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FERTILIZER TESTS WITH FLUE-CURED TOBACCO
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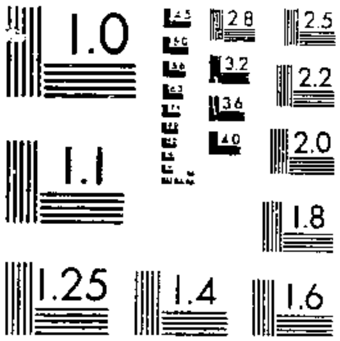
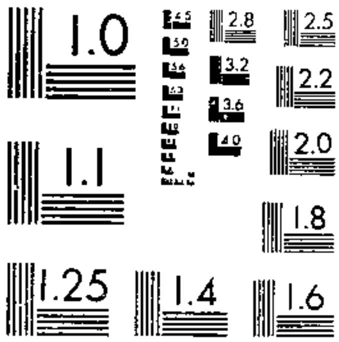


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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

TECHNICAL BULLETIN No. 12 — OCTOBER, 1927

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

FERTILIZER TESTS WITH FLUE-CURED TOBACCO

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The Tests Reported in this Bulletin were made by the United States Department of Agriculture in cooperation with the North Carolina Department of Agriculture, the Virginia and North Carolina Agricultural Experiment Stations, the Georgia State College of Agriculture, and the Georgia Coastal Plain Experiment Station

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INTRODUCTION

The land now used for growing bright or flue-cured tobacco in the United States covers an area of approximately three-quarters of a million acres and produces, in round numbers, a little more than half a billion pounds, or more than one-third of the total tobacco production of the country. There is considerable fluctuation in the total number of pounds produced from year to year, owing largely to the demands of the market or the prices of the preceding year, but also to a considerable extent to the seasonal conditions. During the last quarter of a century there has been a rapid increase in the demand for flue-cured tobacco in the manufacture of cigarettes and for export, and this has been largely responsible for stimulating the production of this particular type of tobacco.

The use of fertilizers in the growing of flue-cured tobacco has been a general practice among tobacco growers for many years. The proper use of the various fertilizing materials employed in the production of this type of tobacco has been and still is a much-discussed subject. Figures are not available as to the total fertilizer tonnage used for bright tobacco, but probably the quantity used for tobacco ranks close to the number of tons used for the cotton crop grown within the bright-tobacco territory. As this type of tobacco is usually grown on the rather weak light types of sandy soil in this section, a liberal quantity of the proper fertilizing materials must be applied in order to produce the desired quality; but an excess of fertilizer, especially one high in ammonia, should be avoided, as such fertilization often produces an undesirable grade of tobacco. In order, therefore, for the grower to obtain the largest returns from the tobacco crop, yield and quality must balance. In other words, too small a quantity of fertilizer gives low yields, but a heavy application may injure the quality.

Flue-cured tobacco is grown in the southern part of Virginia, in the north-central and eastern sections of North Carolina, in the eastern section of South Carolina, in southern Georgia, and in northern Florida. The territory of southern Virginia and north-central North Carolina, in the Piedmont section, is commonly known as the "old belt," whereas the area used in growing tobacco in the Coastal Plain section of the Carolinas and Georgia is known as the "new belt." The old belt covers that portion of the Piedmont section which includes the lower tier of counties of south-central Virginia and the two upper tiers of counties in the north-central portion of North Carolina. A large percentage of the total production for this section borders along the North Carolina-Virginia State line. The new belt includes practically all the section directly east of Warren, Franklin, and Wake Counties, N. C., extending almost to the coast in some places, and includes also the greater portion of that section south and southeast of Raleigh. Wilson, N. C., is near the center of production for this section and is the largest loose-leaf tobacco market in the country. Marion, Horry, Dillon, Darlington, Florence, Lee, Sumter, Clarendon, and Williamsburg are the principal tobacco-producing counties of South Carolina. In recent years tobacco growing has become of considerable importance in several counties of the southern part of Georgia and a few counties in northern Florida. The principal area of production in Georgia, however, centers around Coffee County.

In general, the differences between the tobaccos of the old belt and the new belt are mainly due to the differences in the types of soil upon which each is grown. The soils of the Piedmont section are residual in character, having been formed by the gradual disintegration of the underlying rock. Most of the soils in this section are clayey, but some are more or less sandy, and the sandy type, as a rule, produces the best type of bright tobacco. In the Coastal Plain section, or new belt, the soils are sedimentary or transported, having been brought down by the streams from the mountains or hill country to the west, and deposited in the sea, which at that time covered this entire area. A large percentage of the soils in this part of the tobacco belt belong to the more sandy types of soil of the Norfolk series and when naturally well drained are considered good soils for growing tobacco. It may be well to mention here that care should be taken to avoid the unusually deep types of sandy soil, as they do not retain the soluble plant-food materials, especially during seasons of heavy rainfall. Tobacco soils of either the Piedmont or Coastal Plain sections should have a rather sandy or sandy-loam somewhat incoherent topsoil to a depth of 6 to 10 inches underlain by a sandy, sand-clay, or clay subsoil. Such soils, of course, are usually more or less deficient in plant-food supply, especially nitrogen, and naturally they contain little organic matter.

Prior to the Civil War it was a common practice among tobacco farmers, especially those of the old belt, to clear new lands every year or so, in preparation for the tobacco crop. In that period the newly cleared lands generally produced a grade of tobacco which commanded a relatively high market value, and the same holds true even at the present time. As this practice of clearing new lands continued from year to year, the forest or wooded areas in time became limited, so that during the last half century tobacco growers have been forced to return to the older cultivated areas. The older fields were more or less deficient in plant nutrients and organic matter, so it became necessary to supply these artificially in the form of commercial fertilizers and manure. The importance of the plant-food elements furnished by commercial fertilizers will be considered more fully in the later pages of this bulletin.

EXPERIMENTAL DATA [1]

LOCATION OF TESTS AND TYPES OF SOIL USED

During the last few years experimental work has been in progress at several widely separated stations to determine the effects of the various forms and rates of application of fertilizers on the yield and quality of tobacco. This work has been conducted by the Bureau of Plant Industry in cooperation with the North Carolina Department of Agriculture, the Virginia and North Carolina Agricultural Experiment Stations, the Georgia State College of Agriculture, and the Georgia Coastal Plain Experiment Station. The experiments have been conducted at three points within the Piedmont region and at a like number in the Coastal Plain territory.

The locations are as follows: 3 miles north of Chatham, Pittsylvania County, Va.; 1 mile southwest of Oxford, Granville County, N. C.; 4 miles south of Reidsville, Rockingham County, N. C.; 1 mile west of Timmonsville, Florence County, S. C.; 2 miles southwest of Manning, Clarendon County, S. C.; 2 miles northwest of Tifton, Tift County, Ga.

The soils of the different counties in which the fertilizer tests have been conducted in the flue-cured district have been classified by the Bureau of Soils, and a brief description of the soil type used at each location is given herewith.

The soils on which the experimental plots are located near Chatham, Va., belong to the gravelly fine sandy loam or "gray lands" of the Cecil series. When dry the surface soils vary from a gray to yellowish gray, but when wet the color is somewhat brown or reddish brown. The topsoil is a fine sandy loam with an abundance of small

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[1] Credit is due the following-named individuals for portions of these data, as indicated: R. P. Cocke, of the Virginia Agricultural Experiment Station, for results at Chatham, Va., for 1910–1912; J. C. Hart, formerly of this office and the Virginia Agricultural Experiment Station, for results at Chatham for 1913 and 1914 and at Tifton, Ga., for 1922-1925; E. H. Mathewson, formerly of this office, for results at Reidsville, N. C., for 1912–1921; Zack J. McKinney, formerly of this office, for results at Reidsville for 1922 and 1923; R. C. Thomas, of this office, for a portion of the results at Tifton for 1925 and 1926; J. P. Young, of this office, for results at Timmonsville and Manning, S. C.

quartz gravel to a depth of 8 to 10 inches, and is underlain by a rather stiff or brittle red-clay subsoil for a depth of 3 or more feet. This is not generally considered the best type of soil in this section for growing tobacco, but it represents the character of soil on which most of the tobacco is grown in this part of the State and covers about 16 per cent of the total area of Pittsylvania County. Although the Cecil series are usually well supplied with potash, the total nitrogen is somewhat deficient.

TABLE 1.—*Chemical analysis of soil from unfertilized plot, Durham coarse sandy loam, North Carolina Tobacco Branch Station, Oxford, N. C.*

[Sample No. 2589, plot No. 9, surface soil to a depth of 6¾ inches, weighing 2,000,000 pounds per acre. Analysis by North Carolina Agricultural Experiment Station]

Plant-food constituents	Percentage of constituents	Quantity of constituents per acre (pounds)
Nitrogen (N)	0.030	600
Phosphoric acid (P_2O_5)	.052	1,040
Potash (K_2O)	.276	5,520
Lime (CaO)	.128	2,560

Although of residual origin, the soils of the tobacco experiment station near Oxford, N. C., are sandy in character and contain little organic matter. The soil is derived mainly from granite composed chiefly of quartz and feldspar. All of the fertilizer tests in the general series (Table 10) and the potash-magnesia plots (Table 12) are located on the Durham coarse sandy loam. The open, porous, quartzlike topsoil consists of a gray to yellowish gray and sometimes whitish coarse sandy loam to a depth of 8 to 15 inches, and is underlain by a yellow to pale-yellow heavy, coarse sandy-loam subsoil which grades rather abruptly into a coarse sandy clay, becoming somewhat mottled in places. About 13 per cent of the soil area of the county belongs to this particular type. Table 1 shows the chemical analysis of the surface soil from an unfertilized area in proximity to the general fertilizer and the potash-magnesia test plots. The hydrogen-ion concentration of the soil from the fertilizer-test plots in the general series is shown in Table 2. The unfertilized plots on each field were sampled and a composite sample made for each field. The samples from the ends of the plots to which dolomite had been added were kept separate from the ends receiving no dolomite. These samples were taken and determinations made electrometrically in the spring of 1926.

TABLE 2.—*Hydrogen-ion concentration of soil from unfertilized plots with and without addition of dolomite, Durham coarse sandy loam, North Carolina Tobacco Branch Station, Oxford, N. C.*

[Sampled and analyzed by L. G. Willis, soil chemist, North Carolina Agricultural Experiment Station]

Field No.	No dolomite	Dolomite
1	5.98	7.38
2	5.76	7.38
3	5.66	7.24

The special potash tests (Table 11) are located on the Durham sandy loam, and are situated on a different part of the farm from that occupied by the general fertilizer and the potash-magnesia plots. The topsoil consists of a light to yellowish gray, rather porous, sandy loam to a depth of 8 to 10 inches and is underlain by a 4 or 5 inch stratum of rather heavy, light-colored soil, which passes into a heavy yellow sandy loam to sandy clay, which may be mottled in some areas. Durham sandy loam is derived almost entirely from granite rock and when naturally well drained is considered one of the best types of soil in Granville County for growing tobacco. The Durham sandy loam occupies a little more than 6 per cent of the total soil area of Granville County, but is probably the most widely distributed of the Durham series.

The soil near Reidsville, N. C., on which the various fertilizer tests (Tables 8 and 9) with tobacco were located for a number of years, is of about the same general character as the soil described above for the special potash tests at Oxford. During the earlier period, beginning in 1912, tests with fertilizer (Tables 6 and 7) were conducted on another field, the soil of which belongs to the Cecil series and is similar in character to the soil of the experimental field at Chatham.

The soil on which the tobacco experimental work has been conducted at Timmonsville, S. C., has been classed as Norfolk sandy loam. The topsoil varies from a medium to a rather coarse gray sand to loamy sand for a depth of 4 to 6 inches and is underlain by a pale yellowish loamy sand to sandy loam of about the same texture, which extends to a depth of 10 to 20 inches; then passes rather abruptly into a light and sometimes mottled sandy clay. Norfolk sandy loam is the predominating type of Florence County, and the Norfolk series represents most of the soils of this entire section.

The soil used in the tests in Clarendon County, S. C., is of the same general character as that on which the plots are located at Timmonsville, differing from the latter mainly in degree of fineness of both the surface and the subsoil. The soil of the experimental field near Manning is of a somewhat finer texture than the soil at Timmonsville and has been classified as Norfolk fine sandy loam. The field is practically level, but well drained, and varies from 15 to 20 feet above the normal water level of the near-by streams. About 9 per cent of the soils of Clarendon County belong to the Norfolk fine sandy-loam type.

The soil of the experimental fields at the Coastal Plain Experiment Station, Tifton, Ga., is fairly uniform in general character and is slightly rolling. It is a grayish, rather coarse, incoherent soil which easily absorbs water. On account of the topography of the land and the open character of the soil, there seems to be little necessity for artificial drainage. In a survey made of the fields occupied by the various tobacco-fertilizer tests the soil has been separated into two types, namely, a light-phase Tifton sandy loam and a heavy-phase Norfolk sandy loam. The Tifton sandy-loam type of soil covers more than half the area of Tift County, whereas the Norfolk sandy loam occupies only about 11 per cent of this area. The surface soil of the typical Tifton sandy loam is a gray, medium to coarse, sandy loam for a depth of 6 to 12 inches and carries considerable quantities of iron gravel or concretions. At a depth of 6 to 12 inches below the surface the subsoil consists of a yellow or orange-yellow and sometimes rather sticky sandy clay. A small quantity of iron concretions is often found in the subsoil. The Norfolk sandy loam at this location is a heavy phase of about the same characteristics as those described for the soil used at Timmonsville, S. C. The principal difference between the Tifton and the Norfolk sandy loams in this particular area is the presence of iron concretions in the former. The soil of the experimental fields as a whole is in reality of an intermediate type bordering between the more typical Tifton and Norfolk sandy loams, and there might well be differences of opinion as to the series to which the soil properly belongs. Too much importance, therefore, is not to be attached to distinctions made in the classification of different parts of the experimental field.

Tobacco-fertilizer tests have been conducted at Tifton from 1922 to 1926. Some of these tests were located on soil classed as Tifton sandy loam, while the soil on which others were located has been classed as Norfolk sandy loam. The percentage-composition tests begun in 1924 (Table 16) were located on the heavy-phase Norfolk sandy loam in 1924 and 1925. In 1926 these tests were shifted to another field, the soil of which has been classified as a light-phase Tifton sandy loam. In the years 1922 to 1924 the potash plots (Table 19) were located on the heavy-phase Norfolk sandy loam, but in 1925 and 1926 these tests were located on the light-phase Tifton sandy loam. From 1922 to 1926 plots 1 to 4 of the tests using ammonia from different sources (Table 18) were located on the heavy-phase Norfolk sandy loam, whereas plots 5 to 20 of the same series were located on the light-phase Tifton sandy loam. The fertilizer tests in combination with cropping tests (Table 15) were located on the light-phase Tifton sandy loam during the entire period. The percentage composition tests begun in 1922 (Table 17) were located on the heavy-phase Norfolk sandy loam throughout the period covered.

WEATHER CONDITIONS

There is usually sufficient rainfall over the bright-tobacco territory for ordinary crop requirements, but this does not always come at the right time to supply the growing plant with the necessary water. Some years are very dry, especially at the critical period of growth, while others may be unusually wet during that same period. Either extreme materially affects both the weight and the quality of the leaf. Weather that is too dry and then too wet, especially when the plant is nearing the ripening stage, often causes what is commonly known as second growth. Tobacco plants which have made this so-called second growth ripen very slowly and are usually hard to cure, even to a fair degree of quality. As a general rule, however, tobacco plants produce heavier yields during the seasons of rather limited rainfall, or during the so-called dry years. When the rainfall has been heavy or excessive during most of the growing period, the leaf is usually thin, light, and chaffy, and the yields are much lower than during the comparatively dry seasons. The ideal growing season is one in which the temperature remains relatively high and the rainfall is sufficient for the plant to make rapid and uninterrupted growth from the time of transplanting until it reaches maturity. As practically all of the tobacco soils of the flue-cured district receive an application of fertilizers just prior to transplanting or about that time, the amount of precipitation which follows during the spring and summer months is a very important factor. Heavy rains on the lighter types of soil, especially during the early part of the growing season, either wash away or leach out a considerable quantity of soluble plant-food elements, particularly the soluble nitrogen or nitrates and oftentimes some of the other soluble nutrients which have been supplied by the fertilizers, causing the plant to make a rather poor growth and show lack of green color. During the extremely dry years, on the other hand, there may be insufficient moisture to dissolve the plant foods supplied by the fertilizers, and this of course reduces both yield and quality.

The rainfall records in 10-day periods for the growing seasons and the monthly records for the fall and winter months at the different stations, or at points near by, are given in Table 3. The arrangement of the data by 10-day intervals serves to show approximately the distribution of rainfall through the growing season.

TABLE 3.—*Rainfall at Danville, Va., Reidsville and Henderson, N. C., Florence, S. C., and Tifton, Ga., for 10-day periods during the months March to September, inclusive, and the total monthly precipitation for January, February, October, November, and December for the years shown*

[Data in inches; T.=trace]

Month and 10-day period (dates inclusive)	Danville, Va.				
	1910	1911	1912	1913	1914
January total	3.38	3.15	2.06	3.13	2.16
February total	2.06	1.67	4.12	1.96	3.74
March:					
1 to 10	1.17	1.14	1.10	.14	.32
11 to 20	.37	.89	5.78	3.42	1.80
21 to 31	0	.78	2.84	1.57	.55
Total	1.54	2.81	9.72	5.13	2.67
April:					
1 to 10	.58	1.70	.86	0	.75
11 to 20	3.50	1.65	.76	3.08	1.55
21 to 30	.28	.32	2.16	T.	0
Total	4.36	3.67	3.78	3.08	2.30
May:					
1 to 10	.96	.37	.84	.22	1.18
11 to 20	.47	.20	2.29	.83	.93
21 to 31	.71	.41	.46	3.37	.82
Total	2.14	.98	3.59	4.42	2.93
June:					
1 to 10	1.01	.22	1.17	.77	.34
11 to 20	3.34	1.97	1.67	.88	0
21 to 30	.80	.08	4.79	2.55	1.54
Total	5.15	2.27	7.63	4.20	1.88
July:					
1 to 10	2.82	.76	.64	3.39	1.81
11 to 20	.65	2.18	1.48	2.54	1.70
21 to 31	.34	.20	.25	.25	.27
Total	3.81	3.14	2.37	6.18	3.78
August:					
1 to 10	.08	1.04	.45	2.33	.21
11 to 20	1.99	.38	.38	.20	.10
21 to 31	2.10	4.01	0	1.12	.56
Total	4.17	5.43	.83	3.65	.87
September:					
1 to 10	5.24	.24	1.81	3.65	0
11 to 20	0	.38	1.76	.14	.36
21 to 30	0	.56	3.28	1.16	.20
Total	5.24	1.18	6.85	4.95	.56
October total	3.36	4.94	1.00	3.76	2.45
November total	1.02	3.49	3.97	4.01	2.41
December total	3.04	3.48	1.64	3.27	6.27
Total for year	39.27	36.21	47.56	47.74	32.02

TABLE 3.—*Rainfall at Danville, Va., Reidsville and Henderson, N. C., Florence, S. C., and Tifton, Ga., etc.*—Continued

[Data in inches; T.=trace]

Month and 10-day period	Reidsville, N. C.											
	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923
January total	2.60	3.43	2.55	3.83	1.27	4.31	5.92	4.61	3.24	5.02	4.06	3.83
February total	4.01	2.27	4.33	3.00	4.72	2.09	.51	3.38	4.02	3.68	4.39	3.17
March:												
1 to 10	1.38	.57	.46	.92	.79	3.73	1.38	3.15	.71	.04	3.21	1.70
11 to 20	5.50	3.14	2.14	.47	.10	1.36	.39	.34	2.92	.46	1.56	3.77
21 to 31	2.91	1.86	.78	.32	.75	2.27	1.91	.54	.96	.90	.62	.41
Total	9.79	5.57	3.38	1.71	1.64	7.36	3.68	4.03	4.59	1.40	5.69	5.88
April:												
1 to 10	.95	.02	1.40	1.06	1.07	1.88	2.79	1.17	1.80	1.04	.73	1.23
11 to 20	.07	2.93	1.95	.47	0	.19	[illegible]	2.25	1.04	1.64	1.27	1.54
21 to 30	1.93	.05	.44	0	.29	.12	2.73	1.13	1.90	1.20	1.14	1.78
Total	3.85	3.00	3.79	1.53	2.36	2.19	6.78	4.55	4.74	3.88	3.14	4.55
May:												
1 to 10	.13	1.30	.77	1.32	.25	2.05	.84	2.97	.94	.76	1.09	1.23
11 to 20	2.82	.30	.73	1.29	.20	.01	1.83	1.67	.65	.82	3.35	.87
21 to 31	.07	4.18	.35	1.56	6.54	.94	1.04	1.79	.73	1.30	.09	.55
Total	3.02	5.78	1.85	4.17	6.99	3.00	3.71	6.43	2.32	2.88	4.53	2.65
June:												
1 to 10	1.62	.95	.12	2.99	2.22	2.10	.49	1.06	3.57	2.33	3.50	0
11 to 20	1.23	.88	.27	.32	2.24	.56	.57	.37	1.02	.34	8.65	.81
21 to 30	1.78	2.47	1.12	.06	2.22	.68	2.24	1.86	.51	.93	.42	.42
Total	4.63	4.30	1.51	3.37	6.68	3.34	3.30	3.29	5.10	3.60	12.57	1.23
July:												
1 to 10	1.33	3.13	2.48	.77	1.64	.76	.30	.27	1.01	.65	4.64	1.40
11 to 20	.37	1.29	.39	.53	1.51	2.74	1.31	4.98	2.12	.58	2.66	.63
21 to 31	.32	1.39	.25	.35	2.38	.67	1.02	1.27	.21	.63	0	3.04
Total	2.02	5.81	3.12	1.65	5.53	4.17	2.63	6.52	3.34	1.86	7.30	5.07
August:												
1 to 10	.58	3.31	.06	3.40	.09	.69	.09	.94	2.38	.15	.59	3.15
11 to 20	.42	1.18	.09	.44	2.06	.60	4.24	1.22	5.03	.62	1.56	.84
21 to 31	.56	2.18	1.06	7.30	2.23	1.98	.10	.10	.56	.04	1.06	2.17
Total	1.56	6.67	1.21	11.23	4.98	3.27	4.43	2.26	7.97	.81	3.21	6.16
September:												
1 to 10	.83	4.31	.56	.72	.31	3.19	1.74	.69	.29	.62	0	1.50
11 to 20	1.04	.92	.53	0	.66	.31	1.06	0	.40	1.39	.94	.22
21 to 30	2.96	.74	.52	.61	.72	1.39	1.50	.16	1.42	1.83	0	2.18
Total	4.83	5.97	1.61	1.33	1.69	4.89	4.30	.85	2.11	3 84	.94	3.90
October total	1.51	4.49	3.53	5.21	2.43	2.75	1.57	4.18	.57	1.74	3.48	1.15
November total	3.23	3.50	2.29	1.78	.99	1.06	2.10	1.65	6.07	3.07	.25	2.58
December total	1.37	3.04	7.23	3.40	2.94	2.49	4.46	1.55	5.75	1.22	3.70	2.81
Total for year	42.42	54.43	36.40	42.21	42.12	40.92	43.39	43.30	49.82	33.00	53.28	42.98

TABLE 3.—*Rainfall at Danville, Va., Reidsville and Henderson, N. C., Florence, S. C., and Tifton, Ga., etc.*—Continued

[Data in inches; T.=trace]

