fer-

[3] Fertilizer constituents are given in this bulletin in the order—ammonia, phosphoric acid, and potash. The fertilizer analyses or ratio are on the ammonia basis, as this was common practice when the experiments were in operation.

FIGURE 1.—Cotton and corn grown in rotation on the plots on Norfolk fine sandy loam at the Pee Dee Experiment Station, South Carolina

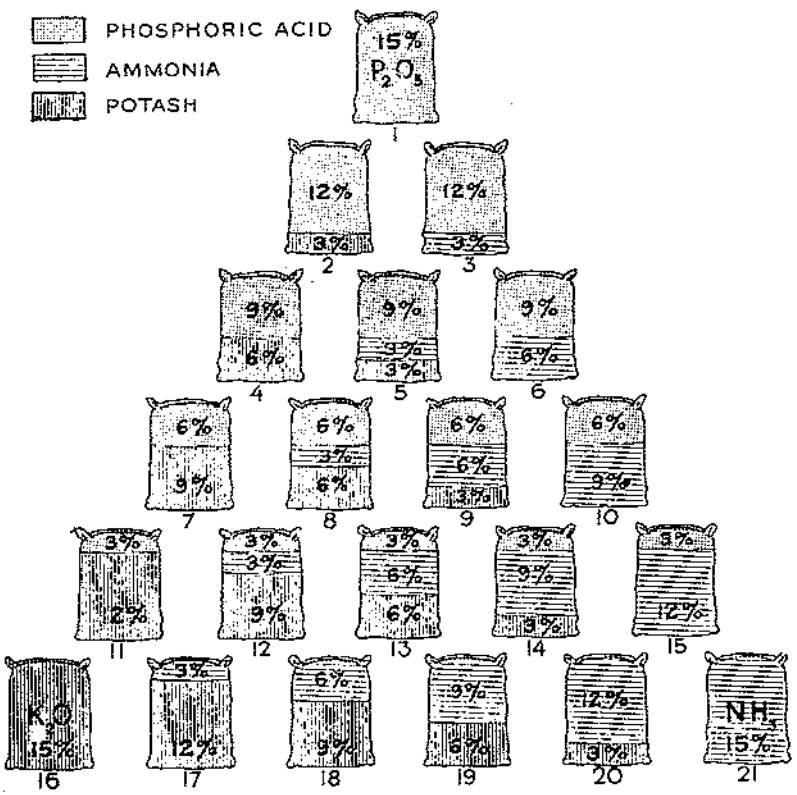

FIGURE 2.—Bags of fertilizers, arranged in a triangle, showing percentages of each fertilizer ingredient in the 21 fertilizers used in experiments

tilizer occur from the bag at the top of the triangle (marked 1) downward toward the base. Similarly a gradual decrease in ammonia and increase in phosphoric acid and potash take place from the bag marked 21 toward the opposite side of the triangle. The fertilizers in the bags inside the triangle are complete fertilizers, whereas those in the bags on the outside lines are combinations of two fertilizer elements. The bags on the extreme points contain maximum amounts of single elements used in the experiment.

The fertilizer constituents in each fertilizer total 15 per cent, whether one, two, or three of the constituents is present. Each plot received the same number of pounds of plant-food constituents but in different ratios. The fertilizer was applied each year at the rate of 900 pounds per acre to cotton and 450 pounds per acre to corn. In other words, each plot received 135 pounds of plant food per acre for cotton and 67.5 pounds per acre for corn, or a total of 202.5 pounds in the course of the two years.

The phosphoric acid used in the fertilizer mixtures was from superphosphate, the nitrogen from one-third each of nitrate of soda, sulphate of ammonia, and cottonseed meal, and the potash from sulphate of potash. All the fertilizer was applied in the seed furrows about one week before planting time. The experiment was continued for 10 years, 1919 to 1928, inclusive.

COTTON ON NORFOLK FINE SANDY LOAM

Table 1 gives results obtained in experiments with cotton on Norfolk fine sandy loam from 1919 to 1928. These data are possibly easier to study by means of the triangle diagram, and in order that the results may be readily visualized the yield for each year, the average yield for the 10 years, and the average per cent of cotton open at the first picking are given in Figures 3 and 4.

The average composition or ratio of ammonia, phosphoric acid, and potash in the three fertilizer mixtures which produced the largest yield in each diagram, or in each year, is given in the following tabulation:

Year:	NH_3–P_2O_5–K_2O
1919	12– 2–1
1920	4– 9–2
1921	4–10–1
1922	5– 8–2
1923	4– 7–4
1924	4– 7–4
1925	4– 7–4
1926	5– 7–3
1927	5– 8–2
1928	8– 1–6

In the first four years of the experiment there is more or less variation from year to year in the composition of the three mixtures which produced the highest yields, and the average fertilizer analysis falls at different points on the triangle diagram. These points or ratios are far apart at first, become closer after the first year, remain reasonably close for the second, third, and fourth years, are identical for the next three years, vary slightly in the eighth and ninth years, and break in the tenth year, owing undoubtedly to weather conditions.

TABLE 1.—*Yield of seed cotton per acre in fertilizer-ratio experiments on Norfolk fine sandy loam, 1919–1928*

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	1919			1920			1921		
		Yield of first picking Sept. 15	Total yield	Cotton open at first picking	Yield of first picking Sept. 28	Total yield	Cotton open at first picking	Yield of first picking Sept. 26	Total yield	Cotton open at first picking
		Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
1	0-15-0	780	1,780	44	1,140	1,892	60	340	1,540	22
2	0-12-3	680	1,628	42	1,100	1,892	58	620	1,620	38
3	3-12-0	840	1,984	42	1,300	2,160	60	420	1,720	24
X	(1)	500	1,396	36	940	1,480	63	360	1,380	26
4	0-9-6	660	1,562	42	1,040	1,710	61	300	1,160	17
5	3-9-3	760	2,010	38	1,080	2,030	53	360	1,920	19
6	6-9-0	500	2,136	23	720	1,676	43	240	1,740	14
X	(1)	520	1,388	38	780	1,420	54	220	1,460	15
7	0-6-9	520	1,372	38	900	1,600	56	320	1,340	24
8	3-6-6	520	1,676	31	740	1,608	46	220	1,120	20
9	6-6-3	500	2,150	23	740	2,004	37	140	1,360	11
X	(1)	500	1,520	33	600	1,460	41	200	1,160	17
10	9-6-0	420	2,130	19	600	1,620	37	180	1,650	11
11	0-3-12	500	1,446	35	560	1,090	51	112	1,040	10
12	3-3-9	400	1,596	29	760	1,460	52	60	1,060	6
X	(1)	500	1,358	37	880	1,308	64	80	1,000	8
13	6-3-6	440	1,936	23	640	1,486	43	180	1,220	15
14	9-3-3	400	2,270	18	500	1,450	34	140	1,240	11
15	12-3-0	240	2,240	10	580	1,500	37	140	1,120	13
X	(1)	600	2,010	29	660	1,304	51	60	840	7
16	0-0-15	480	1,640	29	640	1,040	61	140	820	17
17	3-0-12	260	1,588	16	720	1,340	54	200	1,020	20
18	6-0-9	260	1,920	14	580	1,180	49	80	840	10
X	(1)	600	1,898	31	720	1,272	57	60	900	7
19	9-0-6	160	2,078	8	260	1,040	25	140	1,060	13
20	12-0-3	180	2,168	8	140	850	16	40	840	5
21	15-0-0	200	2,280	9	160	938	17	10	800	1
X	(1)	400	1,900	21	600	1,256	48	10	840	1
	Average of 7 checks	517	1,635	32	737	1,366	54	141	1,083	13

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	1922			1923			1924		
		Yield of first picking Sept. 13	Total yield	Cotton open at first picking	Yield of first picking Sept. 13	Total yield	Cotton open at first picking	Yield of first picking Sept. 6	Total yield	Cotton open at first picking
		Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
1	0-15-0	320	560	57	740	990	75	330	530	62
2	0-12-3	320	520	62	840	1,240	68	200	440	59
3	3-12-0	420	820	51	880	1,120	79	360	480	75
X	(1)	180	440	41	450	710	65	160	240	67
4	0-9-6	340	680	50	1,040	1,340	77	340	570	60
5	3-9-3	480	940	51	1,120	1,430	78	530	800	66
6	6-9-0	440	1,100	40	980	1,180	83	420	710	59
X	(1)	180	480	38	520	780	69	250	370	68
7	0-6-9	280	580	48	800	1,140	70	340	710	48
8	3-6-6	320	760	42	990	1,350	73	400	860	61
9	6-6-3	400	1,060	43	930	1,370	68	410	790	52
X	(1)	160	400	40	530	910	58	200	370	54
10	9-6-0	360	840	43	420	780	54	320	700	40
11	0-3-12	320	620	52	420	860	49	260	660	40
12	3-3-9	320	580	55	480	960	50	200	640	41
X	(1)	180	360	50	424	744	57	180	390	46
13	6-3-6	320	700	46	624	1,164	54	440	640	52
14	9-3-3	300	680	44	660	1,130	58	240	550	44
15	12-3-0	340	700	49	440	800	55	380	630	60
X	(1)	240	400	60	560	980	59	220	470	47
16	0-0-15	240	320	75	550	930	59	180	430	42
17	3-0-12	240	380	63	500	880	57	360	760	47
18	6-0-9	200	300	67	360	780	46	230	770	25
X	(1)	160	200	80	500	820	60	240	410	59
19	9-0-6	218	318	69	370	830	45	350	720	49
20	12-0-3	180	280	64	300	700	43	350	790	44
21	15-0-0	160	300	53	260	819	32	320	690	46
X	(1)	220	320	69	460	850	54	200	460	43
	Average of 7 checks	188	371	51	495	829	60	297	387	53

[1] Check.

TABLE 1.—*Yield of seed cotton per acre in fertilizer-ratio experiments on Norfolk fine sandy loam, 1919–1928*—Continued

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	1925			1926			1927		
		Yield of first picking Aug. 27	Total yield	Cotton open at first picking	Yield of first picking Sept. 3	Total yield	Cotton open at first picking	Yield of first picking Sept. 12	Total yield	Cotton open at first picking
		Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
1	0-15-0	784	1,148	68	790	1,061	74.3	204	320	63.7
2	0-12-3	1,020	1,554	66	1,100	1,480	74.3	402	546	73.6
3	3-12-0	1,010	1,470	69	1,000	1,290	77.5	514	704	73.0
X	(1)	640	940	68	620	880	70.5	222	368	60.3
4	0-9-6	970	1,550	63	800	1,360	58.8	378	504	75.0
5	3-9-3	1,130	1,644	69	980	1,670	57.5	794	1,244	63.8
6	6-9-0	1,010	1,450	72	1,100	1,730	63.6	798	1,242	64.2
X	(1)	540	1,000	54	080	1,070	63.5	264	348	75.8
7	0-6-9	750	1,424	53	840	1,444	58.2	260	470	55.3
8	3-6-6	980	1,730	57	960	1,730	55.5	422	900	46.9
9	6-6-3	850	1,650	52	710	1,720	41.3	504	1,228	41.0
X	(1)	570	1,070	53	660	1,120	58.9	256	370	69.2
10	9-6-0	560	1,460	38	350	1,390	25.3	418	950	44.0
11	0-3-12	694	1,304	53	610	1,280	47.6	242	460	52.6
12	3-3-9	660	1,444	46	770	1,320	58.3	346	802	43.1
X	(1)	700	1,254	56	600	1,030	58.2	238	394	60.4
13	6-3-6	680	1,570	41	520	1,520	34.2	352	1,128	31.2
14	9-3-3	370	1,444	26	450	1,460	30.8	375	1,196	31.6
15	12-3-0	380	1,364	28	380	1,280	29.7	110	596	18.5
X	(1)	650	1,304	50	630	1,010	62.4	282	518	54.4
16	0-0-15	624	1,554	40	400	1,070	37.4	266	668	39.8
17	3-0-12	330	1,440	23	420	1,180	35.6	222	822	27.0
18	6-0-9	190	1,194	16	480	1,310	36.6	80	740	10.8
X	(1)	770	1,460	53	760	1,200	58.3	488	578	84.4
19	9-0-6	264	1,458	23	340	1,330	25.6	98	784	11.2
20	12-0-3	130	1,040	12	370	1,410	26.2	24	518	4.6
21	15-0-0	84	724	12	360	1,180	30.5	28	384	7.3
X	(1)	754	1,504	50	760	1,290	54.3	442	552	80.1
	Average of 7 checks	661	1,219	51	656	1,086	60.4	313	447	70.0

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	1928			Average 1919–1928		
		Yield of first picking Sept. 8	Total yield	Cotton open at first picking	Yield of first picking Sept. 8	Total yield	Cotton open at first picking
		Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
1	0-15-0	524	604	86.7	595.2	1,042.3	57.1
2	0-12-3	484	568	85.2	682.6	1,148.8	59.4
3	3-12-0	372	412	90.3	711.6	1,216.0	58.6
X	(1)	172	212	81.1	424.4	804.6	52.7
4	0-9-6	440	588	74.8	630.8	1,099.4	57.4
5	3-9-3	528	688	76.7	774.2	1,437.6	54.1
6	6-9-0	484	588	82.3	672.2	1,356.8	49.5
X	(1)	332	440	75.4	426.6	872.6	48.9
7	0-6-9	360	560	64.3	537.0	1,064.0	50.5
8	3-6-6	552	760	72.6	616.4	1,248.4	49.3
9	6-6-3	564	712	79.2	580.8	1,398.4	41.5
X	(1)	312	372	83.9	399.0	875.2	45.6
10	9-6-0	540	732	73.8	448.8	1,239.2	33.8
11	0-3-12	356	504	70.6	407.4	926.4	44.0
12	3-3-9	476	732	65.0	459.2	1,059.4	43.5
X	(1)	280	428	65.4	406.2	832.6	48.8
13	6-3-6	572	812	70.4	476.8	1,217.0	39.2
14	9-3-3	676	916	73.8	411.4	1,233.5	33.3
15	12-3-0	480	548	87.6	347.0	1,084.0	32.0
X	(1)	352	468	75.2	427.4	931.0	45.9
16	0-0-15	288	396	72.7	350.8	880.8	42.9
17	3-0-12	390	536	72.7	384.2	1,001.6	38.4
18	6-0-9	560	832	67.3	392.0	986.6	39.8
X	(1)	384	464	82.7	462.2	921.2	50.2
19	9-0-6	672	824	81.5	286.2	1,014.2	28.2
20	12-0-3	540	730	73.4	225.4	927.2	24.3
21	15-0-0	620	668	85.5	210.2	872.3	24.0
X	(1)	368	452	81.4	415.4	942.4	44.1
	Average of 7 checks	314	405	77.5	422.9	882.8	47.4

[1] Check.