Month and 10-day period	Henderson, N. C.											
	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
January total	3.93	3.01	6.03	1.72	4.44	5.28	4.06	3.14	3.20	5.09	3.42	4.09
February total	2.06	5.28	3.53	3.79	2.29	.67	2.55	2.93	2.72	4.94	3.16	3.56
March:												
1 to 10	.76	.56	.44	1.43	3.32	1.68	1.58	.97	.37	5.53	1.52	.73
11 to 20	2.50	1.11	1.10	.05	1.36	.21	.17	1.09	.54	.86	4.84	.53
21 to 31	.49	.86	.10	.24	2.50	1.01	1.22	.56	1.62	.86	.24	2.34
Total	3.75	2.53	1.64	1.72	7.27	2.90	2.97	2.62	2.53	7.25	6.60	3.60
April:												
1 to 10	.34	.69	1.98	2.81	2.77	2.91	1.20	1.41	.49	.41	1.38	1.68
11 to 20	2.26	1.50	.68	T.	.25	3.34	2.83	.77	.34	1.27	1.64	1.76
21 to 30	.35	.11	0	.15	.15	2.36	.24	1.80	.40	.87	3.00	1.04
Total	2.95	2.30	2.66	2.96	3.17	8.61	4.27	3.98	1.23	2.55	6.02	4.48
May:												
1 to 10	.18	.45	2.19	.10	3.83	.16	1.80	.86	1.06	2.04	.08	1.92
11 to 20	.32	.41	.97	.53	.07	4.39	1.80	.77	1.84	3.12	.61	3.64
21 to 31	2.17	.81	2.82	1.63	.64	1.83	2.19	.65	.27	.72	.37	2.72
Total	2.67	1.67	5.98	2.26	4.54	6.38	5.79	2.28	3.17	5.88	1.06	8.28
June:												
1 to 10	.56	T.	1.14	1.54	2.93	.55	1.73	2.80	1.44	3.02	.05	1.47
11 to 20	1.36	.85	.39	3.85	.90	.53	.25	1.94	.57	3.43	2.35	3.14
21 to 30	1.94	1.07	.30	.71	.38	2.31	2.03	1.87	1.39	.46	.11	1.69
Total	3.86	1.92	1.83	6.10	4.21	3.39	4.01	6.61	3.40	6.91	2.51	6.30
July:												
1 to 10	.96	1.10	1.45	1.01	1.14	.19	1.83	1.15	1.48	1.84	1.04	3.41
11 to 20	.97	1.90	.82	.40	3.60	.29	8.03	2.62	.89	5.28	2.95	.59
21 to 31	.99	4.13	.76	4.77	4.80	1.76	3.72	.11	0	1.76	3.24	.72
Total	2.92	7.13	3.03	6.18	9.54	2.24	13.58	3.88	2.37	8.88	7.23	4.72
August:												
1 to 10	.93	1.91	1.65	1.19	.70	0	2.25	2.14	T.	.57	2.53	------
11 to 20	1.19	2.78	.66	2.65	1.12	2.60	1.15	2.70	.53	1.86	1.05	------
21 to 31	1.76	1.08	1.08	1.99	1.90	1.18	1.35	.11	.09	3.36	.91	------
Total	3.88	5.77	3.39	5.83	3.72	3.78	4.75	4.95	.62	5.79	4.49	------
September:												
1 to 10	4.61	.94	1.37	.35	1.89	1.60	0	.80	.08	.02	1.47	------
11 to 20	2.03	.75	.29	.54	1.35	1.62	0	0	1.21	.03	.51	------
21 to 30	.12	1.22	.71	.85	.60	.74	.59	2.45	1.52	0	2.07	------
Total	6.76	2.91	2.37	1.74	3.84	3.86	.59	3.25	2.81	.05	4.05	------
October total	6.73	2.37	2.53	2.18	2.73	1.40	2.58	1.26	1.42	7.01	1.27	------
November total	1.59	4.25	2.08	1.88	1.07	1.79	.44	7.05	2.70	.34	2.24	------
December total	4.04	4.41	3.60	2.74	2.26	4.59	2.19	5.50	2.62	3.80	2.04	------
Total for year	45.14	43.55	38.67	39.10	49.08	44.89	47.73	47.45	28.79	58.49	44.09	------

TABLE 3.—*Rainfall at Danville, Va., Reidsville and Henderson, N. C., Florence, S. C., and Tifton, Ga., etc.*—Continued

[Data in inches; T.=trace]

Month and 10-day period	Florence, S. C.						Tifton, Ga.				
	1914	1915	1916	1917	1918	1919	1922 [1]	1923	1924	1925	1926 [2]
January total	2.10	6.03	2.01	3.95	2.40	2.20	------	7.04	5.77	8.76	11.02
February total	3.73	3.20	3.03	2.64	1.49	2.94	------	1.97	4.43	2.37	4.66
March:											
1 to 10	.25	1.72	2.26	1.02	0	3.12	------	.91	3.73	0	1.91
11 to 20	.59	.93	T.	.12	1.12	0	------	2.48	.52	.69	.43
21 to 31	1.09	1.10	0	13.9	.25	.43	------	1.85	.57	0	5.96
Total	1.93	3.75	2.26	2.53	1.37	3.55	------	5.24	4.82	.69	8.30
April:											
1 to 10	.46	1.75	.93	1.58	1.69	.78	0	.56	1.37	1.26	1.53
11 to 20	1.91	.15	.06	.36	4.55	.63	.18	.62	3.86	.02	2.02
21 to 30	0.	.10	.05	.85	1.70	.58	.12	.20	.18	0	0
Total	2.37	2.00	1.04	2.79	7.94	1.99	.30	1.38	5.41	1.28	3.55
May:											
1 to 10	.30	1.30	0	1.79	.85	.88	.58	1.24	.36	0	.04
11 to 20	T.	2.46	1.09	.02	7.43	.26	.81	1.41	.61	2.88	3.31
21 to 31	1.40	2.95	1.16	.80	0	1.18	5.69	2.02	.55	0	0
Total	1.70	6.71	2.25	3.21	8.28	2.32	7.08	4.67	1.52	2.88	3.36
June:											
1 to 10	.82	1.10	.90	2.49	2.75	.50	1.86	1.53	3.92	1.57	1.65
11 to 20	2.06	.40	1.91	1.11	.50	0	.59	2.07	.86	2.84	0
21 to 30	1.00	1.53	.86	3.50	.18	2.44	.45	5.27	1.72	1.59	1.23
Total	3.88	3.03	3.67	7.10	3.43	2.94	2.90	8.87	6.50	6.00	2.88
July:											
1 to 10	2.30	1.21	.83	4.25	.68	.32	.28	1.25	1.85	1.40	1.51
11 to 20	.20	1.66	15.22	3.13	2.50	4.47	3.27	2.40	3.01	1.04	1.36
21 to 31	.75	------	4.22	.57	3.57	3.87	2.16	.86	.57	.90	4.69
Total	3.31	2.87	20.27	7.95	6.75	8.66	5.71	4.51	5.43	3.34	7.56
August:											
1 to 10	1.84	3.61	2.21	.35	4.47	3.05	.54	.05	.80	.63	.24
11 to 20	.92	8.01	.61	.60	T.	.83	1.24	.69	1.85	.51	2.78
21 to 31	1.43	1.43	.71	.49	0	.52	.43	3.40	.56	.80	1.18
Total	4.19	13.05	3.53	1.44	4.47	4.40	2.21	4.14	3.21	1.94	4.20
September:											
1 to 10	.59	.34	.16	.93	4.30	1.71	.15	.16	1.30	0	.35
11 to 20	1.10	T.	.94	0	1.40	0	1.34	0	5.52	1.42	.44
21 to 30	1.30	.82	1.15	4.44	.20	T.	0	.89	5.19	1.49	2.06
Total	2.99	1.16	2.25	5.37	5.90	1.71	1.49	1.05	12.01	2.91	2.85
October total	2.66	4.29	2.60	1.00	2.30	3.48	3.79	.58	1.01	6.63	------
November total	2.30	1.54	.90	1.30	1.77	.52	.75	2.01	.26	2.93	------
December total	3.09	3.59	2.35	1.87	6.04	1.03	4.68	2.17	6.63	4.65	------
Total for year	34.34	51.22	46.16	41.15	52.14	35.74	------	43.63	57.00	44.38	------

[1] Rainfall not recorded for January, February, and March, 1922.
[2] Records not available for October, November, and December, 1926.

The Weather Bureau stations nearest the different experimental fields are as follows: Danville, Va., 15 miles south of Chatham; Henderson, N. C., 12 miles east of Oxford; Reidsville, N. C.; Florence, S. C., 11 miles east of Timmonsville and 40 miles northeast of Manning. The data in Table 3 were compiled from the published records of the Weather Bureau with the exception of the rainfall records at Tifton, Ga., which were furnished by the Coastal Plain Experiment Station.

METHODS FOLLOWED IN CONDUCTING TESTS

The composition of materials employed in making the various fertilizer mixtures used for the tests is given in Table 4. There were slight variations from season to season and for the different locations from the percentage composition as given, but the percentages shown in the table are an accurate indication of the average composition of the materials used.

TABLE 4.—*Average content of principal constituents of materials used in mixing fertilizers and for liming*

Kind of fertilizer material	Percentage composition				
	Phosphoric acid (P_2O_5)	Ammonia (NH_3)	Potash (K_2O)	Magnesia (MgO)	Lime (CaO)
Precipitated bone	40.0				
Acid phosphate	16.0				
Basic slag	17.0				
Raw bone meal	21.0	4.0			
Stable manure		.375			
Cottonseed meal	2.5	7.0	1.5	1.0	
Dried blood		16.0			
Nitrate of soda		18.0			
Ammonium sulphate		25.0			
German sulphate of potash			50.0		
German muriate of potash			50.0		
American sulphate of potash			53.0		
American muriate of potash			57.0		
Sulphate of potash magnesia			25.0	12.0	
Kainit			12.6	10.0 to 12.0	
Calcite				.6	50.7
Dolomite				17.6	29.6

The materials used in the various tests were mixed a few days prior to their application in the field. The mixtures were applied in the drill, and the quantity for each row was weighed, so as to insure a uniform application. The distribution was made by hand in a furrow opened for the purpose, after which the land was ridged for transplanting the tobacco. The tobacco was generally transplanted by hand after a rain or natural season, but in some years it was necessary to water the plants when transplanted. The fertilizer was usually applied in the field a week or 10 days prior to transplanting.

In fertilizer formulas given in the following pages the phosphoric acid (P_2O_5) is expressed first; ammonia (NH_3) second; and potash (K_2O) third. For example, the formula "8–5–10" signifies that the fertilizer mixture to which it applies contains 8 per cent phosphoric acid, 5 per cent ammonia, and 10 per cent potash.

The yields and values given in Tables 5 to 19, inclusive, were obtained as here described. In general the cultural and other practices of handling the crop were about as used by the grower of this type of tobacco. The tobacco was harvested by the cutting method at Chatham, Va., for the entire period reported. This method was used in the earlier years at Oxford and Reidsville, N. C., but in later years at these localities the priming method of harvesting was used. The priming method of harvesting was used at Manning and Timmonsville, S. C., and Tifton, Ga., for the entire period reported.

After harvesting and curing, care being taken during these operations to keep the tobacco from the various treatments separate, the leaf tobacco was graded and weighed. Those grades which were of about the same quality were run together and sold on the loose-leaf warehouse floor. The weights and prices obtained in this manner were used in making calculations of the yields and gross values per acre.

The plots used ranged from one-seventieth to one-twentieth of an acre in size. Most of the plots were one-fortieth acre in size and were replicated as many times as conditions permitted. In some experiments a treatment was represented only once, and in others it was represented several times. An extra space of 1 to 2 feet was always allowed between plots. In some cases the tobacco was grown in a rotation with other crops; in other cases it was grown in continuous culture.

The yields in pounds of leaf per acre show wide fluctuations from year to year, due to weather conditions, but as a rule they are fairly consistent in showing differences between the various treatments. The gross value per acre shows an even greater fluctuation than the yield in pounds of leaf, and the differences may or may not be in the same direction as differences in yield. This is due largely to the fact that market demands for the crop each season vary considerably and also to the effects of weather conditions on yields and quality. However, the gross returns for the various treatments are generally consistent in showing differences in the same direction, at least as to the broader differences.

TABLE 5.—*Acre yields and gross values of leaf tobacco in tests of fertilizers from different sources and at different rates, with and without lime, at Chatham, Va., 1910–1914*

[The yields and gross values shown in columns 7–13 record the effects of builders' lime applied broadcast in the spring at the rate of 1 ton to the acre in 1910 and 1911]

Treatment No.	Fertilizer treatment				
	Formula	Rate per acre (pounds)	Source		
			Phosphoric acid	Ammonia	Potash
1	2	3	4	5	6
1	0-0-0 [1]		None	None	None.
2	8-0-0	1,400	Acid phosphate	do	Do.
3	0-4-0	1,400	None	Dried blood	Do.
4	0-0-7	1,400	do	None	Sulphate.
5	8-0-7	1,400	Acid phosphate	do	Do.
6	0-4-7	1,400	None	Dried blood	Do.
7	8-4-0	1,400	Acid phosphate	do	None.
8	8-4-3½	1,400	do	do	Sulphate.
9	8-4-7	1,400	do	do	Do.
10	8-3-3 [2]	800	Unknown	Unknown	Unknown.
11	8-3-0	800	Acid phosphate	Dried blood	Sulphate.
12	8-3-3 [2]	1,400	Unknown	Unknown	Unknown.
13	6-2-3½	1,400	Acid phosphate	Dried blood	Sulphate.
14	0-3-3½	1,400	do	do	Do.
15	8-3-3½	1,400	do	do	Do.
16	8-3-3½	1,400	do	Cottonseed meal	Do.
17	8-3-3½	1,400	do	Nitrate of soda	Do.
18	8-3-3½	1,400	do	Ammonium sulphate	Do.

[1] Unfertilized plots, average of duplicates; other treatments not duplicated. [2] Factory-mixed goods.

TABLE 5.—*Acre yields and gross values of leaf tobacco in tests of fertilizers from different sources and at different rates, with and without lime, at Chatham, Va., 1910–1914*—Continued

Treatment No.	Limed 1910	Limed 1911	Limed 1912	Limed 1913	Limed 1914	Limed Average 1910–1912	Limed Average 1910–1914	Unlimed 1910	Unlimed 1911	Unlimed 1912	Unlimed 1913	Unlimed 1914	Unlimed Average 1910–1912	Unlimed Average 1910–1914
1	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	Acre yield of leaf tobacco (pounds)													
1	725	150	340	540	270	405	405	580	110	190	620	250	293	330
2	1,120	540	500	480	640	720	658	730	460	460	480	460	550	518
3	1,060	420	300	580	800	593	632	930	340	390	600	560	553	504
4	920	450	500	600	720	623	638	820	350	490	540	340	553	508
5	1,060	660	400	940	800	707	772	820	720	600	820	800	713	752
6	1,050	[3] 140	520	820	860	570	678	1,060	220	410	520	760	563	594
7	1,380	[3] 300	580	860	670	753	758	1,290	570	510	900	920	790	838
8	1,540	[3] 370	840	......	1,000	917	......	1,450	880	760	......	1,000	1,030	......
9	1,520	[3] 520	950	1,150	860	996	1,000	1,440	1,030	720	1,160	1,080	1,063	1,086
10	1,180	560	610	......	......	783	......	1,040	520	680	......	......	747	......
11	1,080	330	700	......	......	703	......	900	600	500	......	......	667	......
12	1,490	[3] 310	970	1,160	820	923	950	1,300	860	970	1,440	1,080	1,043	1,130
13	1,080	600	860	......	......	847	......	1,120	580	540	......	......	747	......
14	1,150	870	790	......	......	937	......	1,150	610	650	......	......	803	......
15	1,440	[3] 250	795	[4] 960	860	828	861	1,440	790	700	[4] 980	1,140	977	1,010
16	1,120	810	760	[4] 1,180	880	897	950	1,020	660	610	[5] 1,020	960	763	854
17	1,380	960	900	[5] 1,060	1,020	1,080	1,064	1,100	720	740	[5] 820	940	853	864
18	1,370	920	920	......	......	1,070	......	1,280	670	660	......	......	870	......
	Acre value of leaf tobacco (dollars)													
1	43.62	3.72	15.64	4.60	6.80	20.99	14.88	37.86	2.74	8.50	4.80	5.00	16.37	11.78
2	97.73	43.55	80.37	5.80	28.02	73.88	51.09	63.43	32.80	64.25	7.60	18.40	53.49	37.30
3	61.71	12.60	19.36	6.20	40.00	31.22	27.97	53.95	9.20	19.56	6.40	21.20	27.57	22.06
4	68.44	13.50	30.80	9.80	28.80	37.58	30.27	47.63	20.80	30.68	8.80	10.00	33.04	23.58
5	93.08	40.10	34.70	65.00	38.80	55.96	54.34	84.47	48.40	63.90	65.90	70.80	65.59	66.69
6	76.14	[3] 3.16	33.30	8.60	34.40	37.53	31.12	78.54	8.60	26.40	5.60	30.40	37.85	29.91
7	109.54	[3] 15.80	39.90	40.76	31.44	55.08	47.49	118.85	29.20	37.25	38.65	54.90	61.77	55.77
8	128.96	[3] 16.75	88.95	......	72.80	78.22	......	124.54	59.90	80.83	......	71.60	88.42	......
9	125.57	[3] 26.45	100.50	71.20	50.00	84.17	74.74	134.35	74.10	82.00	75.33	98.00	96.82	92.76
10	93.87	31.20	71.07	......	......	65.38	......	99.33	33.60	74.30	......	......	69.08	......
11	90.37	23.55	74.80	......	......	62.91	......	83.15	44.20	48.77	......	......	58.71	......
12	115.07	[3] 16.71	121.35	110.65	76.40	84.38	88.04	107.49	55.12	127.32	124.20	101.60	96.64	103.15
13	94.38	52.50	100.28	......	......	82.39	......	105.48	41.10	60.63	......	......	69.07	......
14	89.59	42.40	98.77	......	......	76.92	......	94.98	47.10	74.86	......	......	72.31	......
15	124.29	[3] 13.15	89.85	55.70	49.24	75.76	66.45	124.78	56.40	79.40	[4] 76.40	74.80	86.86	82.36
16	106.50	52.65	95.60	[4] 64.20	46.10	84.92	73.01	97.39	39.10	68.95	[5] 62.70	81.60	68.48	69.95
17	123.98	68.20	78.30	[5] 62.00	79.20	90.16	82.34	103.21	44.70	71.70	[5] 47.66	77.80	73.20	69.01
18	111.06	56.40	83.70	......	......	83.72	......	105.64	41.90	63.62	......	......	70.39	......

[3] Low yields caused by poor stands.
[4] Fertilizer formula for this year, 8–3–7.
[5] Fertilizer formula for this year, 8–4–7.

TESTS AT CHATHAM, VA.

Table 5 shows yields and values of tobacco obtained on plots one-fortieth acre in size at Chatham, Va., for the years 1910 to 1914 inclusive.[2] The numbers of the different treatments given do not represent the same location with respect to one another for the different years. A given treatment was always located on the

[2] A summary of a portion of these results and those of similar tests for later years at the same location has been published. *See* HUTCHESON, T. B., and BERGER, D. J. EXPERIMENTS WITH BRIGHT TOBACCO AND OTHER CROPS GROWN ON BRIGHT TOBACCO FARMS. Va. Agr. Expt. Sta. Bul. 233, 19 p., illus. 1923.

same plot when tobacco was grown on the experimental field. Tobacco was the only crop which received fertilizer in the rotation. The rotation used was tobacco; wheat; two years of clover, timothy, and redtop; corn; thus making a five-year rotation. The lime treatment as given was applied to one-half of each of the original plots, which were one-twentieth acre in size, thus giving one-fortieth acre for each treatment. Builders' lime was applied broadcast in the spring in 1910 and 1911, at the rate of 1 ton to the acre. The lime effects shown for 1912, 1913, and 1914 resulted from the previous limings.

TESTS AT REIDSVILLE, N. C.

Table 6 shows yields and gross values per acre of tobacco grown on plots one-twentieth acre in size near Reidsville, N. C. The numbers as given do not represent the same location of plots with respect to one another for the different years, nor do they show the arrangement of the plots. Each individual treatment, however, was always located on the same plot when tobacco was used in the rotation, this being the only crop fertilized in the rotation. The rotation practiced was tobacco, oats, and one or two years of herd's grass (redtop). The yields in 1912, 1915, and 1919 were obtained from plots located on the same area; in 1913, 1917, and 1920 the tests were located on a second area; and in 1914 and 1918 the tests were located on a third area. The yields for 1916 are omitted because the series for this year was not in the regular rotation plots.

TABLE 6.—*Acre yields and gross values of leaf tobacco in fertilizer tests at Reidsville, N. C., in stated years*

[Rate of application 1,600 pounds per acre except as noted in text and footnote [1]]

Treatment No.	Fertilizer formula	Acre yield of leaf tobacco (pounds)							
		1912	1913	1914	1915	1917	1918	1919	1920
1	0-0-0	443	386	612	515	520	530	454	460
2	0-4-0	530	696	766	721	484	693	575	900
3	8-0-0	439	533	736	684	488	837	550	790
4	8-4-0	513	804	1,036	875	751	866	635	1,035
5	6-2-3	807	761	970	780	843	883	800	1,142
6	6-3-3	742	856	968	865	885	1,081	950	1,280
7	6-4-3	717	1,060	1,189	838	975	1,151	925	1,460
8	8-4-3	709	1,048	1,229	801	1,030	1,141	----	1,484
9	8-3-3	538	778	856	601	700	901	660	1,128
		Average by years					**Average by fields**		
		1912–1914	1915, 1917, 1918	1919–1920	1912–1915, 1917, 1918, 1920	1912–1915, 1917, 1920	1912, 1915, 1919	1913, 1917, 1920	1914, 1918
1	0-0-0	480	518	457	494	489	471	465	566
2	0-4-0	664	633	738	684	671	609	693	730
3	8-0-0	569	670	670	644	632	558	604	786
4	8-4-0	784	831	835	840	814	674	863	951
5	6-2-3	846	835	971	884	873	796	915	927
6	6-3-3	855	944	1,115	954	953	852	1,007	1,025
7	6-4-3	969	988	1,193	1,056	1,039	827	1,165	1,170
8	8-4-3	995	1,021	----	1,076	----	----	1,187	1,185
9	8-3-3	707	734	894	779	764	600	852	879

[1] In treatment 9 only 900 pounds was used; during 1918–1920 treatments 2, 3, and 4 received only 800 pounds of the fertilizer shown in the formulas.

TABLE 6.—*Acre yields and gross values of leaf tobacco in fertilizer tests at Reidsville, N. C., in stated years*—Continued

Treatment No.	Fertilizer formula	Acre value of leaf tobacco (dollars)							
		1912	1913	1914	1915	1917	1918	1919	1920
1	0-0-0	24.00	38.17	46.02	52.97	159.90	132.64	293.14	50.00
2	0-4-0	27.70	92.67	39.02	55.06	124.40	153.94	379.90	127.85
3	8-0-0	24.21	100.46	62.73	93.36	149.75	233.39	399.50	90.70
4	8-4-0	26.12	161.76	57.08	80.68	223.19	206.41	423.15	162.22
5	0-2-3	44.71	172.02	100.63	84.64	203.63	256.82	583.04	190.30
6	0-3-3	40.46	188.45	90.79	93.90	272.67	248.37	656.10	225.55
7	0-4-3	38.84	235.80	89.58	83.35	290.64	275.24	673.08	245.80
8	8-4-3	36.87	235.88	93.63	101.70	311.94	284.05	--------	239.66
9	8-3-3	30.22	147.34	81.05	56.43	222.92	265.60	481.60	189.64
		Average by years					Average by fields		
		1912–1914	1915, 1917, 1918	1919, 1920	1912–1915, 1917, 1918, 1920	1912–1915, 1917–1920	1912, 1915, 1919	1913, 1917, 1920	1914, 1918
1	0-0-0	36.06	115.17	171.57	71.96	99.61	123.37	82.69	89.33
2	0-4-0	53.15	111.33	253.88	88.76	125.15	154.44	114.97	96.48
3	8-0-0	92.47	148.83	249.60	104.80	141.64	162.36	116.64	148.06
4	8-4-0	81.85	173.76	292.68	132.72	169.02	179.65	182.38	133.05
5	0-2-3	105.98	201.50	388.63	158.97	212.46	236.76	208.66	178.73
6	0-3-3	106.57	204.98	440.83	165.74	227.04	263.49	228.89	169.58
7	0-4-3	121.41	216.41	459.40	179.89	241.53	265.06	257.41	182.41
8	8-4-3	122.13	232.56	--------	186.25	--------	--------	262.49	188.84
9	8-3-3	86.20	181.65	335.62	141.89	184.35	199.42	186.63	173.33

Acid phosphate was used as the source of phosphoric acid (P_2O_5), dried blood as the source of ammonia (NH_3), and sulphate of potash as the source of potash (K_2O), in all mixtures reported in Table 6. The rate of application was 1,600 pounds per acre except for treatment 9, where 500 pounds per acre of factory-mixed product was used, the sources of materials being unknown. During the period 1918–1920, treatments 2, 3, and 4 received only 800 pounds of the fertilizer shown in the formulas. The yields and value for treatment 9 for the years 1913, 1914, 1915, 1917, and 1918 are averages of duplicate treatments.