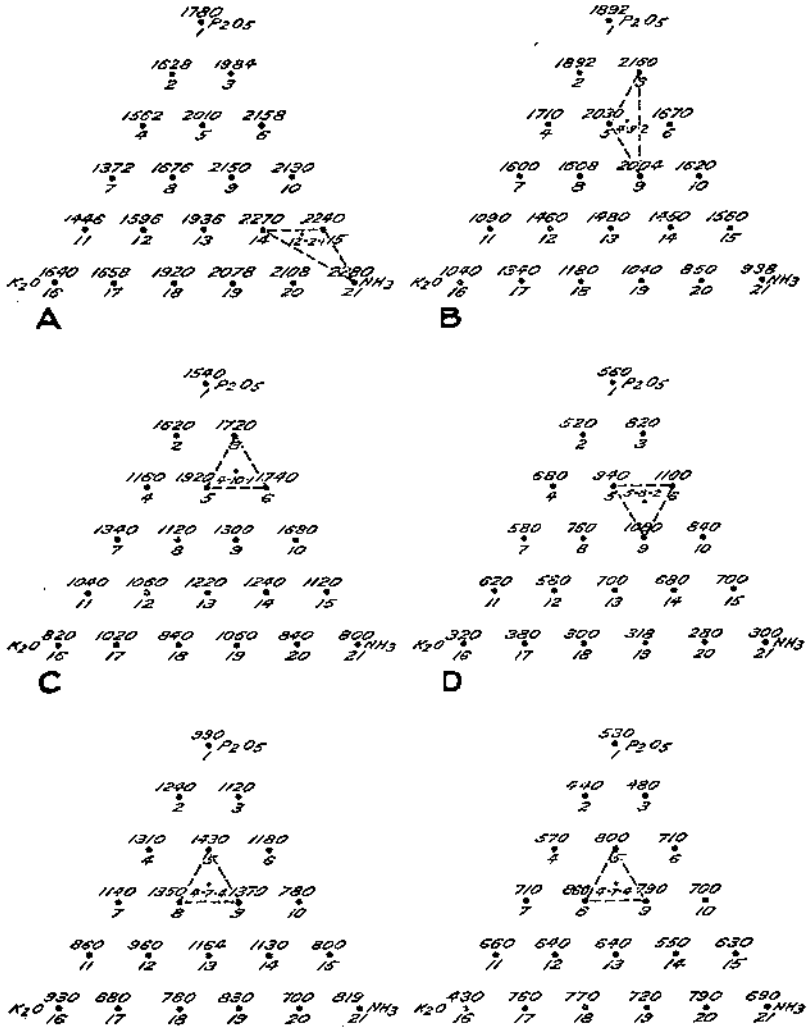

FIGURE 3.—Yields of cotton in pounds per acre on Norfolk fine sandy loam on the Pee Dee Experiment Station for the 21 fertilizers used in the experiment. The three fertilizers which produced the largest yields each year are connected by a heavy black line, and the average ammonia, phosphoric acid, and potash composition of the three mixtures is recorded in the triangle: A, Yields secured in 1919; B, in 1920; C, in 1921; D, in 1922; E, in 1923; F, in 1924

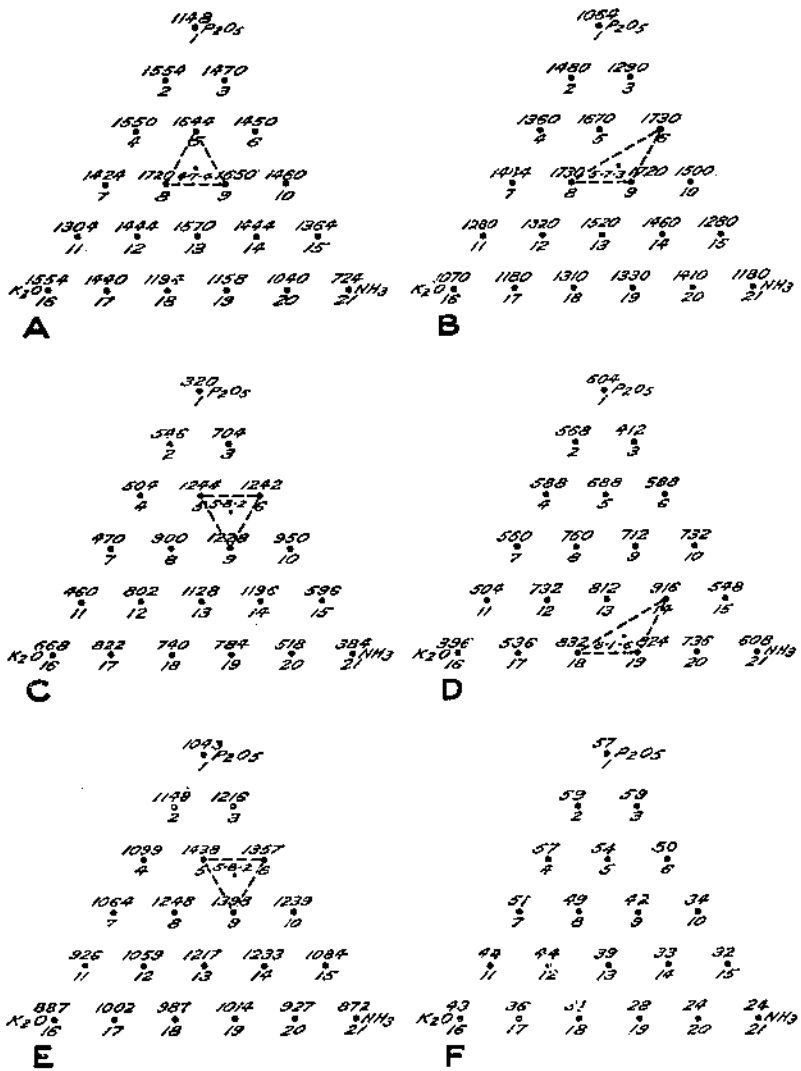

FIGURE 4.—A to E, yields of cotton in pounds per acre on Norfolk fine sandy loam on the Pee Dee Experiment Station from the 21 fertilizers used in the experiment. The three fertilizers which produced the largest yields each year are connected by a heavy black line, and the average ammonia, phosphoric acid, and potash composition of the three mixtures is recorded in the triangle: A, Yields secured in 1925; B, in 1926; C, in 1927; D, in 1928; E, average of 10 years (1919–1928); F, average percentage of the total yield of cotton open at the first picking, 1919–1928

The wide difference in the composition of the three mixtures which produced the highest yields the first year as compared with those in the following years is probably owing to the fact that following the first year the plots in cotton had been planted to corn with cowpeas for green manure. The growing of the peas and turning under of the vegetation undoubtedly made a difference in the requirement for nitrogen. Preceding the first year of the experiments, no vegetation had been turned under, and leguminous crops had not been grown. In arriving at the fertilizer ratio which produced the highest yields according to the data, possibly the first year's results should be omitted. The three mixtures which produced the highest yields, when the average of 10 years is considered as shown in Figure 4, E, are Nos. 5, 6, and 9. These three have an average ratio of ammonia, phosphoric acid, and potash, of 5–8–2, respectively.

Another compilation of the data is presented in Table 2. Here the yields from mixtures on the various lines of the triangle or all the mixtures containing a constant amount of each fertilizer constituent are averaged. The mixtures containing 3 and 6 per cent ammonia have produced highest average yields, the 6 per cent mixtures being higher than the 3 per cent. The 6 and 9 per cent phosphoric-acid mixtures have given highest average yields of the phosphoric-acid group, the 9 per cent giving slightly higher yields than the 6 per cent.