TABLE 7.—*Acre yields and gross values of leaf tobacco in fertilizer tests using ammonia from different sources at Reidsville, N. C., in stated years*

[Formula, 8-4-6; rate of application, 800 pounds per acre]

Treatment No.	Source of ammonia	Acre yield of leaf tobacco (pounds)						Acre value of leaf tobacco (dollars)					
		1911	1914	1915	1918	1919	Average	1911	1914	1915	1918	1919	Average
1	No fertilizer	470	612	515	520	454	514	20.92	46.02	52.97	132.64	293.14	109.14
2	Ammonium sulphate	862	967	809	944	880	892	45.41	89.49	75.50	222.46	431.00	172.77
3	Dried blood	822	968	855	1,081	950	935	64.64	90.79	85.57	248.37	656.10	227.09
4	Nitrate of soda	772	1,066	778	1,050	1,020	938	40.89	100.54	68.45	274.16	730.00	242.81

TABLE 8.—*Acre yields and gross values of leaf tobacco in tests using potash from different sources and at different rates at Reidsville, N. C., 1919–1923*

[Rate of application, 800 pounds per acre]

Plot No.	Fertilizer treatment		Acre yield of leaf tobacco (pounds)						Acre value of leaf tobacco (dollars)					
	Formula	Source of potash	1919	1920	1921	1922	1923	Average	1919	1920	1921	1922	1923	Average
1	8-5-0	None	690	594	508	473	929	639	372.14	20.87	27.36	45.94	115.55	116.37
2	8-5-1½	Sulphate	662	777	876	648	928	778	357.75	33.36	76.24	79.89	140.96	137.64
3	8-5-1½	Muriate	716	857	877	404	894	762	424.62	69.85	90.34	37.20	147.58	153.92
4	8-5-3	Sulphate	621	576	916	333	823	654	325.52	22.86	82.13	18.85	144.28	118.93
5	8-5-3	Muriate	426	831	990	446	1,016	744	210.40	87.52	91.68	43.00	180.28	123.78
6	8-5-0	None	329	576	824	342	910	596	80.30	17.99	68.18	37.51	147.00	70.20
7	8-5-4½	Sulphate	580	766	911	482	1,104	770	350.85	37.74	92.50	44.55	199.33	144.99
8	8-5-4½	Muriate	638	983	963	619	928	826	307.61	124.83	102.26	90.40	169.13	176.85
9	8-5-10	Sulphate	602	822	841	481	1,051	759	311.22	40.94	69.20	27.46	205.96	130.96
10	8-5-10	Muriate	648	922	903	630	1,130	860	380.69	118.36	105.73	86.06	215.19	181.21
11	8-5-0	None	491	586	893	464	858	658	249.64	24.07	61.99	36.17	130.63	100.50
12	8-5-0	None	482	612	684	429	806	603	225.85	23.24	48.84	35.08	134.08	93.42
13	8-5-1½	Sulphate	604	628	824	403	806	653	345.32	33.48	78.39	22.40	145.35	124.99
14	8-5-1½	Muriate	622	756	804	202	920	699	402.55	76.57	94.30	24.11	176.11	155.13
15	8-5-3	Sulphate	632	646	877	508	965	726	331.71	32.65	74.37	30.37	168.39	120.30
16	8-5-3	Muriate	744	768	876	551	946	777	406.58	84.08	77.81	71.87	181.16	170.82
17	8-5-0	None	553	428	543	416	684	525	296.79	15.52	37.48	56.09	100.33	101.24
18	8-5-4½	Sulphate	709	760	860	595	1,086	802	423.75	42.79	70.55	36.37	190.33	154.50
19	8-5-4½	Muriate	744	881	807	690	1,051	830	495.65	100.73	80.40	103.20	190.69	196.55
20	8-5-10	Sulphate	760	741	788	513	1,034	767	432.54	37.53	65.30	42.24	193.25	155.57
21	8-5-10	Muriate	812	1,154	923	704	1,069	936	534.06	127.39	89.85	113.10	186.38	210.10
22	8-5-0	None	710	700	823	516	683	686	419.52	15.05	71.33	68.86	144.88	143.93

TABLE 9.—*Acre yields and gross values of leaf tobacco in fertilizer tests using potash from different sources, in combination with calcitic and dolomitic limestones, at Reidsville, N. C., 1921–1923*

[Formula, 8-5-4½; rate of application, 800 pounds per acre]

Plot No.	Fertilizer treatment		Acre yield of leaf tobacco (pounds)				Acre value of leaf tobacco (dollars)			
	Source of potash	Form of limestone	1921	1922	1923	Average	1921	1922	1923	Average
1	American muriate	Calcitic	1,009	892	1,558	1,173	135.66	212.45	287.32	211.81
2	American muriate	None	789	661	1,191	880	102.19	179.57	225.09	168.95
3	American muriate	Dolomitic	928	761	1,313	1,001	140.01	185.64	237.34	187.60
4	German muriate	Calcitic	806	621	1,349	925	111.74	159.18	253.12	174.68
5	German muriate	None	849	761	1,235	948	137.68	173.24	243.25	184.72
6	German muriate	Dolomitic	877	805	1,349	1,010	123.11	204.23	266.74	198.03
7	American sulphate	Calcitic	798	713	1,235	915	78.24	174.70	248.91	167.31
8	American sulphate	None	871	700	1,192	921	71.44	115.41	223.74	136.86
9	American sulphate	Dolomitic	840	692	1,348	960	107.80	169.00	280.56	185.79
10	German sulphate	Calcitic	859	788	1,200	949	100.60	184.51	216.76	167.29
11	German sulphate	None	780	735	1,236	920	73.95	143.70	233.07	150.24
12	German sulphate	Dolomitic	736	726	1,279	914	84.41	175.50	240.37	166.76
13	Sulphate of potash magnesia	Calcitic	894	823	1,296	1,004	113.03	219.74	242.17	191.65
14	Sulphate of potash magnesia	None	771	643	1,104	839	98.80	160.78	219.82	159.82
15	Sulphate of potash magnesia	Dolomitic	771	774	1,226	924	89.33	178.52	230.88	166.24
16	Kainit	Calcitic	683	796	1,278	919	87.21	219.91	224.50	177.21
17	Kainit	None	665	775	1,384	941	97.95	204.37	235.16	179.16
18	Kainit	Dolomitic	765	775	1,366	969	108.50	194.47	254.40	185.79

The comparison of tests using ammonia from different sources is given in Table 7 for Reidsville, N. C. This table was compiled for the years in which the respective treatments were represented. The plots were one-twentieth acre in size, and the treatment numbers do not indicate the location of plots in relation to one another. The rotation used was the same as that given for the plots in Table 6. Plots receiving treatment were fertilized at the rate of 800 pounds per acre of an 8–4–6 mixture. The phosphoric acid was derived from acid phosphate, the ammonia from the sources indicated, and the potash from high-grade sulphate.

The yields and values reported in Tables 8 and 9 were obtained from plots one-seventieth acre in size, located near Reidsville, N. C. These tests were carried on, for the periods shown, in continuous tobacco culture. The plot numbers show locations of plots with respect to one another, and their arrangement was in a series shown by the numbers. The limestones used were finely ground and applied in the drill at the rate of 1,000 pounds per acre before transplanting the tobacco. The plots shown in Table 9 received 800 pounds per acre of an 8–5–4½ formula. Acid phosphate was the source of phosphoric acid and dried blood the source of ammonia in tests given in Tables 8 and 9, the sources of potash being as indicated in the tables. All plots in Table 8 received the formulas shown at the rate of 800 pounds to the acre.

TESTS AT OXFORD, N. C.

Tobacco yields and values in the series at Oxford, N. C., testing the percentage composition, rate of application, and sources of fertilizer are shown in Table 10. The cropping system followed during the period 1913 to 1918, inclusive, was as follows: First year, tobacco; second year, oats cut for hay followed by a catch crop of cowpeas turned under and field seeded to crimson clover; third year, crimson clover turned under for corn, which was followed by a rye cover crop. The rye was turned under in the spring for tobacco the fourth year. The oats received 100 pounds of nitrate of soda broadcast on all plots in the spring. The corn received a mixture of 100 pounds of cottonseed meal and 200 pounds of acid phosphate at planting time and a top-dressing of 100 pounds of nitrate of soda about the time the corn began to tassel.

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TABLE 10.—*Acre yields and gross values of leaf tobacco in tests of fertilizer from different sources and at different rates, with and without dolomitic limestone, at Oxford, N. C., 1913–1924*

[An asterisk (*) in connection with column numbers (27–32 and 54–59) denotes that ground dolomitic limestone was applied broadcast at the rate of 1 ton per acre 30 to 40 days prior to transplanting the tobacco. In the other cases (unstarred) no dolomitic limestone was used]

Plot No.	Fertilizer treatment					Acre value of leaf tobacco (dollars)			
	Formula	Rate per acre (lbs.)	Source			Field			Average, 1913–1915
			Phosphoric acid	Ammonia	Potash	3, 1913	1, 1914	2, 1915	
1	2	3	4	5	6	7	8	9	10
1	8-3-3	800	Unknown	Unknown	Unknown	138.00	63.04	128.83	109.96
1	8-5-10	800	Acid phosphate	Nitrate of soda (⅛), ammonium sulphate (⅛), cottonseed meal (⅜), dried blood (⅜)	Sulphate	------	------	------	------
2	8-5-10	800	do	Dried blood	do	125.20	74.93	88.33	96.15
3	8-5-10	1,000	do	do	do	106.60	82.12	85.46	91.39
4	8-5-10	600	do	do	do	108.40	79.49	68.40	85.43
5	8-5-10	800	do	do	do	113.20	68.21	69.58	83.66
6	8-5-10	800	do	Cottonseed meal	do	127.70	87.59	90.81	102.03
7	8-3¾-10	800	do	Nitrate of soda	do	103.80	61.61	78.79	81.40
8	8-3¾-10	800	do	Ammonium sulphate	do	101.20	49.19	100.58	83.66
9	8-5-10	800	do	Dried blood	do	107.00	71.89	78.39	85.76
10	0-0-0	0	None	None	None	45.80	44.71	19.76	36.76
11	6-5-10	800	Acid phosphate	Dried blood	Sulphate	105.00	107.10	88.36	100.15
12	6-5-10	800	Basic slag	do	do	93.06	56.22	86.22	78.48
13	6-5-10	800	Raw bone meal	do	do	103.80	79.41	68.35	83.85
14	6-5-10	800	Acid phosphate	do	do	107.20	79.55	55.64	80.80
15	0-5-10	800	None	do	do	40.90	30.98	34.50	35.46
16	8-5-0	800	Acid phosphate	do	None	58.80	70.22	21.28	50.10
17	8-0-10	800	do	None	Sulphate	78.20	33.89	25.29	45.79
18	8-5-20	800	do	Dried blood	do	------	57.58	68.38	------
19	0-0-0	0	None	None	None	18.60	13.87	39.48	40.65
20	0-5-10	800	Acid phosphate	Dried blood	Sulphate	132.60	51.49	82.92	82.34
21	6-5-10	800	Basic slag	do	do	90.00	50.96	74.48	71.81
22	6-5-10	800	Raw bone meal	do	do	84.40	63.94	77.15	75.16
23	6-5-10	800	Acid phosphate	do	do	123.20	81.52	75.24	93.32
24	8-5-10	800	do	do	do	126.80	79.83	77.21	94.61
25	8-5-10	600	do	do	do	125.00	82.75	86.66	98.14
26	8-5-10	1,000	do	do	do	121.40	74.13	124.79	106.77
27	8-5-10	500	do	do	do	95.80	81.68	107.14	94.87
28	8-5-10	800	do	do	Muriate	115.40	95.09	149.76	120.08
29	8-2-2	800	Unknown	Unknown	Unknown	125.60	84.47	82.26	97.44
29	8-5-10	800	Acid phosphate	Nitrate of soda (⅛), ammonium sulphate (⅛), cottonseed meal (⅜), dried blood (⅜).	Sulphate	------	------	------	------
30	8-5-5	800	do	Dried blood	do	114.60	79.02	79.27	90.96
31	8-3¾-10	800	do	Nitrate of soda	do	78.00	61.17	89.68	76.28
32	8-5-10	800	do	Cottonseed meal	do	103.20	47.50	101.95	84.22
33	8-3¾-10	800	do	Ammonium sulphate	do	85.20	34.82	82.26	67.43
34	8-5-10	800	do	Dried blood	do	128.00	57.02	89.51	91.51
35	8-5-10	800	do	do	Muriate	116.80	63.10	100.65	93.52
36	0-0-0	0	None	None	None	62.00	0	7.57	23.19

TABLE 10.—*Acre yields and gross values of leaf tobacco in tests of fertilizer from different sources and at different rates, with and without dolomitic limestone, at Oxford, N. C., 1913–1924*—Continued

Plot No.	Fertilizer formula	Acre value of leaf tobacco (dollars)										
		Field			Average, 1916–1918	Field			Average, 1919–1921	Field		
		3, 1916	1, 1917	2, 1918		3, 1919	1, 1920	2, 1921		3, 1922	1, 1923	2, 1924
1	2	11	12	13	14	15	16	17	18	19	20	21
1	8-3 -3	105.98	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
1	8-5 -10	--------	169.02	93.67	--------	342.44	110.00	86.40	179.61	152.64	238.60	81.20
2	8-5 -10	132.43	158.54	112.18	134.38	264.44	98.30	73.50	145.41	146.40	225.40	91.20
3	8-5 -10	101.96	152.79	168.35	141.03	287.54	88.80	51.20	142.51	139.92	218.40	47.80
4	8-5 -10	128.48	110.12	93.20	110.60	251.86	96.00	52.90	133.59	160.56	192.40	41.00
5	8-5 -10	191.57	129.34	82.55	134.49	269.02	91.00	90.00	150.31	153.84	208.60	43.60
6	8-5 -10	224.05	156.45	116.23	165.58	396.70	112.30	84.50	197.83	198.00	202.00	54.20
7	8-3¾-10	192.92	216.84	109.70	173.15	283.52	100.90	63.00	149.44	163.44	170.20	52.40
8	8-3¾-10	156.13	162.40	73.75	130.76	165.68	35.80	37.80	79.73	107.04	134.00	31.80
9	8-5 -10	203.48	143.99	115.60	154.36	241.56	98.80	61.20	133.85	135.84	177.00	51.50
10	0-0 -0	20.73	17.50	46.20	31.14	40.04	28.00	34.00	34.01	54.48	67.00	14.00
11	6-5 -10	196.57	200.60	114.55	170.64	228.20	81.70	108.30	139.40	133.44	195.20	83.80
12	6-5 -10	228.41	204.47	196.53	200.60	312.30	92.60	76.30	160.40	180.48	180.80	113.80
13	6-5 -10	221.19	164.10	138.85	174.71	267.80	65.90	100.10	144.60	138.72	188.10	108.80
14	6-5 -10	196.48	179.78	134.35	170.20	182.10	41.50	128.70	117.43	100.32	165.60	78.80
15	0-5 -10	111.58	110.10	75.43	99.04	203.54	14.60	62.00	93.38	154.32	95.60	48.40
16	8-5 -0	110.23	43.75	51.35	68.44	73.08	14.40	27.30	38.26	103.44	61.00	40.80
17	8-0 -10	87.15	80.26	86.30	84.57	202.74	104.10	58.10	121.65	113.04	107.80	55.20
18	8-5 -20	189.27	185.89	113.75	162.97	328.66	126.40	68.50	174.52	149.28	229.20	102.00
19	0-0 -0	33.98	7.50	30.35	23.94	50.98	11.80	27.80	30.19	86.64	61.80	20.20
20	6-5 -10	134.86	153.96	142.25	143.69	270.86	121.70	109.30	167.29	194.64	179.40	91.40
21	6-5 -10	174.64	164.45	135.88	158.32	305.52	122.30	87.10	171.64	243.12	224.00	99.80
22	6-5 -10	169.91	135.05	126.80	143.92	362.42	85.60	86.60	178.21	202.56	202.80	79.20
23	6-5 -10	176.80	134.47	125.05	145.47	290.88	65.20	54.70	136.93	165.60	216.80	78.00
24	8-5 -10	161.23	159.07	107.40	142.57	249.30	56.80	62.70	122.93	167.52	153.20	77.00
25	8-5 -10	166.73	126.10	141.63	144.82	248.22	53.00	70.70	123.97	126.72	196.20	73.80
26	8-5 -10	215.04	156.27	134.83	168.71	364.54	85.80	81.70	177.35	150.00	193.20	94.60
27	8-5 -10	145.96	150.94	148.20	148.37	261.14	80.80	55.70	132.54	147.36	198.40	75.80
28	8-5 -10	168.52	203.84	214.43	195.60	413.68	152.60	61.50	209.26	174.00	272.20	103.20
29	8-2 -2	117.73	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
29	8-5 -10	--------	172.62	167.05	--------	308.58	48.00	43.80	133.46	182.48	195.00	106.60
30	8-5 -5	129.59	172.64	101.40	134.54	270.72	54.70	24.60	116.67	158.88	180.60	98.20
31	8-3¾-10	196.62	204.25	121.95	174.27	247.22	83.00	64.80	131.67	189.60	196.40	101.40
32	8-5 -10	219.86	186.92	191.20	199.33	289.82	95.20	95.80	160.27	171.84	193.80	92.00
33	8-3¾-10	159.61	124.39	102.18	128.73	141.50	37.80	33.80	71.03	142.08	160.60	63.00
34	8-5 -10	180.15	164.27	113.53	152.65	246.24	120.50	92.80	153.18	144.72	151.80	86.00
35	8-5 -10	202.00	216.02	248.00	222.01	356.90	153.20	92.40	210.83	204.72	212.90	111.80
36	0-0 -0	44.94	39.60	26.05	36.86	47.60	7.10	15.60	23.43	54.00	57.60	22.40

TABLE 10.—*Acre yields and gross values of leaf tobacco in tests of fertilizer from different sources and at different rates, with and without dolomitic limestone, at Oxford, N. C., 1913–1924*—Continued

[An asterisk (*) in connection with column numbers (27–32 and 54–59) denotes that ground dolomitic limestone was applied broadcast at the rate of 1 ton per acre 30 to 40 days prior to transplanting the tobacco. In the other cases (unstarred) no dolomitic limestone was used]

Plot No.	Fertilizer formula	Acre value of leaf tobacco (dollars): Average, 1922–1924	Average, 1913–1924	Average by field: 3	Average by field: 1	Average by field: 2	Field 1, 1920	Field 2, 1921	Field 3, 1922	Field 1, 1923	Field 2, 1924	Average, 1920–1924	Average, 1920–1924
1	2	22	23	24	25	26	*27	*28	*29	*30	*31	*32	33
1	8-3 -3												
1	8-5 -10	157.48					148.70	81.20	184.32	359.60	205.80	195.92	133.77
2	8-5 -10	154.33	132.57	167.12	130.29	91.30	151.20	115.00	160.08	411.40	206.60	208.98	126.96
3	8-5 -10	133.71	127.16	174.01	134.28	73.20	161.50	155.50	224.64	321.60	235.00	219.65	108.22
4	8-5 -10	131.32	115.23	102.33	110.50	63.88	164.00	188.50	220.06	323.60	187.60	216.76	108.57
5	8-5 -10	135.35	125.95	182.13	124.20	71.43	151.80	135.50	165.84	344.20	235.00	206.47	117.41
6	8-5 -10	151.40	154.21	236.61	139.59	86.44	104.80	124.50	202.08	286.60	210.60	199.52	130.20
7	8-3¾-10	128.68	133.17	185.92	137.39	76.20	148.50	145.30	193.20	251.40	212.20	190.12	110.17
8	8-3¾-10	90.05	96.27	132.40	95.35	60.98	96.90	96.20	160.09	295.20	203.00	170.28	69.20
9	8-5 -10	121.45	123.85	171.97	122.92	76.67	126.90	117.70	179.04	322.80	235.00	196.89	104.87
10	0-0 -0	45.16	36.77	42.51	30.30	28.40	38.70	30.40	49.68	65.60	46.80	46.24	39.50
11	6-5 -10	137.48	136.92	165.80	140.20	98.75	139.90	148.90	197.76	386.20	250.20	224.59	120.49
12	6-5 -10	158.36	151.76	203.55	133.52	118.21	129.40	68.70	213.60	199.20	236.60	169.50	128.80
13	6-5 -10	145.21	137.09	182.88	124.38	104.03	114.60	64.40	232.96	271.40	227.40	182.15	120.32
14	6-5 -10	114.91	120.84	148.53	118.61	99.37	129.40	187.50	190.56	330.40	248.20	219.01	102.98
15	0-5 -10	99.44	81.83	127.59	62.82	55.08	50.30	88.40	189.12	204.80	140.80	136.48	74.98
16	8-5 -0	68.41	56.30	86.30	47.34	35.18	31.90	29.10	108.48	85.80	119.20	74.90	49.39
17	8-0 -10	112.01	91.01	120.28	96.51	56.22	98.00	124.60	141.12	271.40	108.00	148.62	09.65
18	6-5 -20	160.16			149.77	88.16	186.30	207.30	170.16	358.20	252.00	235.99	135.08
19	0-0 -0	56.21	37.75	60.05	23.74	29.46	28.60	32.90	74.16	70.60	41.20	49.49	41.65
20	6-5 -10	155.15	137.12	183.24	126.04	101.47	153.30	158.20	225.84	313.20	188.20	207.75	139.29
21	6-5 -10	188.97	147.69	203.32	140.43	90.31	114.20	50.30	215.52	356.00	194.20	186.04	155.26
22	6-5 -10	161.52	139.70	204.82	121.85	92.4	128.80	62.70	218.64	206.80	103.20	168.03	131.35
23	6-5 -10	153.47	132.30	189.14	124.50	83.25	140.70	103.30	266.64	328.40	201.80	208.17	116.06
24	8-5 -10	132.57	123.17	170.21	112.23	81.08	131.60	106.10	224.40	336.60	209.40	202.02	103.44
25	8-5 -10	132.24	124.79	166.67	114.51	93.20	132.20	129.60	194.88	305.40	212.80	194.98	104.08
26	8-5 -10	147.93	150.19	214.25	127.35	108.98	175.70	103.30	232.80	306.00	217.40	207.56	122.26
27	8-5 -10	140.52	129.08	162.57	127.96	96.71	91.20	141.00	212.88	313.00	223.20	196.20	111.61
28	8-5 -10	183.13	177.02	217.90	180.93	132.22	185.90	128.70	250.32	372.60	320.80	251.66	152.70
29	8-2 -2												
29	8-5 -10	162.03					107.20	100.70	214.56	317.40	225.20	193.01	115.58
30	8-5 -5	145.89	122.02	168.45	121.74	75.87	84.40	97.50	212.88	256.00	233.40	176.84	103.40
31	8-3¾-10	162.47	136.17	177.86	136.21	94.46	96.60	95.90	207.60	309.80	205.20	183.02	127.04
32	8-5 -10	152.55	149.00	196.18	130.86	120.24	105.60	142.80	199.20	263.00	143.00	170.72	129.73
33	8-3¾-10	121.89	97.27	132.10	89.40	70.31	93.80	126.20	197.76	330.80	147.60	179.23	87.46
34	8-5 -10	127.51	131.21	174.78	123.40	95.46	118.00	134.60	166.80	304.60	231.60	191.12	110.16
35	8-5 -10	176.47	175.70	227.60	161.31	138.21	171.10	83.40	220.56	369.20	238.80	216.61	155.00
36	0-0 -0	44.67	32.04	52.14	26.08	17.01	40.10	19.80	73.92	46.60	8.40	37.76	31.34

TABLE 10.—*Acre yields and gross values of leaf tobacco in tests of fertilizer from different sources and at different rates, with and without dolomitic limestone, at Oxford, N. C., 1913–1924*—Continued

Plot No.	Fertilizer formula	Acre yield (pounds)											
		Field			Average, 1913–1915	Field			Average, 1916–1918	Field			Average, 1919–1921
		3, 1913	1, 1914	2, 1915		3, 1916	1, 1917	2, 1918		3, 1919	1, 1920	2, 1921	
1	2	34	35	36	37	38	39	40	41	42	43	44	45
1	8-3 -3	640	595	790	675	506							
1	8-5 -10						670	622		762	860	840	827
2	8-5 -10	510	660	648	616	672	655	608	648	655	740	680	692
3	8-5 -10	500	685	598	594	771	670	674	705	729	820	660	736
4	8-5 -10	500	735	522	586	649	455	576	560	650	880	540	675
5	8-5 -10	540	665	529	578	802	525	553	657	717	820	640	726
6	8-5 -10	720	710	631	687	962	575	582	706	912	820	520	751
7	8-3¾-10	640	615	565	607	809	855	502	772	800	740	480	673
8	8-3¾-10	600	550	688	613	812	670	539	674	557	380	440	459
9	8-5 -10	580	705	530	605	932	590	623	712	675	880	480	678
10	0-0 -0	280	475	159	305	172	70	275	172	143	300	380	274
11	6-5 -10	540	845	591	659	882	800	664	782	679	680	680	680
12	6-5 -10	560	615	547	574	1,006	780	773	853	815	760	780	785
13	6-5 -10	620	735	453	603	999	700	630	776	748	580	920	749
14	6-5 -10	640	660	387	562	955	730	721	802	645	520	760	642
15	6-5 -10	390	355	266	337	615	470	509	531	584	280	600	488
16	8-5 -0	380	600	163	381	605	175	395	392	261	440	480	394
17	8-0 -10	460	315	167	314	505	285	491	427	567	800	500	622
18	8-5 -20		510	508		915	770	733	806	832	900	720	817
19	0-0 -0	400	150	295	282	191	30	254	158	159	180	320	220
20	6-5 -10	600	490	526	539	687	620	684	664	692	900	660	751
21	6-5 -10	500	620	527	549	819	645	608	691	765	1,000	720	828
22	6-5 -10	500	655	567	577	816	530	619	655	946	880	580	802
23	6-5 -10	640	795	547	60[illegible]	822	540	622	661	811	660	460	644
24	8-5 -10	600	705	566	624	801	565	559	648	700	500	420	560
25	8-5 -10	650	685	624	663	797	500	666	654	692	560	440	564
26	8-5 -10	640	755	857	751	1,019	665	761	815	1,028	860	660	849
27	8-5 -10	500	815	737	684	726	610	705	680	734	840	500	691
28	8-5 -10	580	820	911	770	792	690	783	755	955	1,120	600	892
29	8-2 -2	660	655	585	633	610							
29	8-5 -10						620	759		786	600	560	649
30	8-5 -5	600	680	574	618	646	665	583	631	714	560	480	585
31	8-3¾-10	580	620	659	620	915	790	680	795	689	800	600	696
32	8-5 -10	720	455	701	625	960	675	790	808	776	640	560	659
33	8-3¾-10	660	395	665	573	831	465	645	647	485	420	340	415
34	8-5 -10	700	510	647	619	830	615	646	697	679	820	660	720
35	8-5 -10	720	500	638	619	960	730	987	892	821	960	800	860
36	0-0 -0	440	600	61	167	265	160	178	201	170	120	300	197