TABLE 2.—*Effect of different proportions of ammonia, phosphoric acid, and potash in fertilizers on yield of cotton on Norfolk fine sandy loam*

Fertilizer mixtures in Figure 4, E, and Table 1	Percentage of ammonia in each mixture	Ten-year average yield of cotton per acre	Fertilizer mixtures in Figure 4, E, and Table 1	Percentage of phosphoric acid in in each mixture	Ten-year average yield of cotton per acre	Fertilizer mixtures in Figure 4, E, and Table 1	Percentage of potash in each fertilizer mixture	Ten-year average yield of cotton per acre
No.	*Per cent*	*Pounds*	*No.*	*Per cent*	*Pounds*	*No.*	*Per cent*	*Pounds*
1, 2, 4, 7, 11, 16	0	1,028	16, 17, 18, 19, 20, 21	0	948	1, 3, 6, 10, 15, 21	0	1,135
3, 5, 8, 12, 17	3	1,193	11, 12, 13, 14, 15	3	1,104	2, 5, 9, 14, 20	3	1,220
6, 9, 13, 18	6	1,240	7, 8, 9, 10	6	1,237	4, 8, 13, 19	6	1,145
10, 14, 19	9	1,162	4, 5, 6	9	1,208	7, 12, 18	9	1,037
15, 20	12	1,005	2, 3	12	1,182	11, 17	12	964
21	15	872	1	15	1,043	16	15	887

In the mixtures of the varying potash groups, the highest average yield is from the 3 per cent potash fertilizers. From the analysis of the data, it would appear that the best fertilizer is a mixture containing from 3 to 6 per cent ammonia, 6 to 9 per cent phosphoric acid, and 3 per cent potash. A 6–9–3 analysis may be chosen as that giving the highest yield. The ratio of fertilizer constituents is practically the same as derived by this and the former deduction.

The 5–8–2 ratio, when computed to percentage of 100, is 33.3–53.3–13.4 and the 6–9–3 becomes 33.3–50–16.7. From the data of the experiment as a whole, the proper fertilizer would appear to be a mixture containing 5 to 6 per cent ammonia, 8 to 9 per cent phosphoric acid, and 2 to 3 per cent potash.

INCREASED YIELD FROM FERTILIZERS

The results, considered from the point of view of increased yields of the fertilized plots over those having no fertilizer are as given in Table 3. The average of the three fertilizers which produced the highest yield in each year is given and compared with an average of the seven checks or no-fertilizer plots.

TABLE 3.—*Average yield of cotton from the three fertilizers which produced the highest yields, compared to average yield from no-fertilizer plots on Norfolk fine sandy loam, 1919–1928*

Year	Three highest-yielding fertilizers in Table 1	Average yield of seed cotton per acre from—		Increase	
		Three highest yielding fertilizers	No fertilizers		
	No.	*Pounds*	*Pounds*	*Pounds*	*Per cent*
1919	14, 15, 21	2,263	1,635	628	38.4
1920	3, 5, 9	2,065	1,360	699	51.2
1921	3, 5, 6	1,793	1,083	710	65.6
1922	5, 6, 9	1,033	371	662	178.4
1923	5, 8, 9	1,383	829	554	66.8
1924	5, 8, 9	817	387	430	111.1
1925	5, 8, 9	1,671	1,219	452	37.1
1926	6, 8, 9	1,727	1,086	641	59.0
1927	5, 6, 9	1,238	447	791	177.0
1928	14, 18, 19	857	405	452	111.6
Average	5, 6, 9	1,397	883	514	58.2

INFLUENCE OF FERTILIZERS ON TIME OF OPENING OF COTTON

In Figure 4, F, the average percentages for 10 years of total yield of cotton open at the first picking are given. The data for each year and dates of first picking are given in Table 1. The mixtures containing the higher percentages of phosphoric acid, 9, 12, and 15, favor early maturing and opening, whereas mixtures containing the higher percentages of nitrogen have tended to delay maturing and opening. The higher percentages of potash have slightly delayed maturing and opening but not sufficiently to be an appreciable factor in this consideration.

When the data are analyzed from the point of view of the increasing percentages of nitrogen, phosphoric acid, or potash, it is seen that the mixtures containing no phosphate (the group shown in the bottom row, line 16 to 21, fig. 4, F) have matured less cotton early and that early maturing increases with each group or line of mixtures as the phosphate increases. Considering the data with regard to the effect of nitrogen, the no-nitrogen mixtures (group along line between 1 and 16) have produced only slightly higher percentages of cotton earlier than fertilizers containing 3 per cent ammonia (group along line between 3 and 17). The slight differences are in the range of experimental error. There is an appreciable difference in these experiments between the percentage of the total yield of cotton which matured early from 3 per cent ammonia mixtures (group along line between 3 and 17) and 6 per cent ammonia mixtures (group along line between 6 and 18); however, the total yield from the 6 per cent ammonia fertilizers is greater. The application

of fertilizers containing more than 6 per cent of ammonia has resulted in an appreciably lower percentage of cotton opening early. There is little or no correlation between the percentage of potash in the fertilizer and the time of opening of the cotton. The data are in harmony with results secured in other experiments on these and related soil types (*4, 6, 9*).

CORN ON NORFOLK FINE SANDY LOAM

The results of the fertilizer-ratio experiment with corn grown in rotation with cotton for nine years are given in Table 4. There was a marked increase in corn yields from some of the fertilizer mixtures containing high proportions of nitrogen in each year of the experiment. These results are best visualized in the triangle diagram. (Fig. 5.) These are the average yields of corn for the nine years of the experiment. The average of the seven no-fertilizer plots is 29.5 bushels per acre. The high-nitrogen mixtures, Nos. 10, 14, 15, 19, 20, and 21, have given highest yields. The mixtures containing no nitrogen, that is, those in the group along line 1 to 16, gave about the same yield as no fertilizers. There is an increase with the increase of nitrogen up to 9 per cent in the fertilizer; for instance, the mixtures in the group along line 3 to 17, containing 3 per cent ammonia, gave greater yields than those in the group along line 1 to 16, containing no nitrogen, and those in the group along line 6 to 18, containing 6 per cent ammonia, gave greater returns than the 3 per cent ammonia mixtures. Nitrogen is thus shown to be the important fertilizer element for corn on this soil.

TABLE 4.—*Yield of corn per acre in fertilizer-ratio experiments on Norfolk fine sandy loam, 1919–1927*

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	1919	1920	1921	1922	1923	1924	1925	1926	1927	Average
		Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
1	0-15-0	26.9	25.0	40.0	24.0	33.1	33.3	33.3	34.6	38.8	32.1
2	0-12-3	23.6	23.6	38.2	25.2	31.5	34.2	25.3	33.2	29.1	29.7
3	3-12-0	26.4	23.6	50.7	27.6	32.8	36.6	30.8	33.2	37.5	33.2
X	(1)	16.7	22.2	42.1	20.0	29.7	28.8	26.4	27.7	29.1	27.0
4	0-9-6	26.6	23.6	36.5	25.3	29.1	31.3	27.8	26.3	27.7	28.2
5	3-9-3	29.1	25.0	42.3	29.1	34.2	20.6	30.3	33.1	40.2	32.5
6	6-9-0	29.1	44.4	51.0	32.7	35.1	36.8	37.5	46.9	46.8	39.9
X	(1)	16.7	19.4	45.3	23.2	31.7	27.1	26.4	31.3	34.7	28.4
7	0-6-9	19.4	25.0	42.4	21.0	31.5	28.3	29.4	22.2	36.1	28.7
8	3-6-6	24.9	23.6	38.1	26.4	37.1	34.3	30.6	32.2	43.0	32.2
9	6-6-3	23.6	38.8	48.3	38.2	35.1	33.3	36.1	42.7	50.0	39.1
X	(1)	19.4	23.6	40.1	26.7	39.1	36.2	31.9	30.6	41.6	31.5
10	9-6-0	31.8	34.7	56.3	43.0	39.4	45.4	40.3	47.0	55.5	43.7
11	6-3-12	30.5	27.7	35.3	28.0	38.2	36.2	24.4	28.0	36.1	31.6
12	3-3-9	31.8	20.1	42.7	32.3	32.5	36.0	26.4	31.0	40.2	33.6
X	(1)	24.9	26.8	35.1	26.1	29.4	31.9	22.2	31.1	34.7	29.1
13	6-3-6	33.2	44.0	48.0	36.4	27.1	38.0	23.6	42.1	43.0	37.2
14	9-3-3	46.8	41.6	49.2	46.2	34.8	40.5	30.6	51.2	52.7	43.7
15	12-3-0	41.6	56.9	62.3	47.0	40.0	37.4	36.9	49.8	54.1	47.3
X	(1)	13.8	19.4	40.0	39.0	31.5	29.1	15.2	40.1	29.1	28.9
16	6-0-15	15.2	23.6	32.7	30.0	31.1	31.3	11.7	27.7	25.0	25.4
17	3-0-12	23.3	26.4	42.1	33.3	29.7	30.3	14.7	37.1	34.7	30.2
18	6-0-9	27.7	36.1	45.3	38.3	34.2	29.1	22.2	42.6	41.6	35.2
X	(1)	16.7	27.7	36.1	28.1	31.4	28.3	23.6	38.2	34.7	30.0
19	9-6-6	31.1	48.6	58.0	38.6	39.1	29.9	31.9	51.2	55.5	42.7
20	12-6-3	38.8	58.3	53.2	36.2	42.8	27.4	36.1	53.5	61.1	45.3
21	15-6-0	40.2	63.9	56.0	39.1	41.4	28.3	38.9	53.0	56.9	45.4
X	(1)	17.7	33.3	45.1	27.2	32.5	25.8	26.4	42.9	38.8	32.2
	Average of checks	18.0	24.6	41.0	27.2	32.6	28.7	24.6	34.6	34.7	29.5