TABLE 10.—*Acre yields and gross values of leaf tobacco in tests of fertilizer from different sources and at different rates, with and without dolomitic limestone, at Oxford, N. C., 1913–1924*—Continued

[An asterisk (*) in connection with column numbers (27–32 and 54–59) denotes that ground dolomitic limestone was applied broadcast at the rate of 1 ton per acre 30 to 40 days prior to transplanting the tobacco. In the other cases (unstarred) no dolomitic limestone was used]

Plot No.	Fertilizer formula	Acre yield (pounds): Field 3, 1922	Field 1, 1923	Field 2, 1924	Average, 1922–1924	Average, 1913–1924	Average by field 3	Average by field 1	Average by field 2	Field 1, 1920	Field 2, 1921	Field 3, 1922	Field 1, 1923	Field 2, 1924	Average, 1920–1924	Average, 1920–1924
1	2	46	47	48	49	50	51	52	53	*54	*55	*56	*57	*58	*59	60
1	8-3-3	---	---	---	---					---	---	---	---	---	---	---
1	8-5-10	820	1,060	640	847	---	---	---	---	940	840	980	1,300	800	970	852
2	8-5-10	880	940	700	840	699	674	749	674	1,120	820	760	1,360	800	964	788
3	8-5-10	880	1,170	430	827	716	720	836	591	1,080	880	1,060	1,180	920	1,024	792
4	8-5-10	860	950	340	717	634	654	755	495	1,080	900	1,040	1,220	740	996	714
5	8-5-10	860	1,050	350	753	678	752	765	518	960	960	980	1,200	900	940	744
6	8-5-10	980	1,020	300	787	733	894	781	523	1,000	680	1,160	1,150	820	958	740
7	8-3¾-10	940	900	340	727	695	820	778	487	960	880	1,060	1,020	800	944	680
8	8-3¾-10	740	840	280	620	591	677	610	487	780	600	780	1,200	720	816	536
9	8-5-10	760	940	380	693	672	737	776	503	1,120	700	900	1,210	860	958	688
10	0-0-0	420	420	140	327	270	254	316	239	380	340	340	500	300	372	332
11	6-5-10	780	960	520	753	718	720	821	614	940	940	900	1,240	920	988	724
12	6-5-10	960	850	720	843	704	835	751	705	900	780	1,060	870	920	906	814
13	6-5-10	810	990	600	830	740	802	751	666	840	860	1,100	1,070	900	954	798
14	6-5-10	660	940	580	727	683	725	713	612	940	920	1,100	1,280	920	1,032	692
15	8-5-10	940	680	500	707	516	632	446	469	540	700	980	800	640	732	600
16	8-5-0	780	560	440	593	440	507	444	370	540	420	760	540	600	584	540
17	8-0-10	700	720	550	657	505	558	530	427	640	600	620	960	450	700	654
18	6-5-20	880	1,100	700	893	---	---	820	665	1,100	980	1,040	1,220	840	1,036	860
19	0-0-0	500	320	220	347	252	313	170	272	300	420	540	380	260	380	308
20	0-5-10	940	960	620	840	698	730	743	623	1,020	860	1,040	1,120	740	956	816
21	0-5-10	1,200	980	720	967	759	821	811	644	880	760	1,160	1,190	820	962	924
22	6-5-10	1,080	940	530	850	721	836	754	574	980	760	1,200	970	680	918	802
23	6-5-10	840	1,020	460	773	685	778	754	522	1,080	740	1,240	1,280	740	1,016	688
24	8-5-10	840	740	480	687	630	750	633	506	1,000	680	1,080	1,320	820	980	596
25	8-5-10	680	900	480	687	642	712	601	553	980	700	1,020	1,160	780	928	612
26	8-5-10	800	1,000	560	787	800	872	820	710	1,180	660	1,120	1,190	860	1,002	776
27	8-5-10	700	980	500	747	701	680	811	611	1,000	780	1,020	1,120	860	956	710
28	8-5-10	860	1,150	500	837	813	797	945	690	1,280	860	1,120	1,350	1,080	1,138	846
29	8-2-2	---	---	---	---					---	---	---	---	---	---	---
29	8-5-10	1,000	900	560	820	---	---	---	---	980	660	1,120	1,140	820	944	724
30	8-5-5	840	850	580	757	648	700	689	554	700	760	1,020	1,040	800	864	662
31	8-3¾-10	1,040	940	560	847	739	806	788	625	880	680	1,060	1,120	720	892	788
32	8-5-10	960	820	560	780	718	854	648	653	800	720	1,040	1,020	560	828	708
33	8-3¾-10	890	780	460	707	580	714	515	528	700	720	1,000	1,280	620	876	576
34	8-5-10	780	860	560	733	692	747	701	628	800	800	880	1,240	840	912	736
35	8-5-10	980	1,090	580	883	814	870	820	751	1,020	600	1,080	1,340	880	984	882
36	0-0-0	360	380	240	327	223	309	165	195	220	360	480	280	60	280	280

The cropping system as followed from 1919 to 1924, inclusive, was as follows: First year, tobacco followed by winter oats; second year, oats cut for hay and followed by soy beans, which were turned under; third year, rye harvested for grain. During this period the oats received 100 pounds of nitrate of soda as a top dressing to all plots. No fertilizer was applied to the rye. The object in making the above-stated change in the cropping system was to eliminate corn, which seemed to lower the yield and quality of the tobacco.

The plots were originally one-twentieth acre in size, but beginning with the year 1920 one-half of each of the plots was treated with finely ground dolomitic limestone applied broadcast at the rate of 1 ton per acre. This application was made 30 to 40 days prior to transplanting the tobacco, each year. These divided plots were then harvested separately to get the effect of the dolomite treatment.

The above-described modifications account for some of the differences. It will be noted that the first three-year average gave marked decreases in yield where ammonia and phosphoric acid were left off, but this difference is not so marked for the last three-year average. This is due to the fact that some of the other crops used in the rotation had received ammonia and phosphoric acid applications to all plots. The improvement on the no-ammonia plot is doubtless due to the use of legumes and the creeping in of wild legumes.

These plots were arranged in two series according to plot numbers. Plots 1 to 18 were in one series and plots 19 to 36 in another series, with a 10-foot roadway between. Plots 1 and 19 were opposite each other. The plots were originally one-twentieth acre in size, but they were divided when the liming treatment was begun, each plot thereafter being one-fortieth acre in size. The ammonia from the inorganic sources was applied at three-fourths the normal rates, since this form is known to be more readily and more completely available than the organic ammoniates.

The plots at Oxford, N. C., used in testing potash derived from different sources, as reported in Table 11, were kept in tobacco continuously with a rye cover crop during the winter. These plots as laid off were one-twentieth acre in size, but each plot was divided at harvest time into two equal parts, thus giving duplicate series, A and B, of one-fortieth acre area. Beginning with 1920, however, series B was limed with ground dolomitic limestone applied broadcast at the rate of 1 ton every three years. These plots were arranged in the following order: 10, 9, 1, 2, 3, 4, 5, 6, 7, and 8. Plots 9 and 10 were added after the test had been under way for two years. The results for 1916 were lost. In 1915 potash was applied at the rates of 20, 40, and 60 pounds per acre, but thereafter the rates were as indicated in Table 11. All plots received dried blood as the source of ammonia and precipitated bone as the source of phosphoric acid. The formulas shown in the table were applied at the rate of 800 pounds per acre.

TABLE 11.—*Acre yields and gross values of leaf tobacco in fertilizer tests using potash from different sources and at different rates, with and without dolomitic limestone, at Oxford, N. C., 1915, 1917–1924*

[Rate of application of fertilizer mixtures, 800 pounds per acre. Yields and values marked with an asterisk (*) were obtained by the use of ground dolomitic limestone applied broadcast at the rate of 1 ton every three years. In columns showing average yields and values, 1917–1924, the results obtained from the dolomite treatment are not included]

Plot No.	Fertilizer treatment: Formula	Fertilizer treatment: Source of potash	Acre yield of leaf tobacco (pounds): 1915	1917	1918	1919	1920	1921	1922	1923	1924	Average 1917–1924	Average 1917–1919	Average 1920–1924
1-A	8-5- 0	None	440	267	480	230	260	540	600	670	260	394	326	466
1-B			374	365	467	195	*440	*420	*660	*550	*400		342	*494
2-A	8-5- 1½	Sulphate	600	577	631	358	200	440	700	660	320	510	522	476
2-B			540	500	703	403	*600	*600	*720	*700	*640		555	*676
3-A	8-5- 1½	Muriate	740	671	723	453	520	520	600	950	460	505	616	610
3-B			610	610	625	413	*640	*640	*840	*910	*560		549	*718
4-A	8-5- 3	Sulphate	814	724	778	490	460	580	640	840	400	600	664	588
4-B			680	650	663	455	*620	*640	*780	*860	*700		589	*720
5-A	8-5- 3	Muriate	800	683	827	575	620	640	720	990	500	676	695	674
5-B			700	680	787	513	*820	*720	*960	*1,000	*780		660	*856
6-A	8-5- 4½	Sulphate	710	655	720	498	600	660	640	820	360	631	624	616
6-B			710	682	761	545	*640	*760	*940	*900	*720		663	*814
7-A	8-5- 4½	Muriate	690	700	810	613	780	600	740	880	500	720	728	700
7-B			800	755	868	613	*780	*860	*920	*870	*920		745	*874
8-A	8-5- 0	None	354	384	437	263	400	440	560	600	370	423	361	486
8-B			510	447	416	275	*460	*400	*580	*740	*390		379	*514
9-A	8-5-10	Sulphate	----	589	695	443	700	520	760	850	600	623	576	686
9-B			----	605	682	348	*580	*620	*740	*720	*560		545	*644
10-A	8-5-10	Muriate	----	700	874	570	800	640	760	930	440	708	715	714
10-B			----	755	837	485	*920	*760	*840	*930	*920		692	*814

Plot No.	Acre value of leaf tobacco (dollars): 1915	1917	1918	1919	1920	1921	1922	1923	1924	Average 1917–1924	Average 1917–1919	Average 1920–1924
1-A	55.39	52.32	108.45	43.80	20.40	101.60	166.32	132.20	41.00	81.98	68.19	92.30
1-B	46.67	78.50	101.15	50.07	*40.40	*55.00	*177.60	*125.00	*73.40		78.57	*94.28
2-A	75.00	151.56	185.78	95.30	32.80	121.60	191.52	145.40	54.00	142.12	144.21	109.18
2-B	66.74	152.60	223.54	208.57	*105.20	*97.40	*205.68	*175.40	*135.80		194.90	*143.90
3-A	104.19	188.83	228.60	104.22	66.80	176.20	168.48	209.60	85.20	169.49	193.88	141.28
3-B	84.97	172.16	207.32	197.02	*126.00	*150.80	*222.96	*221.10	*126.00		192.17	*169.37
4-A	122.50	208.21	257.06	144.47	40.80	168.40	171.00	188.50	68.40	175.53	216.58	128.74
4-B	100.78	198.08	245.04	194.32	*92.80	*119.00	*213.12	*201.90	*155.20		212.48	*156.40
5-A	117.60	192.65	360.29	295.30	107.20	177.00	213.36	203.80	101.60	224.86	282.75	160.59
5-B	93.24	196.72	350.97	274.55	*147.20	*183.60	*279.60	*255.00	*170.20		274.08	*208.92
6-A	103.30	183.57	290.00	189.30	88.00	182.60	180.72	177.40	64.20	190.16	217.82	138.58
6-B	95.85	191.04	329.96	224.35	*90.42	*225.20	*259.92	*237.30	*153.40		248.45	*193.24
7-A	95.03	222.05	330.35	425.85	155.60	166.60	200.32	177.00	106.00	255.63	326.25	174.30
7-B	110.07	214.08	372.48	374.35	*116.80	*247.80	*245.04	*164.20	*188.20		320.50	*192.41
8-A	43.47	79.20	99.53	58.25	34.00	77.60	143.04	134.40	57.40	89.43	78.99	89.29
8-B	63.77	93.12	101.70	105.52	*35.60	*73.40	*138.96	*154.00	*61.80		100.11	*92.75
9-A	-------	151.18	235.70	167.72	77.60	118.20	191.76	168.80	133.00	169.64	184.87	137.87
9-B	-------	183.47	252.80	185.70	*107.20	*144.00	*205.65	*160.00	*121.80		207.35	*149.05
10-A	-------	199.87	351.60	372.72	115.20	199.40	217.92	197.40	69.40	233.96	308.00	159.86
10-B	-------	215.35	314.28	320.40	*218.40	*203.80	*230.04	*211.60	*112.80		283.34	*195.45

The comparison of calcitic and dolomitic forms of lime when used in combination with potash from different sources is shown in Table 12. The calcite, no-lime, and dolomite treatments were arranged in three parallel series with the following sources of potash extending across each: American muriate, German muriate, American sulphate, German sulphate, sulphate of potash magnesia, and kainit. The series were separated by spaces of 3 feet. One series receives calcitic limestone, finely ground, at the rate of 1,000 pounds per acre, applied in the drill prior to transplanting the tobacco. A second series received no limestone, and a third series received dolomitic limestone, finely ground, at the same rate and applied in the same manner as the calcite. These plots were one-fortieth acre in size. Tobacco was grown on these plots in continuous culture with a cover crop of rye during the winter. All plots were fertilized with a mixture analyzing 8–5–4½ at the rate of 800 pounds per acre. Acid phosphate was the source of phosphoric acid used, dried blood the source of ammonia, and the sources of potash were those indicated in the table.

TABLE 12.—*Acre yields and gross values of leaf tobacco in fertilizer tests using potash from different sources, in combination with calcitic and dolomitic limestones, at Oxford, N. C., 1921–1924*

[Formula, 8-5-4½; rate of application, 800 pounds per acre]

Plot No.	Fertilizer treatment: Source of potash	Fertilizer treatment: Form of limestone	Acre yield of leaf tobacco (pounds): 1921	1922	1923	1924	Average, 1921–1924	Acre value of leaf tobacco (dollars): 1921	1922	1923	1924	Average, 1921–1924
1	American muriate	Calcitic	780	580	800	530	673	275.50	110.40	203.00	63.00	162.98
2		None	920	660	950	640	793	343.30	126.24	270.20	92.00	207.94
3		Dolomitic	1,020	700	1,200	680	900	364.30	157.44	348.80	119.20	247.44
4	German muriate	Calcitic	940	560	790	560	713	349.20	94.56	196.80	65.20	176.44
5		None	720	640	1,080	440	720	260.60	131.28	307.50	55.00	188.60
6		Dolomitic	1,000	860	1,380	580	955	405.80	184.80	433.20	94.40	280.30
7	American sulphate	Calcitic	640	520	790	440	598	203.70	86.36	198.40	42.80	132.82
8		None	600	480	700	420	550	190.40	86.16	216.30	51.00	135.97
9		Dolomitic	920	840	1,110	520	848	364.30	179.04	327.80	78.40	237.30
10	German sulphate	Calcitic	920	640	870	500	733	309.70	112.64	225.50	52.40	175.06
11		None	600	500	740	400	560	185.50	88.08	206.30	49.40	132.32
12		Dolomitic	840	840	1,190	520	848	347.40	190.32	345.20	75.40	239.58
13	Sulphate of potash magnesia.	Calcitic	1,060	780	1,020	500	840	351.10	151.68	306.60	60.80	219.05
14		None	1,100	720	1,050	540	853	398.60	150.00	337.10	77.40	240.78
15		Dolomitic	900	760	1,200	480	835	337.00	154.44	383.00	63.80	234.79
16	Kainit	Calcitic	1,040	800	890	780	878	349.00	162.48	239.00	118.80	217.32
17		None	1,000	800	1,160	760	930	344.70	160.32	364.40	129.80	249.81
18		Dolomitic	1,140	960	1,450	720	1,068	373.50	209.50	438.90	119.20	285.29

TESTS AT TIMMONSVILLE, S. C.

The results of fertilizer tests at Timmonsville, S. C., are given in Table 13. These tests were conducted in a three-year rotation system over a period of six years. By this arrangement each fertilizer plot occupied the same area every third year during the six-year period. The rotation system was as follows: First year, tobacco followed by winter oats; second year, oats cut for hay, after which the field was seeded to cowpeas (broadcast), which were cut for hay; third year, land planted to cotton. The winter oats received 100 pounds of nitrate of soda per acre as a top dressing in the early spring of the second year, and the cowpeas received 300 pounds of acid phosphate per acre just prior to the time of seeding. Cotton received a mixture of 400 pounds of acid phosphate, 300 pounds of cottonseed meal, and 50 pounds of nitrate of soda per acre drilled in at the time of planting.

The fairly liberal application of acid phosphate on the cowpeas and cotton undoubtedly increased the yields of tobacco, especially on the plots receiving no phosphoric acid. All plots were one-twentieth acre in size and arranged in the field according to numbers, as 1, 2, 3, and so on. The phosphoric acid was derived from acid phosphate, ammonia from the sources indicated, and potash from sulphate of potash.

TABLE 13.—*Acre yields and gross values of leaf tobacco in tests using fertilizer from different sources and at different rates at Timmonsville, S. C., 1914–1919*

Plot No.	Fertilizer treatment			Acre yield of leaf tobacco (pounds)								
	Formula	Rate per acre (pounds)	Source of ammonia	1914	1915	1916	1917	1918	1919	Average 1914–1916	Average 1917–1919	Average 1914–1919
1	0-0 - 0	0	None	760	220	570	740	580	610	517	643	580
10	8-3½- 5	1,000	Dried blood	1,100	620	897	830	700	710	872	747	810
11		1,000	Nitrate of soda	1,080	395	577	1,180	960	730	684	957	820
12		1,000	Ammonium sulphate	800	510	700	790	780	600	720	723	722
2	8-5 -10	1,000	Dried blood	1,340	790	940	850	1,080	675	1,023	868	946
14		1,000	Cottonseed meal	820	485	777	970	900	495	694	788	741
15	8-3 - 3	800	Factory product	1,260	580	850	970	1,230	450	897	883	890
7	6-0 - 5	1,000	None	940	260	390	1,020	750	600	530	790	660
16	6-2½- 5	1,000	Dried blood	980	560	730	630	640	610	759	627	693
17	6-3½- 5	1,000	do	604	570	824	1,110	1,260	710	666	1,027	846
8	0-3½- 5	1,000	do	1,060	590	540	880	690	720	730	830	780
6	6-3½- 5	1,000	do	1,240	520	780	1,100	1,230	680	847	1,003	925
5	8-3½- 5	1,000	do	1,000	820	720	1,240	880	460	847	860	853
13	8-5 -10	1,000	do	920	740	760	960	800	580	807	780	793
4	10-5 -10	1,000	do	1,280	720	920	740	960	505	973	735	854
19	8-5 - 5	1,000	do	1,140	760	935	1,240	1,220	690	945	1,050	998
9	6-3½- 0	1,000	do	1,140	430	520	690	860	595	697	715	706
18	8-3½- 5	1,000	do	1,200	555	850	1,180	850	745	868	925	897
3	8-3½-10	1,000	do	1,280	560	950	830	720	830	930	793	862
20	0-0 - 0	0	None	1,020	480	517	----	1,080	410	672	----	----

Plot No.	Acre value of leaf tobacco (dollars)								
	1914	1915	1916	1917	1918	1919	Average 1914–1916	Average 1917–1919	Average 1914–1919
1	82.00	7.30	84.33	129.70	174.60	137.00	57.88	147.10	102.49
10	148.90	34.50	117.13	203.55	247.40	125.01	100.18	191.99	146.08
11	128.61	29.47	97.69	291.90	295.20	127.75	85.26	238.28	161.77
12	101.35	41.20	96.59	164.40	244.20	130.05	79.71	179.55	129.63
2	168.00	36.10	143.63	233.30	413.60	108.00	115.91	251.63	183.77
14	96.08	38.85	110.41	220.10	303.00	93.70	81.78	205.60	143.69
15	154.38	51.10	86.64	254.00	449.80	104.00	97.37	269.27	183.32
7	110.46	18.10	58.00	262.30	267.40	127.90	62.19	219.20	140.69
16	116.40	47.50	88.04	142.50	215.70	135.20	83.98	164.47	124.22
17	69.08	43.60	95.23	227.00	434.80	132.18	69.30	264.66	166.98
8	122.89	38.85	89.41	197.00	313.40	142.20	83.72	217.73	150.73
6	147.13	39.90	119.60	260.85	438.50	101.80	102.21	267.05	184.63
5	123.30	64.60	105.49	279.40	312.20	80.65	97.82	224.08	160.95
13	124.10	54.00	94.16	245.80	251.80	110.20	90.75	202.60	146.68
4	156.50	44.20	116.70	188.80	351.60	89.85	105.80	210.08	157.94
19	141.50	44.00	129.82	284.10	400.80	117.60	105.11	267.50	186.30
9	131.93	14.85	71.40	147.90	303.20	105.15	72.73	185.42	129.07
18	146.80	37.82	112.12	274.80	273.50	131.80	98.91	226.70	162.81
3	158.25	46.50	138.80	208.50	262.80	133.58	114.52	201.63	158.07
20	127.00	22.05	69.01	----	343.20	88.60	72.99	----	----

TESTS AT MANNING, S. C.

The test plots at Manning, S. C. (Table 14), were of the same size, shape, and arrangement as those at Timmonsville. The primary purpose of these tests was to determine whether nematode or root-knot injury can be controlled by crop rotation based on the use of resistant or immune crops when combined with the proper use of fertilizers. With this object in view for the 1915 tobacco crop, oats and Brabham or Iron cowpeas were grown for two years on soil which was heavily infested with nematodes. The cowpeas were seeded broadcast in 1913 and cut for hay in the fall. Oats were seeded in the fall of 1913 and cut for hay in the spring of 1914, after which the land was seeded again to cowpeas, which were turned under in the fall as a green-manure crop. The same rotation was followed prior to the 1918 tobacco crop. In preparation for the 1917 experiments with tobacco, the land was cropped to corn followed by a cover crop of rye in 1913; in 1914 a crop of Iron cowpeas was turned under and oats seeded in the fall; in 1915 a second crop of corn was grown and oats seeded in the fall; in 1916 Iron cowpeas were grown and cut for hay. The 1916 tobacco crop was destroyed by a storm. In the first-named rotation each crop of cowpeas received 600 pounds of acid phosphate per acre, while the oat crop received only 100 pounds of nitrate of soda per acre. The crops grown prior to the 1917 tobacco crop were fertilized as follows: The corn received 200 pounds per acre of a mixture of 300 pounds of acid phosphate, 200 pounds of cottonseed meal, and 100 pounds of sulphate of potash; the cowpeas received 400 pounds per acre of acid phosphate and 50 pounds sulphate of potash; the oats received a top dressing of 100 pounds per acre of nitrate of soda. The rate of application of acid phosphate on the cowpeas doubtless has been largely responsible for the fact that the tobacco plots receiving no phosphoric acid show almost normal yields. The crop of cowpeas turned under in the fall of 1914 undoubtedly supplied this soil with additional nitrogen. Acid phosphate and sulphate of potash were the sources of phosphoric acid and potash, respectively, used in these tests.