[1] Check.

COTTON ON NORFOLK SANDY LOAM

A 3-year experiment was made on Norfolk sandy loam, a soil closely related in physical characteristics to Norfolk fine sandy loam, on which the results discussed in the preceding pages were obtained. These experiments were made on farms in Darlington County, S. C., on new plots each year in fields in which corn was grown the preceding year. The results are valuable in connection with those secured at the Pee Dee Experiment Station. A soil map and plot of the 1922 experiment are shown in Figure 6. Norfolk sandy loam differs from Norfolk fine sandy loam in that it is of a lighter texture, is more sandy, and leaches more readily. The plan of the experiments and rate of fertilizer application are the same as in the former experiments.

Detailed data are given in Table 5 and in Figure 7, A, B, C, and D.

The plots, on the Dargan farm, with varying amounts of nitrogen, are shown in Figures 8 and 9. In 1922, in the experiment on the Dar-

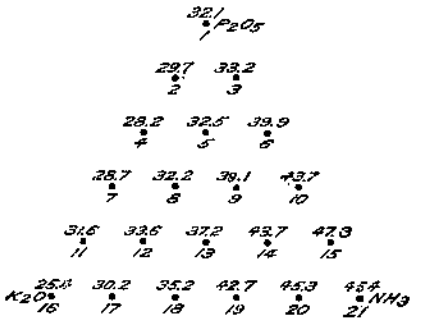

FIGURE 5.—Average acre yield in bushels of corn on Norfolk fine sandy loam at the Pee Dee Experiment Station from the 21 fertilizers used in the experiment, 1919–1927. The composition of the fertilizer mixtures 1 to 21 is given in Table 4 and in Figure 2

gan farm, the three fertilizer mixtures which produced the highest yields were Nos. 6, 10, and 14, of the following respective compositions, 6–9–3, 9–6–0, and 9–3–3, and an average composition of 8–6–1, recorded in Figure 7, A. The average composition of the three fertilizers which produced the highest yield in the first year of the Gillespie-farm experiment is 7–7–1 (fig. 7, B), and in the second year, 7–6–2. (Fig. 7, C.) Averaging the three years' results, the three mixtures which produced the highest yields are Nos. 6, 9, and 10, as shown in Figure 7, D. These three fertilizers have an average analysis of 7 per cent ammonia, 7 per cent phosphoric acid, and 1 per cent potash, which seemed to represent the fertilizer analyses giving best results. The average composition of the three mixtures which produced the highest yields in each year is very nearly the same, and the deduction seems significant. Cotton yields from $\frac{1}{10}$-acre plots fertilized with various mixtures of nitrogen, phosphate, and potash are shown in Figure 10.

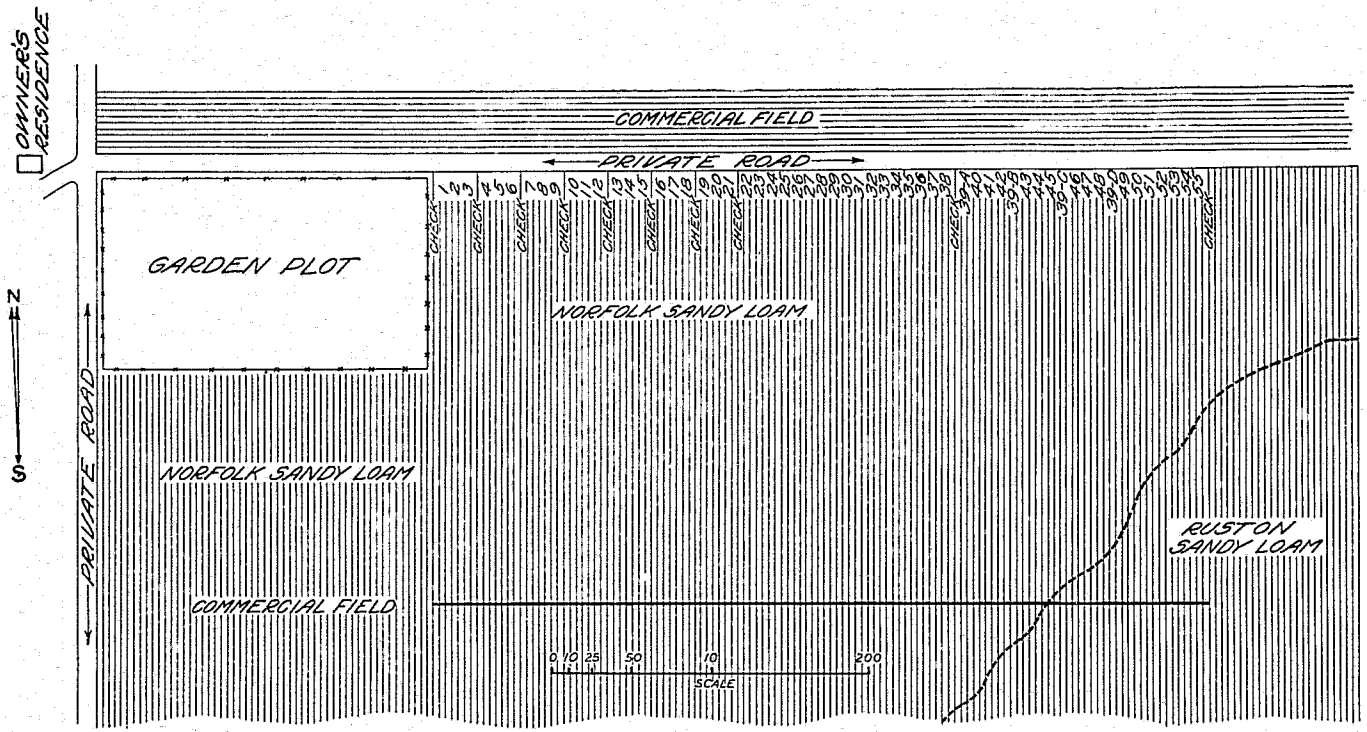

FIGURE 6.—Soil map, showing soil type and arrangement of plots in fertilizer experiment on Norfolk sandy loam in 1922