TABLE 14.—*Acre yields and gross values of leaf tobacco in tests using fertilizers from different sources and at different rates at Manning, S. C., 1915, 1917, and 1918*

Plot No.	Fertilizer treatment			Acre yield of leaf tobacco (pounds)				Acre value of leaf tobacco (dollars)			
	Formula	Rate per acre (lbs.)	Source of ammonia	1915	1917	1918	Average, 1915, 1917, 1918	1915	1917	1918	Average, 1915, 1917, 1918
1	0-0 -0	0	None	470	1,200	350	673	26.67	211.50	88.15	108.77
10	8-3⅓-5	1,000	Dried blood	600	1,341	620	854	41.35	376.20	220.90	212.82
11	8-3⅓-5	1,000	Nitrate of soda	445	1,565	865	958	28.36	451.70	233.15	237.74
12	8-3⅓-5	1,000	Ammonium sulphate.	705	1,260	650	902	41.28	267.90	178.55	162.57
2	8-5 -10	1,000	Dried blood	665	1,710	830	1,068	50.64	331.35	228.65	203.55
14	8-5 -10	1,000	Cottonseed meal	945	1,355	770	1,023	69.01	367.00	227.37	221.13
15	8-3 -3	800	Factory product	665	1,245	545	818	47.07	356.00	164.90	189.32
7	6-0 -5	1,000	None	580	1,072	410	687	49.72	280.85	104.85	147.14
16	6-2½-5	1,000	Dried blood	695	1,335	1,000	1,010	45.97	252.00	302.22	246.73
17	6-3⅓-5	1,000	do	985	1,225	785	998	60.98	340.50	244.77	215.42
8	0-3⅓-5	1,000	do	610	1,305	725	910	40.04	390.20	218.45	216.43
6	6-3⅓-5	1,000	do	705	1,395	735	945	42.33	303.90	199.95	182.06
5	8-3⅓-5	1,000	do	410	1,350	855	872	24.83	270.00	214.87	169.90
13	8-5 -10	1,000	do	1,070	1,335	735	1,047	76.31	383.30	219.25	226.29
4	10-5 -10	1,000	do	730	1,675	800	1,068	48.85	336.00	240.50	208.45
19	8-5 -5	1,000	do	840	1,385	825	1,017	57.31	396.85	261.30	238.49
9	6-3⅓-0	1,000	do	770	905	695	820	57.02	199.00	179.30	145.11
18	8-3⅓-5	1,000	do	660	1,255	735	883	48.29	349.50	233.55	210.45
3	8-3⅓-10	1,000	do	660	1,595	575	943	42.67	333.50	193.55	189.91
20	0-0 -0	0	None	350	525	560	478	19.93	100.50	127.52	82.65

The feature of chief interest in the results at Manning is the demonstration that by proper fertilizing and the use of highly resistant crops in the rotation normal yields of tobacco can be obtained on nematode-infested soil, even where the infestation is heavy. Prior to the initiation of the rotation tests it was impossible to obtain a profitable yield of tobacco even though fertilizers were used.

TESTS AT TIFTON, GA.

The yields and values presented in Table 15 were obtained from plots one-fiftieth acre in size at the Coastal Plain Experiment Station, Tifton, Ga. In these tests tobacco was grown in continuous culture and in two-year rotations with cotton, corn, peanuts, and sweet potatoes. The plan followed requires only a single series of plots for tobacco in continuous culture, while two series are necessary for each of the rotations with other crops, as indicated in the table. Plots 4, 12, 20, 28, and 30, not included in the table, are control plots with respect to other features of the crop-rotation tests which need not be considered here.

TABLE 15.—*Acre yields and gross values of leaf tobacco in cropping tests of different formulas and rates of application of fertilizers at Tifton, Ga., 1922–1926*

[Tobacco following tobacco was always located on the A series of plots. Tobacco following cotton, corn, peanuts, and sweet potatoes was located on the A series of plots in the years 1922, 1924, and 1926, but in the years 1923 and 1925 tobacco following these crops was located on series B, C, D, and E, respectively]

Preceding crop and plot	Fertilizer treatment			Acre yields of leaf tobacco (pounds)					
	Formula	Rate per acre (pounds)	Dolomite (pounds)	1922	1923	1924	1925	1926	Average
Tobacco:									
1-A	6-3⅔-0	500	None.	872	712	408	872	583	689
2-A	0-3⅔-4½	500	None.	475	370	254	182	600	376
3-A	6-0 -4½	500	None.	1,169	792	637	1,201	752	910
5-A		500	None.	1,353	1,414	701	1,098	1,068	1,127
6-A	6-3⅔-4½	500	1,000	853	881	789	1,198	982	941
7-A		1,000	None.	1,350	1,361	987	1,388	1,100	1,237
8-A	0-0 -0	0	None.	594	491	31	62	273	290
Cotton:									
9-A and 1-B	6-3⅔-0	500	None.	1,100	658	465	650	601	708
10-A and 2-B	0-3⅔-4½	500	None.	528	455	287	100	414	357
11-A and 3-B	6-0 -4½	500	None.	1,116	503	587	962	554	744
13-A and 5-B		500	None.	1,172	925	625	975	676	875
14-A and 6-B	6-3⅔-4½	500	1,000	784	1,016	672	1,048	801	864
15-A and 7-B		1,000	None.	1,428	1,289	923	1,325	1,054	1,204
16-A and 8-B	0-0 -0	0	None.	350	133	31	103	177	169
Corn:									
17-A and 1-C	6-3⅔-0	500	None.	1,059	906	431	489	405	658
18-A and 2-C	0-3⅔-4½	500	None.	469	798	200	66	423	391
19-A and 3-C	6-0 -4½	500	None.	1,012	1,018	655	733	630	810
21-A and 5-C		500	None.	1,175	1,236	900	966	733	1,002
22-A and 6-C	6-3⅔-4½	500	1,000	906	1,592	956	1,087	793	1,067
23-A and 7-C		1,000	None.	1,512	1,622	1,056	1,855	878	1,385
24-A and 8-C	0-0 -0	0	None.	582	462	66	75	138	261
Peanuts:									
25-A and 1-D	6-3⅔-0	500	None.	831	1,423	472	500	166	678
26-A and 2-D	0-3⅔-4½	500	None.	525	816	353	106	362	432
27-A and 3-D	6-0 -4½	500	None.	1,272	1,124	992	866	764	1,004
29-A and 5-D		500	None.	1,134	1,071	1,167	1,134	1,024	1,106
30-A and 6-D	6-3⅔-4½	500	1,000	991	1,328	1,195	1,181	962	1,131
31-A and 7-D		1,000	None.	1,312	1,353	1,353	1,622	1,133	1,355
32-A and 8-D	0-0 -0	0	None.	531	459	122	59	152	265
Sweet potatoes:									
33-A and 1-E	6-3⅔-0	500	None.	900	948	634	528	505	703
34-A and 2-E	0-3⅔-4½	500	None.	528	421	387	50	141	305
35-A and 3-E	6-0 -4½	500	None.	950	1,247	931	787	570	857
37-A and 5-E		500	None.	1,481	1,036	1,254	1,031	724	1,105
38-A and 6-E	6-3⅔-4½	500	1,000	953	837	1,297	1,297	1,054	1,088
39-A and 7-E		1,000	None.	1,528	1,619	1,578	1,378	1,300	1,481
40-A and 8-E	0-0 -0	0	None.	503	198	351	103	108	253

TABLE 15.—*Acre yields and gross values of leaf tobacco in cropping tests of different formulas and rates of application of fertilizers at Tifton, Ga., 1922–1926*—Con.

Preceding crop and plot	Acre value of leaf tobacco (dollars)					
	1922	1923	1924	1925	1926	Average
Tobacco:						
1-A	92.12	135.19	61.49	59.26	72.56	78.11
2-A	4.75	25.75	7.62	1.82	51.99	18.39
3-A	69.95	108.80	120.74	97.38	101.25	99.62
5-A	109.64	408.76	128.50	88.19	164.37	179.89
6-A	56.94	217.82	120.87	95.97	137.08	125.74
7-A	159.73	406.96	164.37	116.44	226.22	214.74
8-A	5.94	16.65	.31	.02	7.09	6.12
Cotton:						
9-A and 1-B	65.50	76.84	45.80	46.94	66.08	58.25
10-A and 2-B	21.74	16.07	8.02	1.00	25.89	14.60
11-A and 3-B	34.23	25.64	111.83	70.10	41.55	56.67
13-A and 5-B	116.26	208.49	92.07	65.53	77.88	112.05
14-A and 6-B	77.16	218.66	102.94	80.68	104.31	116.75
15-A and 7-B	157.55	354.94	177.96	101.94	279.67	214.41
16-A and 8-B	3.50	2.66	.31	1.03	3.54	2.21
Corn:						
17-A and 1-C	36.31	151.08	32.25	35.34	41.00	59.52
18-A and 2-C	11.06	63.88	6.00	.66	32.51	22.82
19-A and 3-C	64.89	207.82	108.01	59.00	67.78	101.50
21-A and 5-C	127.77	303.03	164.52	66.35	104.34	153.20
22-A and 6-C	81.22	384.72	180.24	73.44	98.41	163.61
23-A and 7-C	185.31	469.10	223.04	144.98	172.66	239.10
24-A and 8-C	5.62	33.82	.66	.75	2.70	8.72
Peanuts:						
25-A and 1-D	19.01	323.58	35.62	32.20	3.97	82.88
26-A and 2-D	9.58	104.05	10.59	1.06	24.84	30.02
27-A and 3-D	79.18	220.14	191.36	59.12	62.38	122.44
29-A and 5-D	66.06	240.98	187.03	80.60	128.61	143.22
30-A and 6-D	97.08	323.21	203.59	90.54	104.17	165.04
31-A and 7-D	126.14	395.84	285.79	119.48	223.05	230.06
32-A and 8-D	13.06	19.02	2.44	.59	3.00	7.62
Sweet potatoes:						
33-A and 1-E	26.63	183.01	83.03	38.75	43.13	74.91
34-A and 2-E	12.90	19.70	11.61	.50	18.33	12.61
35-A and 3-E	60.26	194.41	152.94	54.75	39.71	100.41
37-A and 5-E	157.93	241.77	243.06	67.06	60.58	155.40
38-A and 6-E	68.15	231.34	277.16	89.00	131.80	159.49
39-A and 7-E	197.40	441.88	349.78	111.23	249.86	270.03
40-A and 8-E	6.81	9.01	17.55	1.03	4.87	8.03

The fertilizer treatments, as shown by the formulas and rate of application, represent 30 pounds of phosphoric acid in the form of acid phosphate, 15 pounds of nitrogen in the form of dried blood, and 22½ pounds of potash as sulphate of potash magnesia. These particular rates were used in order to supply the same total quantities of plant nutrients over a period of years as were used in certain other rotation tests which are not here considered. The cotton, corn, peanuts, and sweet potatoes received the same fertilizer treatments as the tobacco.

The area on which these plots were located had been brought under cultivation only recently when these tests were begun. The tests, therefore, may be regarded as fertilizer experiments on virgin soil.

The results of the tests involving differences in percentage composition of the fertilizers applied at the 1,000-pound rate are shown in Table 16. These tests cover only a short period, but the treatments are duplicated, making the results fairly dependable.

The plots were one-fortieth acre in size and arranged in parallel series, A and B, as indicated by the numbers. These plots were located on the same area in 1924 and 1925, but in 1926 they were moved to another location because of nematode infestation of the land first used. The areas on which these tests were located had been under cultivation for several years prior to their use for these tests. The phosphoric acid was derived from acid phosphate, the ammonia from dried blood, and the potash from its sulphate.

TABLE 16.—*Acre yields and gross values of leaf tobacco in tests with different formulas of fertilizers at Tifton, Ga., 1924–1926*

[Rate of application of fertilizer mixtures, 1,000 pounds per acre; on heavy-phase Norfolk sandy loam in 1924 and 1925 and on light-phase Tifton sandy loam in 1926]

Plot No.	Fertilizer formula	Acre yield of leaf tobacco (pounds)				Acre value of leaf tobacco (dollars)			
		1924	1925	1926	Average	1924	1925	1926	Average
1-A	8-5-5	1,252	1,521	1,112	1,295	218.59	206.99	222.40	215.99
1-B		1,217	1,621	1,326	1,388	251.38	215.60	261.93	242.99
2-A	8-4-5	1,417	1,710	1,257	1,461	276.62	245.19	281.03	267.61
2-B		1,145	1,433	1,191	1,256	237.24	230.46	238.33	235.34
3-A	8-3-5	1,240	1,560	1,230	1,343	214.21	290.25	275.24	259.90
3-B		1,172	1,438	1,083	1,231	224.51	263.97	215.85	234.78
4-A	8-2-5	1,129	1,494	1,128	1,250	210.95	269.71	235.43	240.70
4-B		1,059	1,302	1,055	1,139	201.05	223.03	171.76	198.61
5-A	8-0-5	880	1,022	980	963	158.13	164.90	124.67	149.23
5-B		848	1,236	848	977	177.35	213.11	117.01	169.16
6-A	0-0-0	461	803	348	537	48.30	68.31	20.77	45.79
6-B		576	735	619	643	73.13	55.92	48.15	59.07
7-A	12-3-5	1,169	1,720	1,288	1,392	229.53	310.23	291.90	277.22
7-B		1,060	1,586	1,184	1,277	212.61	283.81	223.31	239.91
8-A	10-3-5	1,217	1,696	1,114	1,342	237.83	289.01	278.67	268.50
8-B		1,211	1,644	1,186	1,347	228.54	321.51	218.42	256.16
9-A	9-3-5	1,159	1,519	1,007	1,228	216.61	253.52	232.41	234.18
9-B		1,315	1,580	1,086	1,327	284.31	313.61	189.38	262.43
10-A	7-3-5	1,150	1,902	1,287	1,446	191.43	294.87	237.71	241.34
10-B		1,277	1,692	1,058	1,342	263.56	327.66	180.41	259.21
11-A	6-3-5	1,096	1,541	1,120	1,252	191.97	264.95	247.62	234.85
11-B		1,350	1,717	1,062	1,376	276.79	281.10	167.72	241.89
12-A	4-3-5	1,156	1,608	1,109	1,291	226.00	239.85	196.16	220.71
12-B		1,413	1,729	1,086	1,409	277.42	212.02	188.63	226.02
13-A	0-3-5	1,195	1,277	899	1,124	235.16	205.06	80.89	173.70
13-B		1,242	1,537	970	1,250	210.53	213.29	107.19	177.00
14-A	0-0-0	886	550	779	738	149.60	61.57	78.99	96.72
14-B		684	989	678	784	73.28	84.64	89.32	82.41
15-A	8-3-8	1,303	1,881	1,215	1,466	266.70	306.38	277.84	283.67
15-B		1,283	1,585	1,262	1,377	275.23	249.50	265.51	263.41
16-A	8-3-6	1,260	2,029	1,213	1,501	245.92	335.17	257.86	279.65
16-B		1,051	1,440	1,161	1,217	202.59	211.61	184.58	199.59
17-A	8-3-4	1,212	1,698	1,186	1,365	217.09	214.66	202.23	211.33
17-B		1,185	1,806	941	1,311	179.62	201.57	181.41	187.58
18-A	8-3-3	1,172	1,583	1,132	1,296	207.72	211.14	178.17	199.01
18-B		1,057	1,452	1,072	1,194	151.60	146.93	181.93	160.17
19-A	8-3-2	1,188	1,424	1,283	1,298	173.29	128.79	162.83	154.97
19-B		1,180	1,269	864	1,104	189.82	153.52	160.46	169.90
20-A	8-3-0	455	1,115	575	715	9.10	69.40	51.44	43.31
20-B		724	920	819	821	41.53	64.10	90.33	65.32

The tests with fertilizer applied at the 800-pound rate but differing in percentage composition (Table 17) during the years 1922 to 1926, inclusive, were located on the same area for the entire period. The plots were one-fortieth acre in size and were arranged as shown by the numbers. The phosphoric acid in the mixture was derived from acid phosphate, the ammonia from dried blood, and the potash from its sulphate. The area on which these tests were located had been in cultivation for several years prior to the initiation of the tests.

TABLE 17.—*Acre yields and gross values of leaf tobacco in tests with different formulas of fertilizers at Tifton, Ga., 1922–1926*

[Rate of application of fertilizer mixtures, 800 pounds per acre, on heavy-phase Norfolk sandy loam]

Plot No.	Fertilizer formula	Yield of leaf tobacco (pounds)						Acre value of leaf tobacco (dollars)					
		1922	1923	1924	1925	1926	Average	1922	1923	1924	1925	1926	Average
1	8-3-7	708	915	641	1,169	901	867	100.27	227.39	133.74	232.02	195.43	177.77
2	8-3-3	1,003	808	583	1,211	791	379	150.79	193.78	104.87	214.09	187.41	170.19
3	8-3-5	670	918	686	1,359	1,052	937	101.52	239.96	136.03	269.05	187.73	186.86
4	8-2-5	1,052	860	658	1,404	733	941	102.97	191.04	135.09	252.56	141.24	164.70
5	8-4-5	873	1,091	803	1,451	969	1,037	123.97	290.30	166.93	253.38	217.01	210.32

The results of the tests using ammonia from different sources are shown in Table 18. These tests were on the same area for the entire period reported. The plots were one-fortieth acre in size and arranged in series in the order indicated by the plot numbers.

The fertilizer mixtures were made up from acid phosphate, ammonia from the sources shown in the table, and sulphate of potash. The formulas shown were applied at the rate of 1,000 pounds per acre. The sulphate of potash and acid phosphate application rates were reduced to compensate for the phosphoric acid (P_2O_5) and potash (K_2O) which the cottonseed meal contained. However, no reduction was made for the content of these materials in manure, which accounts in a measure for the high yields obtained when manure was used. The manure was applied in the drill at the rate of 4 tons per acre. These tests were located on an area which had been under cultivation for several years.

Table 19 gives the yields and values obtained in the use of potash from different sources. These plots were one-fortieth acre in size and arranged in the order shown by the numbers. The plots were located on the same area from 1922 to 1924. On account of nematode infestation of the area first used, these tests were moved to another location in 1925. In 1926 this test was located on a third area. All the areas used had been in cultivation for a number of years prior to the tests.

The fertilizer mixtures were made up of acid phosphate, which furnished the phosphoric acid; 150 pounds of dried blood and 50 pounds of nitrate of soda per acre, which furnished the ammonia; and potash from the sources shown in the table. Thus the percentage of ammonia was slightly higher than is indicated by the formulas stated. The fertilizer mixtures were applied at rates equivalent to

1,000 pounds per acre. In 1926 the potash used on plots 6 and 15 was derived from a mixture consisting of one-half high-grade muriate and one-half high-grade sulphate.

TABLE 18.—*Acre yields and gross values of leaf tobacco in fertilizer tests using ammonia from different sources at Tifton, Ga., 1922–1926*

[Rate of application of fertilizer mixtures, 1,000 pounds per acre]

Plot No.	Fertilizer treatment: Formula	Fertilizer treatment: Source of ammonia	Acre yields of leaf tobacco (pounds): 1922	1923	1924	1925	1926	Average
1	8-0-6	None	825	1,002	021	1,504	704	949
2	8-3-6	Cottonseed meal	980	1,315	987	2,001	1,378	1,332
3	8-3-6	Dried blood	1,098	1,367	1,039	1,691	904	1,220
4	8-3-6	Nitrate of soda	993	1,496	1,351	1,933	1,480	1,451
5	8-3-6	Ammonium sulphate	930	1,320	1,128	1,777	1,256	1,282
6	8-3-6	Dried blood	968	1,200	871	1,000	1,323	1,180
7	8-3-6	Dried blood (½), nitrate of soda (½)	1,043	1,178	971	1,853	1,343	1,278
8	8-3-6	Dried blood (⅓), nitrate of soda (⅓), cottonseed meal (⅓)	1,020	1,245	998	1,598	1,399	1,252
9	8-3-6	Manure	1,070	1,380	1,121	2,150	1,781	1,502
10	8-4½-6	Manure (⅔), nitrate of soda (⅓)	1,325	1,767	1,550	2,271	1,901	1,763
11	8-0-6	None	593	930	658	1,269	1,091	909
12	8-3-6	Cottonseed meal	1,078	1,306	933	1,667	1,272	1,251
13	8-3-6	Dried blood	1,078	1,183	1,000	1,705	1,352	1,264
14	8-3-6	Nitrate of soda	1,233	1,672	1,392	1,905	1,616	1,564
15	8-3-6	Ammonium sulphate	1,168	1,475	1,126	1,712	1,376	1,371
16	8-3-6	Dried blood	1,110	1,237	912	1,631	1,364	1,251
17	8-3-6	Dried blood (½), nitrate of soda (½)	1,403	1,425	1,007	1,695	1,502	1,406
18	8-3-6	Dried blood (⅓), nitrate of soda (⅓), cottonseed meal (⅓)	1,203	1,293	895	1,718	1,344	1,291
19	8-3-6	Manure	1,208	1,316	959	1,892	1,692	1,415
20	8-4½-6	Manure (⅔), nitrate of soda (⅓)	1,193	1,706	1,012	1,962	1,862	1,569

Plot No.	Fertilizer treatment: Formula	Fertilizer treatment: Source of ammonia	Acre value of leaf tobacco (dollars): 1922	1923	1924	1925	1926	Average
1	8-0-6	None	95.60	212.62	128.73	230.96	145.85	162.77
2	8-3-6	Cottonseed meal	165.54	322.12	220.26	343.42	316.45	273.56
3	8-3-6	Dried blood	135.50	365.82	208.26	328.67	225.07	252.78
4	8-3-6	Nitrate of soda	106.54	402.72	305.24	409.32	341.41	313.05
5	8-3-6	Ammonium sulphate	88.96	341.58	268.70	310.66	270.99	256.18
6	8-3-6	Dried blood	137.99	298.92	175.71	285.34	284.34	236.46
7	8-3-6	Dried blood (½), nitrate of soda (½)	147.19	293.24	212.73	375.41	324.38	270.59
8	8-3-6	Dried blood (⅓), nitrate of soda (⅓), cottonseed meal (⅓)	180.79	315.09	219.14	264.96	347.52	265.50
9	8-3-6	Manure	166.80	366.04	286.20	479.28	513.73	302.42
10	8-4½-6	Manure (⅔), nitrate of soda (⅓)	186.04	516.24	392.76	510.66	485.46	418.23
11	8-0-6	None	54.85	174.60	145.35	212.85	234.33	164.40
12	8-3-6	Cottonseed meal	155.30	340.54	222.17	341.54	298.54	272.84
13	8-3-6	Dried blood	137.42	305.62	225.10	329.16	335.40	266.54
14	8-3-6	Nitrate of soda	158.84	445.26	315.03	365.15	479.01	352.40
15	8-3-6	Ammonium sulphate	164.80	401.26	270.85	278.65	353.66	293.86
16	8-3-6	Dried blood	167.12	323.12	204.96	275.34	346.00	263.37
17	8-3-6	Dried blood (½), nitrate of soda (½)	186.07	377.37	222.36	340.85	384.13	302.56
18	8-3-6	Dried blood (⅓), nitrate of soda (⅓), cottonseed meal (⅓)	215.52	340.22	184.70	310.57	363.66	282.87
19	8-3-6	Manure	220.75	351.10	226.88	448.88	428.00	335.12
20	8-4½-6	Manure (⅔), nitrate of soda (⅓)	181.80	495.71	238.42	340.41	531.37	359.36

TABLE 19.—*Acre yields and gross values of leaf tobacco in fertilizer tests using potash from different sources and at different rates at Tifton, Ga., 1922–1926*

[Rate of application of fertilizer mixtures, 1,000 pounds per acre. In 1926 one-half the potash used on plots 6 and 15 was derived from high-grade muriate and one-half from sulphate]

Plot No.	Fertilizer treatment: Formula	Fertilizer treatment: Source of potash	Acre yield of leaf tobacco (pounds): 1922	1923	1924	1925	1926	Average
1	8-3-0	None	663	704	635	1,045	904	778
2	8-3-3	American sulphate	885	1,105	936	1,462	1,386	1,155
3	8-3-3	American muriate	800	1,417	928	1,385	1,451	1,196
4	8-3-3	Sulphate of potash magnesia	745	1,099	807	1,409	1,400	1,092
5	8-3-3	Kainit	875	1,288	788	1,730	1,493	1,237
6	8-3-6	American sulphate	980	1,135	757	1,498	1,587	-------
7	8-3-6	German sulphate	900	1,118	746	1,459	1,450	1,135
8	8-3-6	German muriate	880	1,211	660	1,614	1,644	1,202
9	8-3-6	Sulphate of potash magnesia	1,008	1,068	733	1,518	1,633	1,192
10	8-3-0	None	443	671	432	1,215	1,132	779
11	8-3-3	American sulphate	1,010	1,326	636	1,368	1,350	1,138
12	8-3-3	American muriate	680	1,074	526	1,521	1,402	1,041
13	8-3-3	Sulphate of potash magnesia	790	1,027	633	1,177	984	922
14	8-3-3	Kainit	1,015	1,189	824	1,734	2,048	1,362
15	8-3-6	American sulphate	700	1,118	737	1,382	1,710	-------
16	8-3-6	German sulphate	658	1,132	707	1,023	1,593	1,143
17	8-3-6	German muriate	957	1,379	1,049	1,807	1,656	1,370
18	8-3-6	Sulphate of potash magnesia	1,075	1,315	850	1,587	1,615	1,288
19	8-3-0	None	220	777	195	1,113	1,008	681
20	8-3-6	German sulphate (½), kainit (½)	-------	-------	-------	1,710	1,627	-------

Plot No.	Fertilizer treatment: Formula	Fertilizer treatment: Source of potash	Acre value of leaf tobacco (dollars): 1922	1923	1924	1925	1926	Average
1	8-3-0	None	45.63	174.80	106.06	100.78	109.22	107.30
2	8-3-3	American sulphate	101.81	351.51	215.03	241.44	333.37	248.63
3	8-3-3	American muriate	117.40	441.49	209.86	225.88	376.83	274.29
4	8-3-3	Sulphate of potash magnesia	103.61	302.75	179.55	221.24	357.61	232.95
5	8-3-3	Kainit	79.53	340.81	169.53	267.32	393.74	251.30
6	8-3-6	American sulphate	94.81	323.60	172.12	251.18	434.38	-------
7	8-3-6	German sulphate	117.27	310.22	165.42	259.33	377.45	245.94
8	8-3-6	German muriate	132.17	344.07	139.63	212.66	431.67	252.16
9	8-3-6	Sulphate of potash magnesia	141.03	303.21	157.36	245.47	426.31	254.68
10	8-3-0	None	39.19	117.99	52.20	174.75	172.24	111.27
11	8-3-3	American sulphate	113.60	363.50	131.52	189.31	290.48	218.68
12	8-3-3	American muriate	118.82	308.79	110.38	193.81	349.64	216.29
13	8-3-3	Sulphate of potash magnesia	114.96	259.00	137.65	174.51	221.40	181.50
14	8-3-3	Kainit	137.59	327.74	188.91	230.47	547.91	286.52
15	8-3-6	American sulphate	81.11	317.37	156.17	229.07	476.87	-------
16	8-3-6	German sulphate	71.89	299.71	134.21	233.95	392.34	226.42
17	8-3-6	German muriate	117.49	385.39	259.15	206.19	408.53	293.75
18	8-3-6	Sulphate of potash magnesia	86.84	373.86	186.65	267.40	423.82	267.71
19	8-3-0	None	13.37	125.68	6.45	90.18	159.15	78.97
20	8-3-6	German sulphate (½), kainit (½)	-------	-------	-------	293.92	403.51	-------

DISCUSSION OF RESULTS

At least 10 chemical elements are essential to normal plant growth, namely: Carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, and iron. Some investigators believe that certain other elements need to be taken into consideration, but in field practice the foregoing list includes those most likely to be deficient. Since ordinarily the supply of carbon, hydrogen, and oxygen are beyond practical control in the field, they are not considered here. The remaining seven are present in varying quantities in agricultural soils, and their relative abundance determines the fertilizers to be used to the best advantage. In ordinary fertilizer practice heretofore only three of the above-named elements have been taken into account, as follows: Phosphorus, as phosphoric acid (P_2O_5); nitrogen, as ammonia (NH_3); and potassium, as potash (K_2O). It is now known that on some soils another element, magnesium, is of considerable practical importance. In the case of tobacco this is especially true of the flue-cured district, where the soils are usually very low in nearly all of the plant-food elements. It has been found that some tobacco soils have a very low content of magnesium, and a marked increase in the yield and quality of the product usually results when this element is supplied in addition to the three commonly regarded as important. The practical significance of the remaining essential elements in fertilizer practice, as applied to tobacco culture, has not yet been definitely determined.