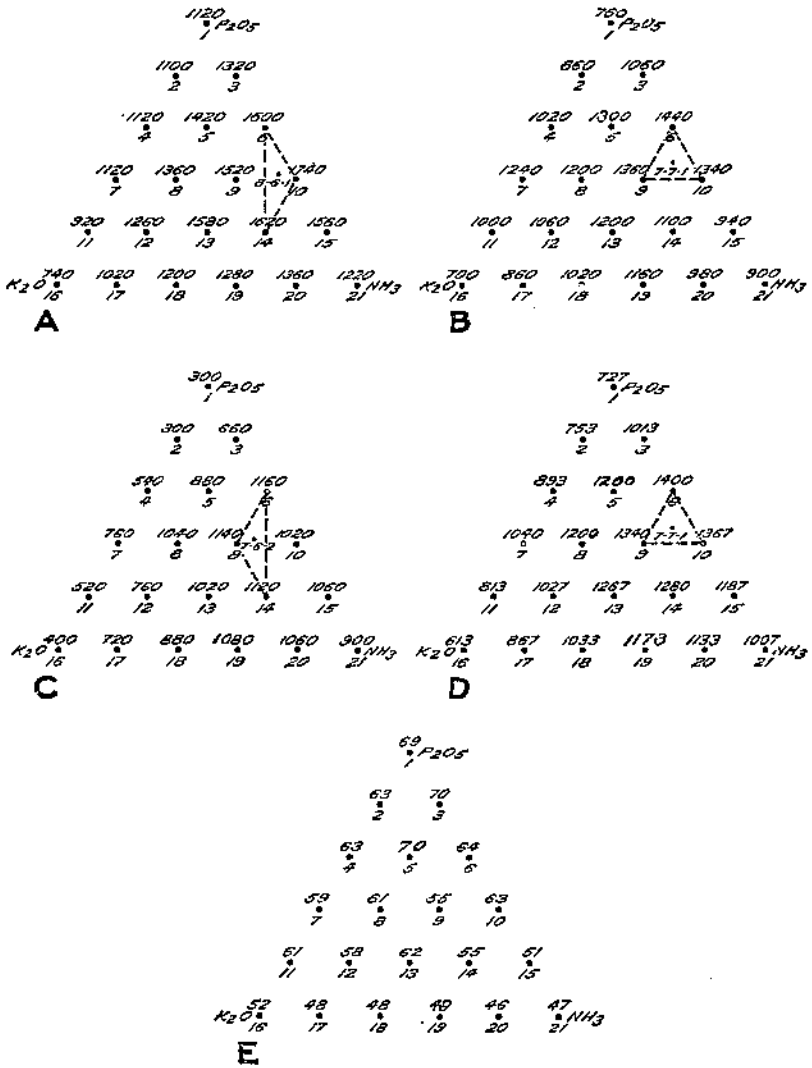

FIGURE 7.—A to D, yields of cotton in pounds per acre on Norfolk sandy loam, Darlington, S. C., from the 21 fertilizers used in the experiment. The three fertilizers which produced the largest crops in each year are connected by a heavy black line, and the average composition in ammonia, phosphoric acid, and potash of each of the three mixtures is recorded in the triangle: A, Yield in 1922, on Dargan farm; B, in 1923, on Gillespie farm; C, in 1924, on Gillespie farm; D, average yield for three years, 1922–1924; E, average percentage of total yield of cotton open at first picking for three years, 1922–1924

FIGURE 8.—Cotton on Norfolk sandy loam: No. 11, on left, received fertilizer containing phosphate and potash but no nitrogen and yielded 920 pounds per acre; No. 12, on right received fertilizer containing phosphate, potash, and nitrogen (3 per cent ammonia) and yielded 1,260 pounds per acre

FIGURE 9.—Cotton on Norfolk sandy loam: No. 12, on left, received fertilizer containing phosphate, potash, and nitrogen (3 per cent ammonia) and yielded 1,260 pounds seed cotton per acre; check, buffer row in middle, received no fertilizer; No. 13, on right, received fertilizer containing phosphate, potash, and nitrogen (6 per cent ammonia) and yielded 1,580 pounds seed cotton per acre

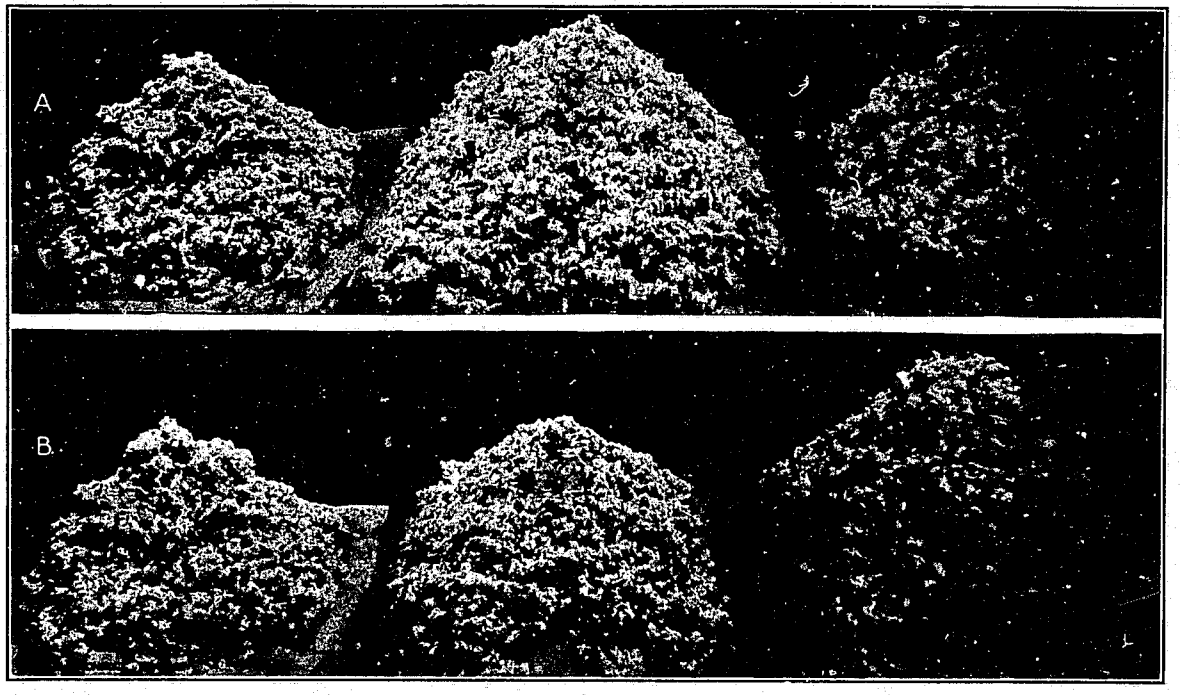

FIGURE 10.—Yield of cotton from $\frac{1}{10}$-acre plots on Norfolk sandy loam in Darlington County, S. C.

A—Check (no fertilizer), yield 32 pounds, equivalent to 640 pounds per acre; 10, fertilizer containing nitrogen (9 per cent ammonia), 6 per cent phosphoric acid, no potash, yield, 87 pounds, equivalent to 1,740 pounds per acre; 11, fertilizer containing no nitrogen, 3 per cent phosphoric acid, 12 per cent potash, yield, 46 pounds, equivalent to 920 pounds per acre.

B—Check (no fertilizer), yield, 32 pounds, equivalent to 640 pounds per acre; 5, fertilizer containing nitrogen (3 per cent ammonia), 9 per cent phosphoric acid, 3 per cent potash, yield, 71 pounds, equivalent to 1,420 pounds per acre; 14, fertilizer containing nitrogen (9 per cent ammonia), 3 per cent phosphoric acid, 3 per cent potash, yield, 81 pounds, equivalent to 1,620 pounds per acre.