PHOSPHORIC-ACID TESTS

The first component of a complete fertilizer mixture to be considered is phosphoric acid (P_2O_5). It is deficient in practically all of the virgin soils of the flue-cured tobacco district. This is well shown in the results on new land at Tifton, Ga. (Table 15.) In this case it is evident that phosphoric acid is the most important constituent of the fertilizer with respect to both yield and quality of the tobacco crop. Such marked responses may not be obtained, of course, from phosphoric acid on old lands which have previously received applications of this nutrient. (Table 16.) In the form of acid phosphate, phosphoric acid is commonly one of the chief constituents of factory-mixed commercial fertilizers. It usually increases yields of tobacco of this type where the other essential elements of plant food are present. Even when used alone on these soils, where a rotation is practiced, it shows relatively large increases, when compared with unfertilized plots, in both yield and quality of product, as indicated in the results at Chatham, Va., and Reidsville, N. C. (Table 20.)

Under special conditions, one or another of the elements of a complete fertilizer may be omitted, but under all ordinary circumstances, on the soils in question, phosphoric acid should not be omitted from the mixture unless heavy applications have been made in years immediately preceding. Excessively heavy applications of acid phosphate will leave enough residual phosphoric acid in the soil for several crops, although the immediate effect on the tobacco crop may be harmful.

The yields and values given in Table 20 show that phosphoric acid is an essential component of a complete fertilizer which is to be used over an extended period on the same soil. Although there was no increase in yields from the use of this material at Manning, S. C., this is not to be considered as contradictory, since these plots were located on a different area each season and these areas had been fertilized heavily with acid phosphate in previous years in growing cowpeas for nematode control. The residual phosphoric acid in each case was enough to take care of the needs of the tobacco crop for a season.

The figures are not altogether consistent in indicating the exact quantity to be used for best returns. In most instances 8 per cent phosphoric acid at the rates of application used at the different localities did not give any larger yields than the 6 per cent formula at the same rate and from the same source when the ammonia and potash remained constant. There is evidence in the figures (Table 20) that there was no increase in yield for the higher rates of phosphoric acid over the lighter rates; in fact, the heavier rates, 8 and 10 per cent of phosphoric acid, seem to have lowered the yields and values of the product at Oxford, Timmonsville, and Manning. The results at Tifton show little or no increase in yield where the mixtures analyzed more than 7 per cent phosphoric acid; however, some of the values are slightly increased by higher percentages. Where this material is used in excessive quantities on the light sandy soils it often causes premature ripening ("firing") of the lower leaves of the plant, which usually decreases the yield. At Reidsville and Chatham, where heavier soils are found, the yields and values obtained with the 8 per cent mixtures were slightly better than with the 6 per cent.

TABLE 20.—*Average acre yields, gross values, and prices of leaf tobacco in fertilizer tests using phosphoric acid from different sources and at different rates at several localities in stated years*

Location, date, and treatment or plot No.	Fertilizer treatment			Yield (lbs.)	Gross value	Price per 100 pounds
	Formula	Rate per acre	Source of phosphoric acid			
Chatham, Va., 1910–1912:						
1	0-0 - 0	0	None	293	$10.37	$5.59
2	8-0 - 0	1,400	Acid phosphate	550	53.49	9.73
6	0-4 - 7	1,400	None	563	37.85	6.72
9	8-4 - 7	1,400	Acid phosphate	1,063	96.82	9.11
14	6-3 - 3½	1,400	do	803	72.31	9.00
15	8-3 - 3½	1,400	do	977	86.86	8.89
Reidsville, N. C., 1912–1915, 1917, 1918, 1920:						
1	0-0 - 0	0	None	494	71.96	14.57
3	8-0 - 0	1,600	Acid phosphate	644	104.80	16.27
7	6-4 - 3	1,600	do	1,056	179.89	17.04
8	8-4 - 3	1,600	do	1,076	186.25	17.31
Oxford, N. C., 1913–1924:						
15	0-5 -10	800	None	516	81.83	15.86
5, 9, 24, 27	8-5 -10	800	Acid phosphate	670	125.51	18.73
11, 14, 20, 23	6-5 -10	800	do	696	131.80	18.94
12, 21	6-5 -10	800	Basic slag	762	149.73	19.65
13, 22	6-5 -10	800	Raw bone meal	731	138.40	18.93
Timmonsville, S. C., 1914–1919:						
8	0-3⅓- 5	1,000	None	780	150.73	19.32
6	6-3⅓- 5	1,000	Acid phosphate	925	184.63	19.96
5	8-3⅓- 5	1,000	do	853	160.95	18.87
13	8-5 -10	1,000	do	793	146.68	18.50
4	10-5 -10	1,000	do	854	157.94	18.49
Manning, S. C., 1915, 1917, 1918:						
8	0-3⅓- 5	1,000	None	910	216.43	23.78
6	6-3⅓- 5	1,000	Acid phosphate	945	182.06	19.27
5	8-3⅓- 5	1,000	do	872	160.90	19.48
13	8-5 -10	1,000	do	1,047	220.29	21.01
4	10-5 -10	1,000	do	1,068	208.45	19.52
Tifton, Ga., 1922–1926 (cropping tests):						
2, 10, 18, 26, 34	0-3⅔- 4½	500	None	372	19.70	5.30
5, 13, 21, 20, 37	6-3⅔- 4½	500	Acid phosphate	1,043	148.76	14.26
Tifton, Ga., 1924–1926:						
7, A and B	12-3 - 5	1,000	do	1,335	258.57	19.37
8, A and B	10-3 - 5	1,000	do	1,315	202.33	19.50
9, A and B	9-3 - 5	1,000	do	1,278	248.31	19.43
3, A and B	8-3 - 5	1,000	do	1,287	247.34	19.22
10, A and B	7-3 - 5	1,000	do	1,394	250.28	17.95
11, A and B	6-3 - 5	1,000	do	1,314	238.37	18.14
12, A and B	4-3 - 5	1,000	do	1,350	223.37	16.55
13, A and B	0-3 - 5	1,000	do	1,187	175.35	14.77
14, A and B	0-0 - 0		None	761	89.57	11.77

Where no phosphoric acid is used in the fertilizer mixture the plants are slow to start growth after transplanting and commonly are very late in maturing, although if allowed to remain on the hill long enough, the tobacco finally makes a fair-sized plant. (Fig. 1.) Such a plant is usually green and hard to cure properly. The right use of phosphoric acid is of great aid in insuring the proper ripening of the tobacco plant, which is essential for good curing, a matter of great importance with flue-cured tobacco.

The phosphoric acid of the fertilizer mixtures was derived from acid phosphate, basic slag, and raw bone meal, as illustrated by the data in Table 20, relating to Oxford, N. C. In this table the use of basic slag and raw bone meal shows slight improvement in yields over acid phosphate, but in Table 30 (p. 50), where dolomite is used, this difference changes in favor of acid phosphate. The reason for this difference, therefore, would seem to be due to magnesia furnished by the basic slag and raw bone meal. The basic slag and raw bone meal produce a plant which matures later than a plant on

FIG. 1.—Tobacco showing effects of phosphoric acid (P_2O_5) in the form of acid phosphate. Plot 14 (B) fertilized with 800 pounds per acre of 0–5–10 mixture, plot 15 (A) fertilized with 800 pounds per acre of 0–5–10 mixture, Oxford, N. C., 1924 crop. (See Table 10 for yields and values)

which acid phosphate is used. This fact indicates that phosphoric acid in this form is not so quickly available as in the acid-phosphate form, for when phosphoric acid is omitted a late-maturing plant is the result. Acid phosphate therefore is the most satisfactory source of phosphoric acid, as judged by these tests.

AMMONIA TESTS

The second ingredient of the fertilizer mixture, as usually expressed in the formula, is ammonia. On account of its nitrogen content it is the most expensive component of the fertilizer mixtures used in growing flue-cured tobacco. Generally speaking, nitrogen is the most deficient element of plant food in the soils on which this type of tobacco is grown. The organic matter in these soils is very low, owing to their nature; and since most of the nitrogen of the soil is a constituent of its organic matter, when the one is low usually the other also is low. This element is essential to the proper growth of the plant. To make maximum growth, the tobacco plant must be grown in a soil in which ammonia is relatively abundant or the fertilizer used must carry a liberal supply of this ingredient. On the other hand, to obtain flue-cured tobacco of fine quality a coarse or rank type of growth must be avoided. It is essential, therefore, that the nitrogen or ammonia supply be under the control of the grower. This type of tobacco must be grown under conditions of comparative nitrogen hunger. If the nitrogen supply is too abundant in the soil the quality of the leaf for flue curing is damaged. The leaf will not cure properly and will be rough and unfit for the purposes for which flue-cured tobacco is used. Whether derived from the soil or from fertilizer, the ammonia must be readily available to the growing plant. Flue-cured tobacco is grown best with a source of ammonia which promotes rapid and uninterrupted growth. When ammonia is too abundant in the soil or fertilizer the leaf in curing remains green or turns red, brown, or sometimes almost black in color. The best product is obtained where the ammonia becomes partially exhausted at ripening time, resulting in a loss of the dark-green color of the leaves while they are yet in the field. This loss of color which starts in the field is continued in the barn, and the yellow or very light green becomes fixed in the curing process. The proper use of nitrogen gives a very light green or yellow leaf on curing, which, when the cured tobacco leaf is packed down, results in the desired clear lemon or orange-yellow color of flue-cured tobacco.

The figures given in Table 21 demonstrate strikingly that the supply of ammonia must be carefully controlled to produce tobacco of the desired yield and quality. With ammonia as its only fertilizer, flue-cured tobacco gives a fair yield, but the quality of leaf obtained is poor, as shown by the average price per 100 pounds. The quality is even poorer than where no fertilizer at all is used. This comparison is shown in treatments Nos. 1 and 3 at Chatham, Va., and treatments Nos. 1 and 2 at Reidsville, N. C. The tendency in practically every instance is to decrease the quality of the tobacco where the ammonia supply is increased abnormally without corresponding increase of the other fertilizer elements. This is especially true as regards the potash supply, which will be considered in later pages. When the supply of ammonia from a given source is increased, and the supply of phosphoric acid and potash kept constant, there is a marked tendency in some seasons for the leaf-spot diseases, including wildfire and blackfire, to be more prevalent. The proper quantity of ammonia for best yields and quality of flue-cured tobacco necessarily varies for different sources, soils, and seasons. The data presented are not very extensive, but the indications are that 30 to 40 pounds of ammonia per acre, in the fertilizer combinations tested, can be used to advantage, thus obtaining a good yield and quality.

TABLE 21.—*Average acre yields, gross values, and prices of leaf tobacco in fertilizer tests using ammonia from different sources and at different rates at several localities in stated years*

Location, date, and treatment or plot No.	Fertilizer treatment: Formula	Fertilizer treatment: Rate per acre (pounds)	Fertilizer treatment: Source of ammonia	Yield (pounds)	Gross value	Price per 100 pounds
Chatham, Va., 1910–1912:						
1	0-0 -0	0	None	293	$16.37	$5.59
3	0-4 -0	1,400	Dried blood	553	27.57	4.99
5	8-0 -7	1,400	None	713	65.59	9.20
9	8-4 -7	1,400	Dried blood	1,063	96.82	9.11
13	8-2 -3½	1,400	do	747	69.07	9.25
14	8-3 -3½	1,400	do	803	72.31	9.00
15	8-3 -3½	1,400	do	977	86.80	8.89
16	8-3 -3½	1,400	Cottonseed meal	763	68.48	8.98
17	8-3 -3½	1,400	Nitrate of soda	853	73.20	8.58
18	8-3 -3½	1,400	Ammonium sulphate	870	70.39	8.09
Reidsville, N. C., 1912–1920:						
1	0-0 -0	0	None	489	99.61	20.37
2	0-4 -0	1,600	Dried blood	671	125.15	18.65
5	6-2 -3	1,600	do	873	212.46	24.34
6	6-3 -3	1,600	do	953	227.04	23.82
7	6-4 -3	1,600	do	1,039	241.53	23.25
Reidsville, N. C., 1911, 1914, 1915, 1918, 1919:						
1	0-0 -0	0	None	514	109.14	21.23
2	8-4 -6	800	Ammonium sulphate	892	172.77	19.37
3	8-4 -6	800	Dried blood	935	227.09	24.29
4	8-4 -6	800	Nitrate of soda	938	242.81	25.89
Oxford, N. C., 1917–1924:						
17	8-0 -10	800	None	577	108.44	18.79
5, 9, 27, 34	8-5 -10	800	Dried blood	690	135.39	19.62
6, 32	8-5 -10	800	Cottonseed meal	722	164.81	22.83
7, 31	8-3¾-10	800	Nitrate of soda	732	148.09	20.23
8, 33	8-3¾-10	800	Ammonium sulphate	558	97.10	17.40
1, 20	8-5 -10	800	Nitrate of soda (⅛), ammonium sulphate (⅛), dried blood (⅜), cottonseed meal (⅜).	756	156.29	20.67
Timmonsville, S. C., 1914–1919:						
7	6-0 -5	1,000	None	660	140.69	21.32
16	6-2½-5	1,000	Dried blood	693	124.22	17.92
17	6-3⅓-5	1,000	do	846	166.98	19.74
10	8-3⅓-5	1,000	do	810	146.06	18.03
11	8-3⅓-5	1,000	Nitrate of soda	820	161.77	19.73
12	8-3⅓-5	1,000	Ammonium sulphate	722	129.63	17.95
2	8-5 -10	1,000	Dried blood	946	183.77	19.43
14	8-5 -10	1,000	Cottonseed meal	741	143.69	19.39
Manning, S. C., 1915, 1917, 1918:						
7	6-0 -5	1,000	None	687	147.14	21.42
16	6-2½-5	1,000	Dried blood	1,010	246.73	24.43
17	6-3⅓-5	1,000	do	993	215.42	21.56
10	8-3⅓-5	1,000	do	854	212.82	24.92
11	8-3⅓-5	1,000	Nitrate of soda	958	237.74	24.82
12	8-3⅓-5	1,000	Ammonium sulphate	902	162.57	18.02
2	8-5 -10	1,000	Dried blood	1,068	203.55	19.06
14	8-5 -10	1,000	Cottonseed meal	1,023	221.13	21.62
Tifton, Ga., 1922–1926:						
1, 11	8-0 -6	1,000	None	929	163.59	17.61
2, 12	8-3 -6	1,000	Cottonseed meal	1,292	273.20	21.15
3, 13	8-3 -6	1,000	Dried blood	1,242	259.66	20.91
4, 14	8-3 -6	1,000	Nitrate of soda	1,508	332.70	22.07
5, 15	8-3 -6	1,000	Ammonium sulphate	1,327	275.02	20.72
6, 16	8-3 -6	1,000	Dried blood	1,216	249.92	20.55
7, 17	8-3 -6	1,000	Dried blood (½), nitrate of soda (½).	1,342	280.58	21.35
8, 18	8-3 -6	1,000	Dried blood (⅓), nitrate of soda (⅓), cottonseed meal (⅓).	1,272	274.19	21.56
9, 19	8-3 -6	1,000	Manure	1,459	348.77	23.90
10, 20	8-4½-6	1,000	Manure (⅔), nitrate of soda (⅓).	1,661	388.80	23.41

TABLE 21.—*Average acre yields, gross values, and prices of leaf tobacco in fertilizer tests using ammonia from different sources and at different rates at several localities in stated years*—Continued

Location, date, and treatment or plot No.	Fertilizer treatment			Yield (pounds)	Gross value	Price per 100 pounds
	Formula	Rate per acre (pounds)	Source of ammonia			
Tifton, Ga., 1922-1926 (cropping tests):						
3, 11, 19, 27, 35	6-0 - 4½	500	None	873	$96.13	$11.01
5, 13, 21, 29, 37	6-3⅓- 4½	500	Dried blood	1,043	148.76	14.26
Tifton, Ga., 1922-1926:						
4	8-2 - 5	800	do	941	164.70	17.50
3	8-3 - 5	800	do	937	186.86	19.94
5	8-4 - 5	800	do	1,037	210.32	20.28
Tifton, Ga., 1924-1926:						
1, A and B	8-5 - 5	1,000	do	1,342	229.49	17.10
2, A and B	8-4 - 5	1,000	do	1,359	251.48	18.50
3, A and B	8-3 - 5	1,000	do	1,287	247.34	19.22
4, A and B	8-2 - 5	1,000	do	1,195	219.76	18.39
5, A and B	8-0 - 5	1,000	do	970	159.20	16.41
6, A and B	0-0 - 0	0	None	590	52.43	8.89

FIG. 2.—Group of tobacco plants showing potash deficiency. Plot 16, dolomite added, at Oxford, N. C., 1924 crop. (See Table 10 for yields and values.) Note the drawn, rough leaves, markedly crimped under at tips and margins. Compare with Figures 3 and 7

The source from which the ammonia is derived is of some importance. The yields given in Table 21 show no marked, consistent differences in using ammonia from different sources except at Oxford, N. C., and Tifton, Ga. At Oxford the cumulative effect of ammonium sulphate has become very marked in depressing the yield where no lime is used. However, when dolomitic limestone was used in addition to the different ammonia carriers (Table 30, p. 50), the ammonium sulphate at Oxford shows a marked improvement in yield, which is only slightly lower than yields from other sources. The quality of leaf produced, as indicated by the price per 100 pounds, is as good as that from any other ammonia carrier. Where the ammonia was derived from mixed sources at Oxford there is a slight increase in yields (Tables 21 and 30), indicating that none of the materials tested, when used as the sole source of ammonia, is as good as the mixed sources. Results at Tifton, however, show that nitrate of soda and stable manure produced decidedly the best yields and quality when compared with the other sources of ammonia. Ammonium sulphate, cottonseed meal, dried blood, and mixed nitrogen carriers gave about the same yields and value when compared one with the other. From the results at Tifton covering a period of five years, it seems that nitrogen is not a very important limiting factor in this partiular soil, especially as compared with similar tests in other localities. This fact possibly explains the above-stated results with the different sources of ammonia.

The organic ammonia carriers used in these tests do not show, on the average, any advantage over the inorganic. It is true, however, that there is less danger of an oversupply of ammonia and of its loss from leaching when organic sources are used. It would seem best therefore to use mixtures of the two, thus combining the best qualities of both.

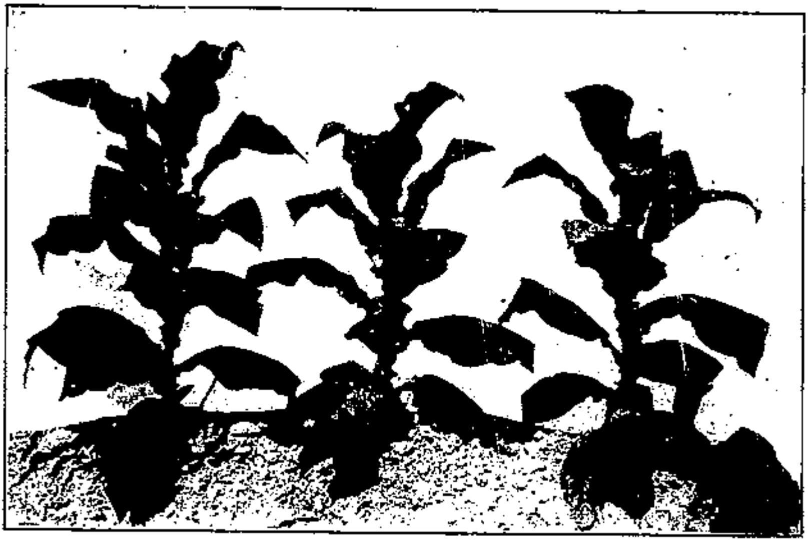
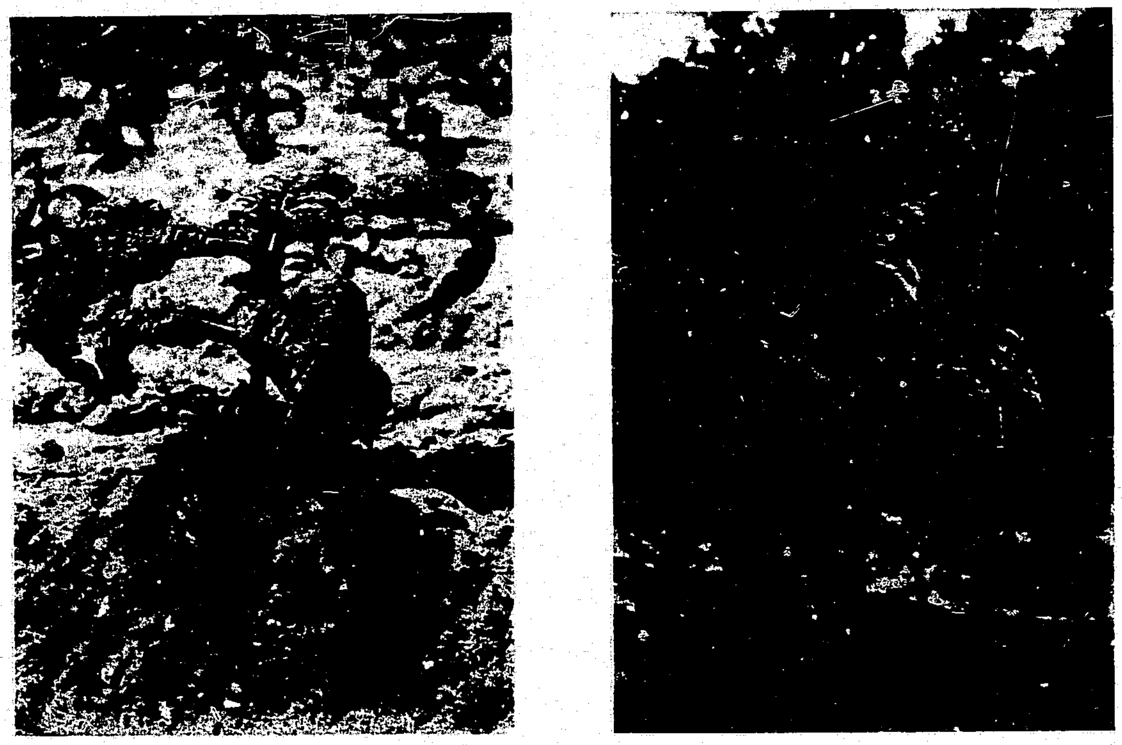


FIG. 3.—Group of tobacco plants showing type of growth obtained when the essential plant-food elements are supplied. Note the smooth leaf surface of these plants. Plot 9, dolomite added, at Oxford, N. C., 1924 crop. (See Table 10 for yields and values.) Compare with Figures 2 and 7,

POTASH TESTS

Potash, the last constituent usually expressed in the fertilizer formula, is possibly the most important ingredient of the fertilizer mixture for tobacco when quality is to be considered. Most of the soils of the flue-cured tobacco belt, especially the more typical tobacco soils, are deficient in this nutrient. A tobacco crop of the best quality always contains considerable potash in the ash. Under field conditions the growing plant always shows a characteristic, more or less abnormal type of growth when this particular fertilizer constituent is deficient in the soil and not supplied in the fertilizer. (Pl. 1, A.) The plant is smaller in size in most cases. (Figs. 2 and 3.) The leaves are puckered and rough and show considerable mottling of a light-yellow color. (Pl. 1, A.) The mottling begins at the tip of the leaf and is often followed by the appearance of small centers or specks of dead tissue. (Pl. 2, A, B.) These specks later enlarge



A B

TOBACCO PLANTS OF FLUE-CURED TYPE, SHOWING CHARACTERISTIC SYMPTOMS OF POTASH DEFICIENCY (A) AND OF MAGNESIA DEFICIENCY OR SAND DROWN (B)

(For detailed description of these symptoms, see text)

TOBACCO LEAVES SHOWING POTASH STARVATION

The chlorosis or mottling begins at the tip, as shown in initial stage (A) and progresses as shown in the later stage (B). Note the numerous small spots which represent dead tissue. This spotting or localized dying of the tissue distinguishes the symptoms of potash deficiency from those of magnesia deficiency or sand drown and coalesce, forming large dead areas around the margins and between the veins of the leaves. The dead areas fall out in some cases, causing the margins to become ragged and leaving large holes in the interior portions of the leaves. The parts of the leaves which remain green continue to grow around the dead tissue, giving the leaves a rough rim-bound type of growth. The plant as a whole has the appearance of being dark or bluish green overcast with a rusty or copper color.

Under some conditions the use of potash seems to control partially several of the leaf-spot diseases, including wildfire and blackfire, especially when used at a liberal rate. When the weather conditions favor the development of leaf-spot diseases the physiological breakdown herein described resulting from potash deficiency probably allows the organisms causing certain leaf spots to gain entrance into the plant tissue, and these hasten the breakdown of the leaf

FIG. 4.—Tobacco plants showing extreme damage sometimes caused by leaf spot when potash is omitted from the fertilizer. Compare with Figure 5, showing results from a liberal application of potash. Plot 10, Oxford, N. C., 1917 crop. (See Table 10 for yields and values)

tissue. At any rate, it is known that potash in some way aids in maintaining the general vigor of the plant. On those plots which were fertilized with a mixture carrying heavy rates of ammonia with little or no potash the various leaf-spot troubles have been more prevalent, causing serious damage; but with more potash added to the fertilizer there has been much less damage from leaf spot. This difference was especially noticeable at Oxford, N. C., in 1917 (Table 10), when the leaf-spot diseases caused serious losses generally. (Figs. 4 and 5.)

It would seem from the data in Table 22 that, with the rates of ammonia and phosphoric acid used in these tests, 40 to 60 pounds of potash (K_2O) per acre gives as satisfactory a yield as when heavier rates are used. In certain instances higher rates gave better yields, but on the whole the fertilizer mixtures carrying 5 or 6 per cent potash when used at 800 to 1,000 pounds per acre gave the most economical returns and a product of good quality. These results indicate that there is no special reason for increasing the rates of application of potash beyond 40 or 60 pounds except for the purpose of partially preventing or controlling the various leaf-spot maladies. Accurate data are not readily obtainable as to the most profitable rates of applying potash as an aid in the control of leaf-spots other than those due directly to potash hunger.

No consistent differences in the yields are obtained where American muriates and sulphates are used in comparison with the German salts. In practically every instance the muriate gives a better yield and value of tobacco than the sulphate of potash, owing in part to the fact that the muriate gives somewhat better protection against firing than does the sulphate. As will be shown later in this bulletin, however, the advantage of the muriate over the sulphate may be materially reduced when an adequate supply of magnesia is added

FIG. 5.—Tobacco plants showing comparative leaf smoothness when fertilized with a liberal application of potash. This plot received a fertilizer analyzing 8–5–20 at the rate of 800 pounds per acre. Lower rates of potash than this have seemed to control the leaf-spot trouble in average seasons. Plot 18, Oxford, N. C., 1917 crop (See Table 10 for yields and values.) Compare with Figure 4

to the soil. Moreover, at this point, it is well to call attention to the fact that the figures as to values are somewhat misleading. The values as given were obtained in such a manner as to give no consideration to one of the important factors of quality in flue-cured tobacco, namely, the burn or fire-holding capacity of the leaf. Since the prestige of flue-cured tobacco has been built up largely on the fact that it is especially suitable for manufacture of cigarettes and pipe-smoking tobaccos, this type of leaf must possess good burning qualities if it is to attain its widest degree of usefulness in this direction. The question of the burn, or fire-holding capacity of cured tobacco leaf, has been studied by careful investigators in extensive experiments too numerous to mention here. One of the outstanding results of these investigations is that tobacco grown with potash salts high in chlorine as the sole source of potash is likely to show a poor burn, and consequently a poor aroma, when compared with tobacco grown with potash derived from sources with a low content of chlorine.

It is undoubtedly true that there are various other factors which may influence the combustibility of tobacco, so that the effects of a given percentage of chlorine in the fertilizer will not be the same under all conditions. It is to be expected, of course, that other things being equal, the extent of the injury to the quality of tobacco will depend on the quantity of chlorine furnished by the potash salts used in the fertilizer.

TABLE 22.—*Average acre yields, gross values, and prices of leaf tobacco in fertilizer tests using potash from different sources and at different rates at several localities in stated years*

Location, date, and treatment or plot No.	Fertilizer treatment			Yield (pounds)	Gross value	Price per 100 pounds
	Formula	Rate per acre (pounds)	Source of potash			
Chatham, Va., 1910–1912, 1914:						
1	0-0 -0	0	None	283	$13.53	$4.78
4	0-0 -7	1,400	Sulphate	500	27.28	5.46
7	8-4 -0	1,400	None	823	60.05	7.30
8	8-4 -3½	1,400	Sulphate	1,023	84.22	8.23
9	8-4 -7	1,400	do	1,068	97.12	9.09
Reidsville, N. C., 1912–1915, 1917, 1918, 1920:						
4	8-4 -0	1,600	None	840	132.72	15.80
8	8-4 -3	1,600	Sulphate	1,076	186.25	17.31
Reidsville, N. C., 1919–1923:						
1, 6, 11, 12, 17, 22	8-5 -0	800	None	618	104.28	16.87
2, 13	8-5 -1½	800	Sulphate	716	131.32	18.34
3, 14		800	Muriate	731	154.53	21.14
4, 15	8-5 -3	800	Sulphate	690	124.12	17.99
5, 16		800	Muriate	761	150.30	19.75
7, 18	8-5 -4½	800	Sulphate	786	149.78	19.06
8, 19		800	Muriate	831	186.70	22.47
9, 20	8-5 -10	800	Sulphate	763	143.27	18.78
10, 21		800	Muriate	898	195.69	21.79
Oxford, N. C., 1914–1924:						
16	8-5 -0	800	None	445	56.08	12.60
30	8-5 -5	800	Sulphate	652	122.69	18.82
27, 34	8-5 -10	800	do	705	131.80	18.70
18	8-5 -20	800	do	779	147.17	18.89
26, 35	8-5 -10	800	Muriate	829	181.84	21.93
Oxford, N. C., 1917–1924:						
1, 8	8-5 -0	800	None	409	85.71	20.96
2	8-5 -1½	800	Sulphate	510	142.12	27.87
3		800	Muriate	595	169.49	28.49
4	8-5 -3	800	Sulphate	609	175.53	28.82
5		800	Muriate	676	224.86	33.26
6	8-5 -4½	800	Sulphate	631	190.16	30.14
7		800	Muriate	720	255.63	35.50
9	8-5 -10	800	Sulphate	623	169.64	27.23
10		800	Muriate	708	233.96	33.05
Timmonsville, S. C., 1914–1919:						
9	6-3⅓-0	1,000	None	706	129.07	18.28
6	6-3⅓-5	1,000	Sulphate	925	184.63	19.96
18	8-3⅓-5	1,000	do	897	162.81	18.15
3	8-3⅓-10	1,000	do	862	158.07	18.34
Manning, S. C., 1915, 1917, 1918:						
9	6-3⅓-0	1,000	None	820	145.11	17.70
6	6-3⅓-5	1,000	Sulphate	945	182.06	19.27
18	8-3⅓-5	1,000	do	883	210.45	23.83
3	8-3⅓-10	1,000	do	943	189.91	20.14

TABLE 22.—*Average acre yields, gross values, and prices of leaf tobacco in fertilizer tests using potash from different sources and at different rates at several localities in stated years*—Continued

Location, date, and treatment or plot No.	Fertilizer treatment			Yield (pounds)	Gross value	Price per 100 pounds
	Formula	Rate per acre (pounds)	Source of potash			
Tifton, Ga., 1922-1926:						
1, 10, 19	8-3 -0	1,000	None	740	$90.18	$13.29
2, 11	8-3 -3	1,000	American sulphate	1,146	233.76	20.40
3, 12	8-3 -3	1,000	American muriate	1,110	245.29	21.92
4, 13	8-3 -3	1,000	Sulphate of potash magnesia	1,007	207.23	20.58
5, 14	8-3 -3	1,000	Kainit	1,300	268.96	20.69
7, 16	8-3 -0	1,000	German sulphate	1,139	236.18	20.74
8, 17	8-3 -0	1,000	German muriate	1,286	272.96	21.23
9, 18	8-3 -0	1,000	Sulphate of potash magnesia	1,240	261.20	21.06
Tifton, Ga., 1922-1926 (cropping tests):						
1, 9, 17, 25, 33	6-3⅓-0	500	None	687	70.73	10.30
5, 13, 21, 29, 37	6-3⅔-1½	500	Sulphate of potash magnesia	1,043	148.76	14.26
Tifton, Ga., 1922-1926 (formula tests):						
2	8-3 -3	800	Sulphate	879	170.19	19.36
3	8-3 -5	800	do	937	186.80	19.94
1	8-3 -7	800	do	867	177.77	20.50
Tifton, Ga., 1924-1920:						
14, A and B	0-0 -0	None.	None	761	89.57	11.77
15, A and B	8-3 -8	1,000	Sulphate	1,422	273.54	19.24
16, A and B	8-3 -6	1,000	do	1,359	239.62	17.63
3, A and B	8-3 -5	1,000	do	1,287	247.34	19.22
17, A and B	8-3 -4	1,000	do	1,338	199.43	14.91
18, A and B	8-3 -3	1,000	do	1,245	179.59	14.42
19, A and B	8-3 -2	1,000	do	1,201	162.47	13.53
20, A and B	8-3 -0	1,000	None	768	54.32	7.07

From the standpoint of the smoker it is extremely difficult, if not impossible, to determine the exact degree of combustibility which flue-cured tobacco should possess for the best results, or to specify the quantity of chlorine required to exert a given effect on the combustibility of the tobacco. In this connection, however, it is to be remembered that any shortcoming in bright leaf as to combustibility will favor increasing partial substitution of other and better burning types for blending purposes on the part of the manufacturer in order to insure satisfactory combustibility in the finished product. Obviously, the interests of the flue-cured tobacco industry as a whole will be best served by the general use of fertilizers which will aid in producing free-burning tobacco, in addition to insuring satisfactory results as to the other elements of quality and as to yield. It is to be remembered also that differences in burning qualities are not taken into account by buyers in arriving at comparative valuations for different crops or grades of flue-cured tobacco, so that relative market prices do not accurately reflect differences in smoking qualities. On the other hand, the demand for the bright type of tobacco as a whole, the ability of the tobacco to withstand the competition of other types, and the general price level it is able to maintain will be materially affected in the long run by the quality of the product, and one of the prime elements of quality is good burn.

In order to obtain direct evidence as to the effects of different forms of potash on the burning qualities, samples of the cured leaf from the potash-test plots were subjected to systematic tests in several instances, and the results are shown in Tables 23 to 28. In making these tests the leaf was ignited at several points by means of an artificially prepared punk stick, and a record was made of the number of seconds the ignited leaf continued to glow. In some cases the tobacco also was made into cigarettes which were tested as to fire-holding capacity, rate of burn, and color of ash.

TABLE 23.—*Potash from different sources and applied at different rates as related to the burn or fire-holding capacity of leaf tobacco grown at Oxford, N. C., 1916, 1917, and 1923*

[Tests made by the punk-stick method. See Table 11, page 24, for details of fertilizer treatment]

Plot No.	Fertilizer treatment		Duration of glow by grades (seconds)												
			1916 crop							1917 crop				1923 crop	
	Formula	Source of potash	Trash lug or third lug	Sand lug or second lug	Best or first lug	First leaf	Second leaf	Tips or third leaf	Average	Lug	Leaf	Tips	Average	No dolomite	Dolomite
1	8-5-0	None	----	----	----	----	----	----	----	7.3	9.3	7.0	7.9	----	----
2	8-5-1½	Sulphate	10.5	9.0	13.0	12.0	10.1	8.5	10.5	11.5	10.1	7.2	9.0	----	----
3	8-5-1½	Muriate	8.4	12.3	9.7	9.7	10.4	12.4	10.5	8.8	8.1	6.2	7.7	----	----
4	8-5-3	Sulphate	9.4	11.0	10.7	11.7	12.4	12.4	11.3	9.7	9.0	6.1	8.3	----	----
5	8-5-3	Muriate	5.3	6.7	8.0	8.7	8.6	8.9	7.7	5.4	5.9	4.2	5.2	----	----
6	8-5-4½	Sulphate	10.5	10.0	10.0	10.3	9.0	8.5	9.9	8.8	10.6	7.6	9.0	12.7	11.8
7	8-5-4½	Muriate	5.8	7.2	7.1	7.3	5.7	7.2	6.7	4.8	7.0	5.1	5.6	9.4	7.1
8	8-5-0	None	10.0	12.4	11.5	11.7	11.2	11.5	11.4	11.7	10.0	7.5	9.9	----	----
9	8-5-10	Sulphate	----	----	----	----	----	----	----	16.7	12.1	6.0	11.6	8.2	14.4
10	8-5-10	Muriate	----	----	----	----	----	----	----	5.5	3.9	3.6	4.3	9.7	8.3

TABLE 24.—*Potash from different sources and applied at different rates as related to the burn or fire-holding capacity of cigarettes made from leaf tobacco grown at Oxford, N. C., 1915–1917*

[See Table 11 for details of fertilizer treatment]

Plot No.	Fertilizer treatment		Average duration of cigarette burning (minutes)		
			Ceased to glow		Entirely consumed, 1917 crop
	Formula	Source of potash	1915 crop	1916 crop	
1	8-5-0	None	4.8	4.5	6.3
2	8-5-1½	Sulphate	----	5.3	7.3
3	8-5-1½	Muriate	----	4.6	8.3
4	8-5-3	Sulphate	----	5.2	7.3
5	8-5-3	Muriate	----	4.4	7.3
6	8-5-4½	Sulphate	10.0	4.7	6.2
7	8-5-4½	Muriate	9.6	3.5	9.5

TABLE 25.—*Relation of potash from different sources in combination with calcitic and dolomitic limestones to the burn or fire-holding capacity of leaf tobacco grown at Oxford, N. C., 1924*

[Tests made by the punk-stick method. See Table 12 for details of fertilizer treatment]

Plot No.	Source of potash	Average duration of glow (seconds)			
		Calcitic limestone	No limestone	Dolomitic limestone	Average
1-3	American muriate	7.31	7.09	6.87	7.09
4-6	German muriate	7.22	6.09	7.39	6.90
16-18	Kainit	5.08	3.12	4.53	4.24
7-9	American sulphate	10.35	8.03	8.73	9.04
10-12	German sulphate	11.39	7.54	8.39	9.11
13-15	Sulphate of potash magnesia	10.27	8.47	6.49	8.41
	Average for salts of high and low chlorine content:				
1-6, 16-18	Chloride salts	6.54	5.43	6.26	6.08
7-15	Sulphate salts	10.67	8.01	7.87	8.85

TABLE 26.—*Relation of potash from different sources to the burn of leaf tobacco grown at Clarkton, N. C., 1923*

[All plots received 800 pounds per acre of 8-5-4½ formula. Acid phosphate was the source of phosphoric acid, dried blood the source of ammonia; source of potash was as shown]

Plot No.	Source of potash	Punk-stick method, duration of glow (seconds)	Average of cigarette trials		
			Consumed before ceasing to burn (per cent)	Ceased to glow (minutes)	Color of ash
1	American muriate	6.63	26	2.91	Black.
2	German muriate	5.70	30	0.30	Do.
3	American sulphate	11.66	86	10.95	White.
4	German sulphate	15.10	90	13.15	Do.
5	Sulphate of potash magnesia	13.24	83	8.38	Gray.
6	Kainit	4.96	24	2.85	Black.
	Average for salts of high and low chlorine content:				
1, 2, 6	Chloride salts	5.76	29	4.02	Do.
3, 4, 5	Sulphate salts	13.33	86	10.83	White.

TABLE 27.—*Potash from different sources and applied at different rates as related to the burn of leaf tobacco grown at Wentworth, N. C., 1925*

[Tests made by the punk-stick method. All plots received the formulas shown at the rate of 800 pounds per acre. Acid phosphate was the source of phosphoric acid; ammonia was derived from dried blood, nitrate of soda, fish meal, cottonseed meal, and ammonium sulphate, one-fifth from each; potash as indicated]

Plot No.	Fertilizer treatment		Duration of glow by grades (seconds)			
	Formula	Source of potash	Lugs	Leaf	Tips	Average
1	8-3-0	None	4.1	4.3	5.8	4.7
2	8-3-2½	Sulphate	6.0	7.3	6.9	6.7
3	8-3-2½	Muriate	3.5	5.4	6.1	5.0
6	8-3-7½	Sulphate	7.3	8.1	8.1	7.8
7	8-3-7½	Muriate	1.1	2.0	4.0	2.4
10	8-3-12½	Sulphate	6.7	5.5	6.2	6.1
11	8-3-12½	Muriate	1.0	2.1	3.0	2.2

TABLE 28.—*Potash from different sources and applied at different rates as related to the burn of leaf tobacco grown at Tifton, Ga., 1926*

[Tests made by the punk-stick method. See Table 10 for details of fertilizer treatment]

Plot No.	Fertilizer treatment		Duration of glow (seconds)			
	Formula	Source of potash	First priming	Third priming	Fourth priming	Average
1, 10, 19	8-3-0	None	5.4	9.0	7.2	7.2
2, 11	8-3-3	American sulphate	4.4	8.7	7.6	6.9
3, 12	8-3-3	American muriate	5.2	6.2	5.6	5.7
4, 13	8-3-3	Sulphate of potash magnesia	5.7	7.6	6.9	6.7
5, 14	8-3-3	Kainit	1.2	2.8	4.0	2.7
6, 15	8-3-6	American sulphate (½), American muriate (½)	5.2	6.7	6.4	5.8
7, 16	8-3-6	German sulphate	5.0	7.2	6.9	6.4
8, 17	8-3-6	German muriate	2.0	4.3	4.6	3.6
9, 18	8-3-6	Sulphate of potash magnesia	3.6	6.7	5.8	5.4
20	8-3-6	American sulphate (½), kainit (½)	.2	2.8	4.0	2.3

From Tables 23 to 28 it can readily be seen that in practically every instance flue-cured tobacco grown with potash derived from salts carrying large percentages of chlorine, such as muriate and kainit, show a lower fire-holding capacity and a slower burn than leaf grown without potash or with its potash derived from salts carrying little or no chlorine, such as high-grade sulphate of potash and sulphate of potash magnesia. In practically every instance this harmful effect on the burn of salts containing considerable quantities of chlorine becomes more marked as the rate of potash application increases. In view of the fact that high-grade muriate of potash

FIG. 6.—Tobacco, fertilized (A, plot 11) and unfertilized (B, plot 10), Oxford, N. C., 1924 crop. (See Table 10 for yields and values)

does not seem to harm materially the burn of the leaf when used at the lighter rates, there probably would be some advantage in using a mixture of muriate and sulphate as sources of potash, provided the quantity of chlorine supplied is not in excess of 20 to 25 pounds per acre, thus obtaining maximum results as to yield without serious injury to the quality of the product.

Although these burning tests (Tables 23 to 28) give a direct comparison of the effect of potash salts high in chlorine and low in chlorine on the combustion of leaf tobacco in different localities, the data presented are not to be construed as accurately portraying the burning qualities of tobacco of a given locality, since the results usually cover the crop for only one year on the particular soil areas used in the tests.

FERTILIZER RATE-OF-APPLICATION TESTS

Flue-cured tobacco is grown mostly on soils which require fertilizers, and by their use the grower is able to control to some extent the yield and type of growth of the crop. As a rule this type of tobacco is grown under conditions of restricted plant-food supply, especially with respect to nitrogen or ammonia. It is only by the intelligent use of fertilizers that the desired product is obtained.

Table 29 and Figure 6 show conclusively the necessity for the use of a fertilizer to produce flue-cured tobacco on the soils used in these tests. The results as to the best rate to use do not show very striking differences in some instances, but in every case where the rate of application was increased the yield also was increased. The gross return per acre in each case shows enough increase in yield for a profit above the cost of the fertilizer. It can be seen that there is a tendency toward decrease in quality of the tobacco where the rate of application is increased abnormally. This is shown in the price per 100 pounds of leaf in the Reidsville and Oxford, N. C., figures.

TABLE 29.—*Average acre yields, gross values, and prices of leaf tobacco grown in fertilizer tests for different localities in stated years*

Location and treatment or plot No.	Fertilizer treatment		Yield (pounds)	Gross value	Price per 100 pounds
	Formula	Rate per acre (pounds)			
Chatham, Va., 1910–1912:					
1	0-0-0	0	203	$16.37	$5.59
10	8-3-3	800	747	69.08	9.25
12	8-3-3	1,400	1,043	96.64	9.27
Reidsville, N. C., 1912–1915, 1917, 1918, 1920:					
1	0-0-0	0	494	71.96	14.57
9	8-3-3	500	779	141.89	18.21
8	8-4-3	1,600	1,076	186.25	17.31
Oxford, N. C., 1913–1924:					
10, 19, 36	0-0-0	0	248	35.52	14.32
4, 25	8-5-10	600	638	120.01	18.81
2, 5, 24, 27	8-5-10	800	677	127.70	18.86
3, 26	8-5-10	1,000	758	138.68	18.30
Timmonsville, S. C., 1914–1919:					
1	0-0-0	0	580	102.49	17.67
15	8-3-3	900	890	183.32	20.60
Manning, S. C., 1915, 1917, 1918:					
1, 20	0-0-0	0	576	95.71	16.62
15	8-3-3	800	818	189.32	23.14
Tifton, Ga., 1922–1926:					
8, 16, 24, 32, 40	0-0-0	0	246	6.54	2.66
5, 13, 21, 29, 37	6-3⅔-4½	500	1,043	148.76	14.26
7, 15, 23, 31, 39	6-3⅔-4½	1,000	1,332	233.80	17.55

MAGNESIA TESTS

The question as to whether lime is required for tobacco to give the best yield and quality has been much studied and very little understood. The use of lime is not usually recommended, because in some sections it favors the development of black root rot (*Thielavia basicola*), and under special conditions, particularly where the soil contains considerable humus, it liberates ammonia in the soil for the growing plant, giving a rank, dark-green growth which is very undesirable for flue-cured tobacco. It is known that tobacco is not as sensitive to soil acidity as are some other crops, and as a rule the plant seems to grow best on moderately acid soils. It appears that under some conditions the cautious use of lime for tobacco may give profitable returns.