TABLE 5.—*Yield of seed cotton per acre in fertilizer-ratio experiment on Norfolk sandy loam, Darlington County, S. C., 1922–1924*

[Pounds per acre seed cotton]

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	Dargan farm, 1922			Gillespie farm, 1923		
		Yield, first picking Sept. 7	Total yield	Cotton open Sept. 7	Yield, first picking Sept. 18	Total yield	Cotton open Sept. 18
		Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
1	0-15-0	800	1,120	71	560	760	74
2	0-12-3	740	1,100	67	620	860	72
3	3-12-0	880	1,320	66	760	1,060	74
	(1)	600	900	67	640	820	78
4	0-9-6	760	1,120	68	760	1,020	69
5	3-9-3	1,020	1,420	72	1,080	1,360	79
6	6-9-0	1,000	1,600	66	1,040	1,440	72
	(1)	560	940	59	600	880	68
7	0-6-9	680	1,120	61	840	1,240	68
8	3-6-6	840	1,360	62	780	1,200	65
9	6-6-3	960	1,520	63	660	1,300	50
	(1)	640	960	67	600	880	68
10	9-6-6	1,100	1,740	63	800	1,340	60
11	0-3-12	600	920	65	620	1,000	62
12	3-3-9	700	1,260	60	700	1,060	66
	(1)	600	820	73	480	720	67
13	6-3-6	980	1,580	62	740	1,200	62
14	9-3-3	1,000	1,620	62	520	1,100	47
15	12-3-0	920	1,560	59	300	940	32
	(1)	600	840	72	480	720	67
16	0-0-15	120	740	57	340	700	49
17	3-0-12	600	1,020	59	440	860	51
18	6-0-9	640	1,200	53	520	1,020	51
	(1)	520	760	69	600	740	81
19	9-0-6	740	1,280	58	480	1,160	41
20	12-0-3	760	1,360	56	380	980	39
21	15-0-0	700	1,220	57	400	900	44
	(1)	480	640	74	640	860	74
	Average unfertilized	571	837	69	577	803	72

Fertilizer No.	Fertilizer ratio (NH_3-P_2O_5-K_2O)	Gillespie farm, 1924			Average		
		Yield, first picking Sept. 19	Total yield	Cotton open Sept. 19	Yield, first picking	Total yield	Cotton open first picking
		Pounds	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*
1	0-15-0	140	300	47	500	727	69
2	0-12-3	60	300	20	473	753	63
3	3-12-0	460	660	70	707	1,013	70
	(1)	240	320	75	493	680	73
4	0-9-6	240	540	44	567	893	63
5	3-9-3	460	880	52	837	1,200	70
6	6-9-0	580	1,160	50	893	1,400	64
	(1)	280	380	74	480	733	65
7	0-6-9	320	760	42	613	1,040	59
8	3-6-6	580	1,040	56	733	1,200	61
9	6-6-3	600	1,140	52	740	1,340	55
	(1)	240	300	80	493	713	69
10	9-6-6	700	1,020	69	867	1,367	63
11	0-3-12	260	520	50	493	813	61
12	3-3-9	340	760	45	600	1,027	58
	(1)	160	240	67	413	593	70
13	6-3-6	640	1,020	63	787	1,267	62
14	9-3-3	600	1,120	54	707	1,289	55
15	12-3-0	600	1,060	57	607	1,187	51
	(1)	160	260	62	413	607	68
16	0-0-15	200	400	50	320	613	52
17	3-0-12	240	720	29	417	867	48
18	6-0-9	320	880	36	493	1,033	48
	(1)	200	300	67	440	600	73
19	9-0-6	460	1,080	43	560	1,173	49
20	12-0-3	420	1,060	40	520	1,133	46
21	15-0-0	320	900	36	473	1,007	47
	(1)	160	280	57	427	593	72
	Average unfertilized	206	297	69	451	645	70

(1) Unfertilized.

The computation of the data presented in Table 6, where an average is made of the fertilizers according to their nitrogen, phosphoric acid, and potash content, confirms in a general way the fertilizer analyses discussed above. The 6 per cent and 9 per cent ammonia mixtures have given the largest average yields in the nitrogen group, and the 6 per cent and 9 per cent phosphoric acid the largest yields in the varying phosphate group. The 3 per cent potash mixture gave the largest average yield in the potash group; it is followed closely by the 6 per cent potash mixtures. The yield from these two groups, however, does not greatly exceed the average yield from the no-potash mixtures.

TABLE 6.—*Yields of cotton from fertilizers containing different proportions of ammonia, phosphoric acid, and potash on Norfolk sandy loam*

Fertilizer mixtures in Figure 7, D, and Table 5	Percentage of ammonia in fertilizer mixture	Ten-year average yield of cotton per acre	Fertilizer mixtures in Figure 7, D, and Table 5	Percentage of phosphoric acid in fertilizer mixture	Ten-year average yield of cotton per acre	Fertilizer mixtures in Figure 7, D, and Table 5	Percentage of potash in fertilizer mixture	Ten-year average yield of cotton per acre
No.	*Per cent*	*Pounds*	*No.*	*Per cent*	*Pounds*	*No.*	*Per cent*	*Pounds*
1, 2, 4, 7, 11, 16	0	895	16, 17, 18, 19, 20, 21	0	971	1, 3, 6, 10, 15, 21	0	1,117
3, 5, 8, 12, 17	3	1,061	11, 12, 13, 14, 15	3	1,115	2, 5, 9, 14, 20	3	1,141
6, 9, 13, 18	6	1,269	7, 8, 9, 10	6	1,237	4, 8, 13, 19	6	1,133
10, 14, 19	9	1,273	4, 5, 6	9	1,165	7, 12, 18	9	1,033
15, 20	12	1,160	2, 3	12	883	11, 17	12	840
21	15	1,097	1	15	727	16	15	613

The soil on which the experiments were made has not responded markedly to potash. A mixture containing approximately 6 per cent ammonia, 6 to 8 per cent phosphoric acid, and a relatively low proportion of potash would be selected on the basis of the analysis of the data. This is very similar to the 7–7–1 ratio deduced from the data first considered. Considering the data as a whole, a mixture containing 6 to 7 per cent ammonia, 6 to 8 per cent phosphoric acid, and 1 to 3 per cent potash might be chosen.

INCREASED YIELD FROM FERTILIZERS

The increased yield from fertilizers was great each year. In 1922, the average yield from the checks, or no-fertilizer plots, was 837 pounds per acre and that from the three mixtures producing highest yields (Nos. 6, 10, and 14) was 1,653, an increase of 816 pounds or 97.5 per cent. In 1923, the average of the checks was 803 pounds per acre and of the three mixtures producing highest yields (Nos. 6, 9, and 10), 1,380 pounds, an increase of 577 pounds or 71.8 per cent. In 1924, the checks averaged 297 pounds and the three mixtures producing highest yields (Nos. 6, 9, and 14) 1,140 pounds, an increase of 843 pounds or 283.8 per cent. For three years, the checks gave an average yield of 451 pounds and the three mixtures producing highest yields (Nos. 6, 9, and 10) an average of 1,369 pounds, an increase of 918 pounds or 203.5 per cent.

INFLUENCE OF FERTILIZER ON THE TIME OF OPENING OF THE COTTON

The percentage of cotton open at the first picking in the experiment on Norfolk sandy loam, as an average for three years, is given in Figure 7, E. The data for each year and dates of picking are given in Table 5. Mixtures containing higher percentages of phosphoric acid have caused early maturing and opening of cotton. Fertilizer mixtures containing no phosphate matured cotton late. There is no close correlation between the amount of nitrogen or potash in the fertilizer and the time of maturing and opening of cotton.