In the fertilizer tests at Oxford, N. C., where a liberal supply of phosphoric acid, ammonia, and potash had been used, it was found that a characteristic chlorosis developed (pl. 1, B), which lowered the yield and quality of the tobacco produced. This trouble was found to be due to an insufficient supply of magnesia in the soil and fertilizer. It was found that by using dolomitic limestone this trouble could be corrected, the yield increased, and the quality improved. (Tables 30 to 32.) This chlorosis was also remedied by using potash salts carrying magnesia and was partially controlled by light applications of cottonseed meal and other organic sources of ammonia carrying magnesia. Basic slag and raw bone meal when used in the fertilizer mixture seemed to control partially this trouble. Muriate of potash also seems to give partial control of this trouble, but this effect is not lasting when it is used continuously on the same soil. Symptoms of magnesium deficiency are more noticeable in wet seasons and on sandy soil, and for this reason it is commonly known as "sand drown."

The fact that this chlorosis is prevented by various salts of magnesia, such as the sulphate and the chloride, shows that the value of dolomitic limestone as a remedy for the trouble does not depend on its action in correcting soil acidity. A clear distinction is to be made, therefore, between the use of lime, as such, for tobacco and the use of dolomitic limestone as a remedy for sand drown or magnesium deficiency.

TABLE 30.—*Summary of the effects of dolomitic limestone on yields, gross values, and average prices of leaf tobacco in tests of fertilizers from different sources and applied at different rates at Oxford, N. C., 1920–1924*

Plot No.	Fertilizer treatment					Dolomite treatment			No dolomite		
	Formula	Rate per acre (pounds)	Source			Acre yield (pounds)	Acre value	Price per 100 pounds	Acre yield (pounds)	Acre value	Price per 100 pounds
			Phosphoric acid	Ammonia	Potash						
10, 19, 36	0-0-0	0	None	None	None	344	$44.50	$12.94	307	$37.50	$12.21
4, 25	8-5-10	600	Acid phosphate	Dried blood	Sulphate	962	205.87	21.40	663	106.33	16.04
2, 5, 24, 27	8-5-10	800	do	do	do	965	203.43	21.08	711	114.86	16.15
3, 26	8-5-10	1,000	do	do	do	1,013	213.61	21.09	784	115.24	14.70
17	8-0-10	800	do	None	do	700	148.62	21.23	654	99.65	15.24
5, 9, 27, 34	8-5-10	800	do	Dried blood	do	942	197.60	20.99	721	113.26	15.71
6, 32	8-5-10	800	do	Cottonseed meal	do	893	185.12	20.73	724	129.97	17.95
7, 31	8-3¾-10	800	do	Nitrate of soda	do	918	186.57	20.32	734	118.61	16.16
8, 33	8-3¾-10	800	do	Ammonium sulphate	do	846	174.76	20.66	556	78.38	14.10
1, 29	8-5-10	800	do	Ammonium sulphate (⅛), nitrate of soda (⅛), dried blood (⅜), cottonseed meal (⅜).	do	960	194.47	20.26	788	124.68	15.82
15	0-5-10	800	None	Dried blood	do	732	136.48	18.64	600	74.98	12.50
5, 9, 24, 27	8-5-10	800	Acid phosphate	do	do	959	200.41	20.90	686	109.33	15.94
11, 14, 20, 23	6-5-10	800	do	do	do	998	214.88	21.53	730	119.71	16.40
12, 21	6-5-10	800	Basic slag	do	do	934	177.77	19.03	869	142.03	16.34
13, 22	6-5-10	800	Raw bone meal	do	do	936	175.09	18.71	800	125.84	15.73
16	8-5-0	800	Acid phosphate	do	None	584	74.90	12.83	540	49.39	9.15
30	8-5-5	800	do	do	Sulphate	864	176.84	20.47	662	103.40	15.62
27, 34	8-5-10	800	do	do	do	934	193.69	20.74	726	115.39	15.89
18	8-5-20	800	do	do	do	1,036	235.99	22.78	860	135.08	15.71
28, 35	8-5-10	800	do	do	Muriate	1,061	234.14	22.07	864	153.85	17.81

TABLE 31.—*Summary of acre yields, gross values, and average prices of leaf tobacco in fertilizer tests using potash from different sources and applied at different rates, with and without dolomitic limestone, at Oxford, N. C., 1920–1924*

[See Table 11 for details of fertilizer treatment]

Plot No.	Fertilizer treatment		Dolomite treatment			No dolomite		
	Formula	Source of potash	Yield (lbs.)	Gross value	Price per 100 pounds	Yield (lbs.)	Gross value	Price per 100 pounds
1	8-5-0	None	494	$94.28	$19.09	466	$92.30	$19.81
2	8-5-1½	Sulphate	676	143.00	21.29	476	109.18	22.94
3	8-5-1½	Muriate	718	169.37	23.59	610	141.26	23.16
4	8-5-3	Sulphate	720	156.40	21.72	588	128.74	21.89
5	8-5-3	Muriate	856	208.92	24.41	674	160.59	23.83
6	8-5-4½	Sulphate	814	193.24	23.74	616	138.58	22.50
7	8-5-4½	Muriate	874	192.41	22.01	700	174.30	24.90
8	8-5-0	None	514	92.75	18.04	486	89.29	18.37
9	8-5-10	Sulphate	644	149.05	23.14	686	137.87	20.10
10	8-5-10	Muriate	814	195.45	24.01	714	159.86	22.39
Average, without regard to sources of potash:								
1, 8	8-5-0	None	504	93.52	18.56	476	90.80	19.08
2, 3	8-5-1½	Sulphate and muriate	697	156.64	22.47	543	125.22	23.06
4, 5	8-5-3	do	788	182.66	23.18	631	144.67	22.93
6, 7	8-5-4½	do	844	192.83	22.85	656	156.44	23.78
9, 10	8-5-10	do	729	172.25	23.63	700	148.87	21.27

TABLE 32.—*Summary of acre yields, gross values, and average prices of leaf tobacco in fertilizer tests using potash from different sources in combination with calcitic and dolomitic limestone, at Oxford, N. C., 1921–1924*

[See Table 12 for details of fertilizer treatment]

Plot No.	Fertilizer treatment		Yield (pounds)	Gross value	Price per 100 pounds
	Source of potash	Form of limestone			
1	American muriate	Calcitic	673	$162.98	$24.22
2	American muriate	None	793	207.94	26.22
3	American muriate	Dolomitic	900	247.44	27.49
4	German muriate	Calcitic	713	176.44	24.75
5	German muriate	None	720	188.60	26.19
6	German muriate	Dolomitic	955	280.30	29.35
7	American sulphate	Calcitic	598	132.82	22.21
8	American sulphate	None	550	135.97	24.72
9	American sulphate	Dolomitic	848	237.39	27.99
10	German sulphate	Calcitic	733	175.06	23.88
11	German sulphate	None	560	132.32	23.63
12	German sulphate	Dolomitic	848	239.58	28.25
13	Sulphate of potash magnesia	Calcitic	840	219.05	26.08
14	Sulphate of potash magnesia	None	853	240.78	28.23
15	Sulphate of potash magnesia	Dolomitic	835	234.79	28.12
16	Kainit	Calcitic	878	217.32	24.75
17	Kainit	None	930	249.81	26.86
18	Kainit	Dolomitic	1,068	285.29	26.71
Average for potash salts of similar composition:					
1, 4	American and German muriates	Calcitic	693	169.71	24.49
2, 5	American and German muriates	None	757	198.27	26.19
3, 6	American and German muriates	Dolomitic	928	263.87	28.43
7, 10	American and German sulphates	Calcitic	666	153.94	23.11
8, 11	American and German sulphates	None	555	134.15	24.17
9, 12	American and German sulphates	Dolomitic	848	238.49	28.12
13, 16	Sulphate of potash magnesia and kainit	Calcitic	859	218.19	25.40
14, 17	Sulphate of potash magnesia and kainit	None	892	245.30	27.50
15, 18	Sulphate of potash magnesia and kainit	Dolomitic	952	260.04	27.32

This trouble of magnesium deficiency is very characteristic, as is illustrated by Plates 1, B, and 3. Ordinarily it develops first on the lower leaves of the plant, usually beginning at the tip and progressing inwardly on the leaf toward its base, along the margins and between the veins. The malady advances progressively from the lower leaves of the plant upward. The relative severity and progress of the disease are shown by the extent of the loss of green color in the leaf. (Pl. 1, B.) At times only the tip of the leaf will be pale green or almost white; then again only the veins will remain green, and in extreme cases even the veins lose most of their green color and the entire leaf area of the plant becomes almost white. In all cases observed the bud tends to remain green. This type of chlorosis is distinguished from the mottling characteristic of potash deficiency in that the leaf tissue does not break down so readily (compare pls. 2 and 3). Plants manifesting symptoms of potash deficiency show discolored areas of the leaf of a light-yellow color which occur in splotches between the veins, and on these specking frequently is to

FIG. 7.—Group of tobacco plants showing magnesia deficiency. Plot 9, no-dolomite portion, Oxford, N. C., 1924 crop. (See Table 10 for yields and values.) Note small size of plants. Compare with Figures 2 and 3

be found; whereas the discolored areas caused by magnesia deficiency give a very light-green or almost white color and progress more regularly from the tip toward the base of the leaf at the margins and between the veins. The magnesia chlorosis also progresses more uniformly from the base of the plant upward (compare pl. 1, A and B). The puckered or savoyed effect commonly seen in cases of pronounced potash deficiency is absent in magnesia deficiency. In magnesia deficiency the leaf has usually reached full size before the translocation of the magnesia from the lower to the upper parts of the plant takes place, and the plant therefore is not as rough (compare figs. 2 and 7) as a plant showing potash deficiency. Both troubles are sometimes confined largely to one side of the leaf.

The lime used on the Chatham, Va., field was builders' lime, which does not contain much magnesia, and it was applied broadcast in the spring before the tobacco was transplanted. At this location the liming does not seem to have given any benefit when a liberal application of fertilizer was used. It does show, however (Table 33), an

TOBACCO LEAVES, FLUE-CURED TYPE, SHOWING CHLOROSIS OR SAND DROWN CAUSED BY MAGNESIUM DEFICIENCY

Leaf A has lost practically all green color except at its base and along the large veins. These leaves represent very well the stages that may be seen on an individual plant from its base upward (A to D) increase in the yield on the unfertilized plot and on all plots receiving only acid phosphate or sulphate of potash. It also shows an increased yield when used in combination with either nitrate of soda or ammonium sulphate as sources of ammonia. In most cases where dried blood has been used as the source of ammonia the use of lime actually shows a decreased yield.

TABLE 33.—*Summary of the effects of lime on acre yields, gross values, and average prices of leaf tobacco in tests of fertilizers from different sources and applied at different rates at Chatham, Va., 1910–1912*

Treatment No.	Fertilizer treatment: Formula	Fertilizer treatment: Rate per acre (lbs.)	Source: Phosphoric acid	Source: Ammonia	Source: Potash	Limed: Yield (lbs.)	Limed: Gross value	Limed: Price per 100 lbs.	Unlimed: Yield (lbs.)	Unlimed: Gross value	Unlimed: Price per 100 lbs.
1	0-0-0	0	None	None	None	405	$20.96	$5.18	293	$16.37	$5.59
2	8-0-0	1,400	Acid phosphate.	do	do	720	73.88	10.26	550	53.49	9.73
3	0-4-0	1,400	None	Dried blood	do	593	31.22	5.26	553	27.57	4.99
4	0-0-7	1,400	do	None	Sulphate	623	37.58	6.03	553	33.04	5.97
5	8-0-7	1,400	Acid phosphate.	do	do	707	55.96	7.92	713	65.59	9.20
6	0-4-7	1,400	None	Dried blood	do	570	37.53	6.58	563	37.85	6.72
7	8-4-0	1,400	Acid phosphate.	do	None	753	55.08	7.31	790	61.77	7.82
8	8-4-3½	1,400	do	do	Sulphate	917	78.22	8.53	1,030	88.42	8.58
9	8-4-7	1,400	do	do	do	996	84.17	8.45	1,063	96.82	9.11
10	8-3-3	800	Unknown	Unknown	Unknown	783	65.38	8.35	747	69.08	9.25
11	8-3-6	800	Acid phosphate.	Dried blood	Sulphate	703	62.91	8.95	667	58.71	8.80
12	6-3-3	1,400	Unknown	Unknown	Unknown	923	84.38	9.14	1,043	96.04	9.27
13	6-2-3½	1,400	Acid phosphate	Dried blood	Sulphate	847	85.39	10.08	747	69.07	9.25
14	6-3-3½	1,400	do	do	do	937	76.92	8.21	803	72.31	9.00
15	8-3-3½	1,400	do	do	do	828	75.76	9.15	977	86.86	8.89
16	8-3-3½	1,400	do	Cottonseed meal.	do	897	84.92	9.47	763	68.46	8.98
17	8-3-3½	1,400	do	Nitrate of soda.	do	1,080	90.16	8.35	853	73.20	8.58
18	8-3-3½	1,400	do	Ammonium sulphate.	do	1,070	83.72	7.82	870	70.39	8.09

Lime, as ground limestone in both the calcitic and dolomitic forms, seems to have given some increases in yields and values at Reidsville, N. C. There is no indication in Table 34 that the use of magnesia in any form produced increased yields. However, in another test at Reidsville, which is not reported here, magnesia gave larger yields and better quality of leaf.

The question of the value of lime at Oxford, N. C., seems to be one largely of the magnesia which the lime contains. Ground dolomitic limestone gave strikingly better yields whenever used in combination with phosphoric acid, ammonia, and potash from sources which are low in magnesia. From Table 30, showing the effects of dolomitic limestone on the action of different formulas and rates of application of fertilizers from various sources, it can be seen that this form of lime gave only slightly better yields when used without any fertilizer, but when fertilizer was used there was a marked improvement in both yield and gross value of the crop per acre. The quality of the leaf tobacco produced was very much improved, as is indicated by the average price per 100 pounds. The largest increase obtained was where dolomitic limestone was used with ammonium sulphate as the source of ammonia. (Table 30 and figs. 8 and 9.) The dolomite treatment also shows a marked improvement in the yields and values of all plots receiving acid phosphate as the source of phosphoric acid. This is especially so where 600 pounds of the 8–5–10 formula and 800 pounds of the 6–5–10 formula were applied. (Table 30.)

TABLE 34.—*Summary of acre yields, gross values, and average prices of leaf tobacco in fertilizer tests using potash from different sources, in combination with calcitic and dolomitic limestone, at Reidsville, N. C., 1919–1923*

[See Table 9 for details of fertilizer treatment]

Plot No.	Fertilizer treatment		Yield (pounds)	Gross value	Price per 100 pounds
	Source of potash	Form of limestone			
1	American muriate	Calcitic	1,173	$211.81	$18.06
2		None	880	168.95	19.20
3		Dolomitic	1,001	187.66	18.75
4	German muriate	Calcitic	925	174.68	18.88
5		None	948	184.72	19.49
6		Dolomitic	1,010	198.03	19.61
7	American sulphate	Calcitic	915	167.31	18.29
8		None	921	136.86	14.86
9		Dolomitic	960	185.79	19.35
10	German sulphate	Calcitic	949	167.29	17.63
11		None	920	150.24	16.33
12		Dolomitic	914	168.76	18.46
13	Sulphate of potash magnesia	Calcitic	1,004	191.65	19.09
14		None	839	159.82	19.05
15		Dolomitic	924	166.24	17.99
16	Kainit	Calcitic	919	177.21	19.28
17		None	941	179.16	19.04
18		Dolomitic	969	185.79	19.17
	Average for potash salts of similar composition				
1, 4	American and German muriates	Calcitic	1,049	193.25	18.42
2, 5		None	914	176.84	19.35
3, 6		Dolomitic	1,006	192.85	19.17
7, 10	American and German sulphates	Calcitic	932	167.30	17.95
8, 11		None	921	143.55	15.59
9, 12		Dolomitic	937	177.28	18.92
13, 16	Sulphate of potash magnesia and kainit	Calcitic	962	184.43	19.17
14, 17		None	890	169.49	19.04
15, 18		Dolomitic	947	176.02	18.59

Where dolomitic limestone was used (Table 31) in combination with different rates of application of sulphates and muriates of potash it is evident that this material is most effective in increasing the yield and value of the crop when used in connection with sulphate of potash. The sulphate treatments more nearly approach the muriate of potash treatments in yield and value of crop when both are used in combination with dolomitic limestone, as shown in Tables 31 and 32.

That the action of dolomitic limestone is largely one of supplying magnesia is shown in Table 32, giving results where calcitic and dolomitic limestones are compared with no-lime treatments in connection with the use of different sources of potash, some of which supply magnesia while others do not. Calcite in combination with the muriates gives no beneficial effects, but dolomite shows marked increases in yields when used with the muriates. Calcite shows some better yields over no limestone when used with the sulphates of potash, but dolomite gives much greater differences in conjunction with the sulphates of potash. The sulphate yields more nearly approach those of the muriates when both are used with dolomite, as heretofore pointed out in other instances. Where the potash salts carrying magnesia, namely, kainit and sulphate of potash magnesia, are used, there is no beneficial effect from the use of calcite.

The use of dolomite (Table 35) does not show any increase in yields at Tifton, Ga., which, doubtless, is due to the fact that the potash was derived from sulphate of potash magnesia. In Table 22, where sulphate of potash magnesia was used to supply potash at the rate of 60 pounds per acre, there was a slight increase over German sulphate of potash, which furnishes little or no magnesia. In another test at Tifton, the results of which are not reported here, decided increases in yields and quality of the tobacco were produced where magnesia was supplied.

FIG. 8.—Group of tobacco plants showing poor growth and severe magnesium-deficiency symptoms or sand drown. No-dolomite end of plot 8, which received ammonium sulphate as its source of ammonia, Oxford, N. C., 1924 crop. (See Table 10 for yields and values.) Compare with Figure 9

TABLE 35.—*Summary of effects on acre yields, gross values, and average prices of leaf tobacco in fertilizer tests, with and without lime, at Tifton, Ga., 1922–1926*

[See Table 15 for details of fertilizer treatment]

Plot No.	Fertilizer treatment			Yield (pounds)	Gross value	Price per 100 pounds
	Formula	Limestone				
		Rate	Source			
5, 13, 21, 29, 37	6-3⅓-1½	None.		1,043	$148.76	$14.26
6, 14, 22, 30, 38	6-3⅓-1½	1,000	Dolomite	1,018	146.13	14.35

It would seem, therefore, from the foregoing results (Tables 30–35) that the use of ground limestones on the soils represented is not likely to give marked increases in the yield of tobacco unless the limestone carries a considerable quantity of magnesia. Since the magnesia requirement of tobacco is low, it will be advisable to use comparatively small quantities of dolomitic limestone to avoid any complications from root diseases and the liberation of ammonia, which usually result from using lime freely for tobacco. Where no lime has been used previously, the initial application may be comparatively heavy, perhaps 1,000 or more pounds per acre, applied broadcast. If potash salts carrying magnesia are used in quantities supplying 10 to 20 pounds of magnesia per acre, under average conditions little or no increase can be expected from the use of lime on tobacco. This is largely true at least with the fertilizer mixtures used in these tests, for in such mixtures the phosphates used supply sufficient calcium for the plant-food requirements of the tobacco crop. It is possible, however, that some tobacco soils are so acid as to require liming for best results, independently of the supply of plant nutrients in the soil.

FIG. 9.—Group of tobacco plants showing good growth, smooth leaf, and no magnesium-deficiency symptoms. Dolomite-treated end of plot 8, which received ammonium sulphate as its source of ammonia, Oxford, N. C., 1924 crop. (See Table 10 for yields and values.) Compare with Figure 8

SUMMARY

This bulletin presents the results of field tests with fertilizers used for growing flue-cured tobacco, made up from different materials and varying in their analyses and rates of application. The localities at which the data were collected are fairly representative of the flue-cured tobacco district, especially of the old-belt section. The tests located in the new-belt section are less extensive, and for this reason the conclusions to be reached will have a somewhat more limited application in the new-belt region. The soil types represented, namely, Cecil gravelly fine sandy loam, Durham coarse sandy loam, and Durham sandy loam, in the old belt, and Norfolk fine sandy loam, Norfolk sandy loam, and Tifton sandy loam, in the new belt, are typical tobacco soils of the flue-cured district. These soils are more or less deficient in plant food, thus making the production of flue-cured tobacco dependent upon the use of fertilizers.

As far as these tests indicate, phosphoric acid is an essential constituent of the fertilizer mixture on all soils of the flue-cured district for the production of tobacco. It is especially necessary on virgin soils. Acid phosphate gave better results than basic slag or raw bone meal as the source of phosphoric acid. On the lighter sandy soils as found at Oxford, N. C., and Timmonsville and Manning, S. C., the mixtures analyzing 6 per cent phosphoric acid (P_2O_5) gave as good yields and quality as the higher percentage mixtures, when the rate of application of the fertilizer ranged from 800 to 1,000 pounds per acre. This holds true at Tifton, Ga., in regard to yields, but the values are somewhat better where the content of phosphoric acid was increased. Where phosphoric acid is supplied in excess there is a tendency to lower the yield and value of the crop produced, especially on the light types of soil. At Chatham, Va., and Reidsville, N. C., where the heavier soils are found, a fertilizer analyzing 8 per cent phosphoric acid gave yields and values above those of mixtures analyzing 6 per cent phosphoric acid when the rate of application per acre was 1,400 and 1,600 pounds, respectively.

The ammonia supply for growing bright tobacco should be carefully controlled, as this type of tobacco can not be grown to its highest perfection where ammonia is present in excessive quantities. The quantity of ammonia required for flue-cured tobacco varies with the season, soil, and source, but the data presented show that as much as 30 to 40 pounds per acre can be used and a satisfactory yield and quality obtained. Ammonia, from whatever source, gave yields and values larger than those with no ammonia. When used over a period of years on the same soil without the use of lime, nitrate of soda showed average yields and values which were considerably better than were obtained with ammonium sulphate. However, nitrate of soda gave only slightly larger yields and no better quality than did ammonium sulphate over a period of years on a soil limed with ground dolomitic limestone. Dried blood gave good yields and quality of tobacco except on soils deficient in magnesia, and when this deficiency was supplied on such soils by liming with ground dolomitic limestone, good yields and quality were obtained. On soil deficient in magnesia, cottonseed meal gave a higher yield and quality than other sources of ammonia when no dolomite was applied. Cottonseed meal usually gave good yields and quality on the light soils, but did not do so well on the heavy soils. Stable manure produced satisfactory yield and quality of tobacco in tests at Tifton, Ga. The inorganic ammoniates, nitrate of soda and ammonium sulphate, have given satisfactory yields and values when compared with the organic sources, dried blood, cottonseed meal, and stable manure. Ammonia derived from a mixture of nitrate of soda, ammonium sulphate, dried blood, and cottonseed meal usually gave somewhat better yields of tobacco than those obtained from any of these materials as the sole source of ammonia, and there was no decided difference in the quality of the product.

Potash is perhaps the most important single constituent of the fertilizer mixture for growing tobacco from the standpoint of quality of product, as is indicated by the low average value per 100 pounds when this constituent is absent from the fertilizer mixture. The growing plant exhibits characteristic symptoms when potash is deficient. When potash is used at a liberal rate it serves to maintain the vigor of the growing plant, giving it considerable resistance against the leaf spots and other diseases. The results of these tests indicate that, over a period of years, about 40 to 60 pounds of potash per acre is sufficient in the fertilizer combinations tested; but it was observed during the tests that higher rates gave greater resistance against leaf-spot diseases in certain seasons, especially when the weather conditions were favorable to their development. In these tests muriate gave yields higher than those with sulphate of potash, but this larger yield from the muriate is offset by the fact that there is a tendency to injure the combustibility of the leaf, which is an important element of quality for this type of tobacco. However, the results indicate that a portion of the potash, at the above-mentioned rates, may be safely derived from potash salts containing chlorine, provided the quantity of chlorine supplied is not more than 20 to 25 pounds per acre. Such a mixture can be used without serious injury to the combustibility of the leaf, thus combining a good yield with the desired quality.

Although fertilizers are necessary to produce flue-cured tobacco, the proper rate at which a fertilizer of a given analysis is to be applied for maximum yield and value necessarily varies considerably for different soils and conditions and therefore can be ascertained only within wide limits. Where the rate of application is excessive there is a tendency to decrease the quality of the leaf tobacco produced.

The necessity for including magnesia in the fertilizer mixture used or making an application of ground magnesian limestone on some of the soils used in the production of tobacco in the flue-cured district is shown by the data. When magnesia is deficient in the soil and not supplied in the fertilizer mixture or by liming, the yield and quality of flue-cured tobacco may be greatly lowered. The characteristic symptoms of magnesia deficiency are readily recognized in the growing plant. Magnesia can be supplied in the form of potash salts containing this material or by ground magnesian limestone. The results presented do not show any great benefit from liming other than from the magnesia supplied by the ground limestones used. Since the magnesia requirement of tobacco is low, if the magnesia is derived from dolomite it will be advisable to use comparatively small quantities, so as to avoid the possible harmful effects from root diseases and the liberation of ammonia, which usually result when the soil is heavily limed for tobacco.

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September 21, 1927

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