DISCUSSION

For a number of years experiments have been made in the Southern States to ascertain the fertilizer requirements of the various soils for cotton. The work was planned primarily to determine the fertilizer element having most influence on production. In recent experiments with cotton attention has been given to a study of the ratio of the three constituents, nitrogen, phosphate, and potash, in fertilizers. The fertilizer investigations of this bureau with cotton were planned to study not only the suitability of fertilizer materials and quantities of fertilizers needed but also to ascertain the best ratio of nitrogen, phosphoric acid, and potash for specific soil types. Results have been reported of experiments on Portsmouth sandy loam, Dunbar fine sandy loam, Ruston sandy loam, Wickham fine sandy loam, and Georgeville silt loam in North Carolina (*9*, *14*) and Cecil sandy clay loam in Georgia (*5*).

The data given in this bulletin contribute to the knowledge of the proper fertilization of Norfolk fine sandy loam and the related type, Norfolk sandy loam, two soils occurring generally in the coastal plains. These soils are utilized for cotton production possibly more than any other soil types.

The proportion of nitrogen, phosphoric acid, and potash giving the best results in the fertilizer mixture as determined by the triangle system of fertilizer experimentation on these soils does not differ widely from that indicated by data secured from other field experimental schemes. For best results with cotton on Norfolk fine sandy loam, the work indicates a fertilizer containing 3 to 6 per cent ammonia, 6 to 9 per cent phosphoric acid, and 3 per cent potash, and for Norfolk sandy loam a mixture containing 6 to 9 per cent ammonia, 6 to 9 per cent phosphoric acid, and 0 to 3 per cent potash. Preference is for a 5–8–2 grade for the former soil and a 7–7–1 for the latter.

Experiments conducted by the South Carolina Agricultural Experiment Station near Allendale, in Allendale County, on Norfolk sandy loam (*7*) for the three years 1920 to 1923 gave a response from nitrogen and phosphate, but little or none from potash. In this experiment, first the phosphoric acid and potash content of the fertilizer was constant, but that of ammonia varied from 2 to 8 per cent in the mixture; next the nitrogen and potash were constant and the phosphoric acid varied from 2 to 10 per cent; and next the nitrogen and phosphoric acid were constant and the potash varied from 2 to 6 per cent. Fertilizer mixtures containing 6 per cent and 8 per cent ammonia gave the largest yields, those from the 8 per cent

ammonia being slightly larger. There was an increase in yield with additions of phosphoric acid up to 6 per cent. Mixtures containing no potash gave as large yields as did those containing 2 and 4 per cent potash. The fertilizer analysis which appears, from these experiments, to give best results is 6 to 8 per cent ammonia, 6 per cent phosphoric acid, and no potash.

In similar experiments in North Carolina made by the North Carolina Agricultural Experiment Station (*16*), a mixture containing 7 per cent ammonia, 8 per cent phosphoric acid, and 3 per cent potash gave best results on Norfolk sandy loam and one containing 5 per cent ammonia, 6 per cent phosphoric acid, and 3 per cent potash on Norfolk fine sandy loam.

The agronomic research committee of the Southeastern States (*2*), which is made up of the agronomists of the experiment stations of the Southern States east of the Mississippi, a representative of the Bureau of Chemistry and Soils of the United States Department of Agriculture, and a representative of the soil-improvement committee of the National Fertilizer Association, after considering the data secured in fertilizer experiments with cotton conducted by the Department of Agriculture and the State experiment stations recommend for the coastal-plain section of North Carolina and South Carolina, for the lighter types of soils which include those of the Norfolk series, a mixture analyzing 4 to 5 per cent ammonia, 8 per cent phosphoric acid, and 3 to 4 per cent potash. A 5–8–3 and a 4–8–4 analysis are suggested. Fertilizer recommendations by this committee vary according to soil conditions. For use on lighter and sandier phases of the soils, in addition to a 5–8–3 or a 4–8–4 analysis from 18 to 30 pounds of nitrogen per acre from readily available material to be applied as a side application at the first cultivation of the cotton after chopping is recommended. For the heavier types of soils, which include the very fine sandy loams, especially when occurring in the extreme northern section of the Cotton Belt, where early maturity is an essential factor, a mixture containing 5 per cent ammonia, 10 to 12 per cent phosphoric acid, and 3 per cent potash is recommended.

SUMMARY

Results are given of a 10-year fertilizer experiment with cotton and corn grown in rotation on Norfolk fine sandy loam, Florence County, S. C., at the Pee Dee Experiment Station of Clemson College, and of a 3-year fertilizer experiment with cotton on Norfolk sandy loam in Darlington County, S. C.

The plan of the experiments is based on the triangle diagram. The three fertilizer constituents, nitrogen (ammonia), phosphoric acid, and potash, were used singly, in combinations of two, and in combinations of three, the ratios varying in definite proportions. The applications of a 15 per cent plant-food fertilizer were made to cotton at the rate of 900 pounds per acre and to corn at the rate of 450 pounds per acre. One-twentieth-acre plots were used, with unfertilized checks occurring after every third fertilized plot. The data are given in triangle figures, the dots in the triangle representing the fertilizer ratios used. The position of the dot indicates the composition of the fertilizer.

On Norfolk fine sandy loam at the Pee Dee Experiment Station, the largest cotton yields were obtained with fertilizer mixtures containing 3 to 6 per cent ammonia, the 6 per cent mixture giving slightly larger yields. The 9 per cent phosphoric acid mixtures produced the largest yields, and the 3 per cent potash gave the best results. It is concluded from the data as a whole that the fertilizer ratio or analysis giving best results is a mixture containing 3 to 6 per cent ammonia, 6 to 9 per cent phosphoric acid, and 0 to 3 per cent potash. The average results indicate a 5–8–2 analysis as being best for cotton on this soil. This fertilizer ratio does not vary widely from results secured under other experimental plans on similar soil types. The three fertilizer mixtures producing highest yields in each of the 10 years of the experiment gave an average increase in yield ranging from 38.4 per cent to 178.4 per cent over the average in the no-fertilizer plots.

Fertilizer mixtures containing higher percentages of phosphoric acid produced early maturing and early opening of cotton. Fertilizers containing 9 per cent or more of phosphoric acid matured cotton earlier than mixtures containing less of this constituent. Mixtures containing the higher percentages of nitrogen used in the experiments delayed maturing and opening. This was true when the fertilizer contained as much as 9 per cent ammonia. Potash did not have an appreciable effect on the time of maturing and opening of the cotton, though the higher percentages delayed opening slightly.

The effects of the various fertilizer mixtures on corn on Norfolk fine sandy loam were variable. The high nitrogen fertilizer mixtures gave the largest yields.

On Norfolk sandy loam the largest cotton yields were secured with fertilizer mixtures containing 6 to 9 per cent ammonia, 6 to 9 per cent phosphoric acid, and 0 to 3 per cent potash. The three fertilizers giving best average yields for three years had an average composition of 7 per cent ammonia, 7 per cent phosphoric acid, and 1 per cent potash. Phosphate had a decided effect in causing the cotton to mature and open early on this soil, and the mixtures containing high percentages of nitrogen caused late maturing and opening of the cotton. Considering the data as a whole, a mixture for this soil should contain 6 to 7 per cent ammonia, 6 to 8 per cent phosphoric acid, and 1 to 3 per cent potash. The three fertilizer mixtures producing highest yields gave an increase over no fertilizer of 97.5 per cent in 1922, 71.8 per cent in 1923, and 283.8 per cent in 1924.

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