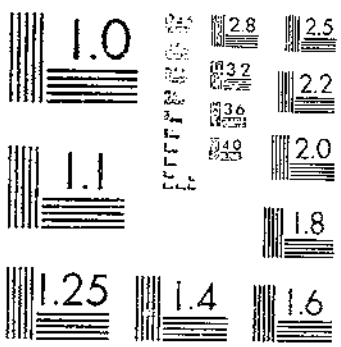
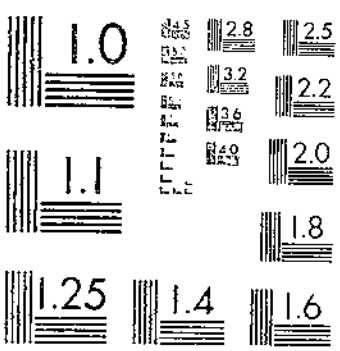
START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TECHNICAL BULLETIN No. 335 NOVEMBER, 1932

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

FERTILIZERS FOR SWEETPOTATOES BASED ON INVESTIGATIONS IN NORTH CAROLINA

By J. J. SKINNER, *Senior Biochemist, Division of Soil Fertility, Soil Investigations, Bureau of Chemistry and Soils*, and C. B. WILLIAMS, *Head, Department of Agronomy*, and H. B. MANN, *Associate in Soil Investigations, North Carolina Agricultural Experiment Station*

(The Bureau of Chemistry and Soils in Cooperation with the North Carolina Agricultural Experiment Station)

CONTENTS

INTRODUCTION

With an increase in the production of sweetpotatoes in North Carolina, interest has developed in fertilizer problems pertaining to this crop. The area in sweetpotatoes in the State in the 5-year period, 1924–1928, averaged 83,000 acres annually, which exceeded the acreage in any other State except Georgia and Texas. (*18*)[1]. The average production of sweetpotatoes in North Carolina from 1924 to 1928 was 7,989,000 bushels annually, which was exceeded only by Georgia. In 1929 there were produced in North Carolina 9,126,000 bushels of sweetpotatoes, having an estimated value of $8,213,400, and in 1930, 9,506,000 bushels, having an estimated value of $8,555,000. The production in North Carolina in 1930 was larger than in any other State.

The average annual acre yield of sweetpotatoes in North Carolina for the 10-year period, 1919–1928, was 101 bushels, for 1929, 117 bushels; and for 1930, 97 bushels. The average annual acre yield of all the producing States for this 10-year period was 95.2 bushels; for 1929, 102.9 bushels; and for 1930, 84.9 bushels. The average acre yield of sweetpotatoes in North Carolina for the 10-year period, 1919–1928, was exceeded by 13 States, in 1929 by 11 States, and in 1930 by 23 States. The average acre yield of 4 States in 1929 was 140 bushels or more.

Sweetpotato growers in North Carolina, faced by the necessity of producing larger acre yields at lower cost and confronted with difficulties in securing good stands, although using large applications of

[1] Italic numbers in parentheses refer to Literature Cited, p. 45.

130350°—32——1

commercial fertilizers, appealed to the North Carolina Agricultural Experiment Station and the United States Department of Agriculture for assistance. This interest on the part of growers resulted in the establishment of cooperative fertilizer experimental work with sweetpotatoes by the agronomy division of the North Carolina Agricultural Experiment Station and the soil fertility division of the Bureau of Chemistry and Soils of the United States Department of Agriculture.

Experiments were planned by which to study the effect on the growth of young plants and yields of sweetpotatoes on some of the principal soil types used for sweetpotato growing, of (1) various fertilizer analyses or ratios of nitrogen, phosphoric acid, and potash; (2) different quantities of fertilizers; (3) different potash sources; (4) different nitrogen sources; (5) concentrated fertilizer; and (6) fertilizer placement and time of application.

Investigations were undertaken in Carteret County with Porto Rico sweetpotatoes on Norfolk sandy loam, the prevailing soil type used for sweetpotatoes in the central coastal district of North Carolina. In 1930 [2] there were planted in this county, 2,002 acres, and 256,256 bushels of sweetpotatoes were produced, with an average yield of 128 bushels an acre.

In Craven County experiments were conducted with Porto Rico sweetpotatoes on Portsmouth fine sandy loam, a soil type occurring generally in the central coastal district of the State. In 1930, there were planted in this county, 1,377 acres, and 151,470 bushels were produced, or an average yield of 110 bushels an acre. In 1930, 18,904 acres were planted to sweetpotatoes in the central coastal district, which comprises 12 counties. Results secured in the experiments in the two counties apply generally in this district.

Fertilizer investigations with Nancy Hall sweetpotatoes were made in Catawba County on Cecil sandy loam, the prevailing soil type in the central, southern, and northern piedmont districts of the State. In this county, 1,628 acres were planted to sweetpotatoes in 1930, and 159,544 bushels, or an average yield of 98 bushels an acre, were produced. In 1930 there were planted 10,500 acres in the central piedmont district, comprising 10 counties; 8,832 acres in the southern piedmont district, comprising 11 counties; and 10,590 acres in the northern piedmont district, comprising 13 counties. The soil type chosen for these experiments is widely distributed in the piedmont section of the State, and results of the experiments on this soil have broad applications.

Fertilizer investigations with Big-Stem Jersey sweetpotatoes were started in 1925 in Currituck County on Norfolk loamy fine sand. Currituck County is in the northern coastal district of the State, and a large acreage of Norfolk loamy fine sand is used for the growing of early sweetpotatoes. In 1930, 4,663 acres were planted to sweetpotatoes in this county, and the production was 419,670 bushels, or an average yield of 90 bushels an acre. In the northern coastal district, comprising 16 counties, 15,999 acres of sweetpotatoes were planted in 1929. However, Norfolk loamy fine sand is not found generally in this district. The largest areas are in lower Currituck County, where a large sweetpotato industry has developed.

[2] Figures on sweetpotato production by counties and districts in North Carolina are from the cooperating crop-reporting service of the North Carolina Department of Agriculture and the United States Department of Agriculture.

FERTILIZER RATIO EXPERIMENTS

PLAN OF EXPERIMENTS

The fertilizer mixtures used in the fertilizer ratio experiments are those shown as bags of fertilizer in Figure 1, and charted on the triangle shown in Figure 2. In this scheme of studying fertilizer ratios, 21 different treatments of single fertilizer elements and combinations of two and three elements are used. The plan consists of using the fertilizer constituents, nitrogen, phosphoric acid, and potash, singly, two together, and three together, the ratios varying in 3 per cent

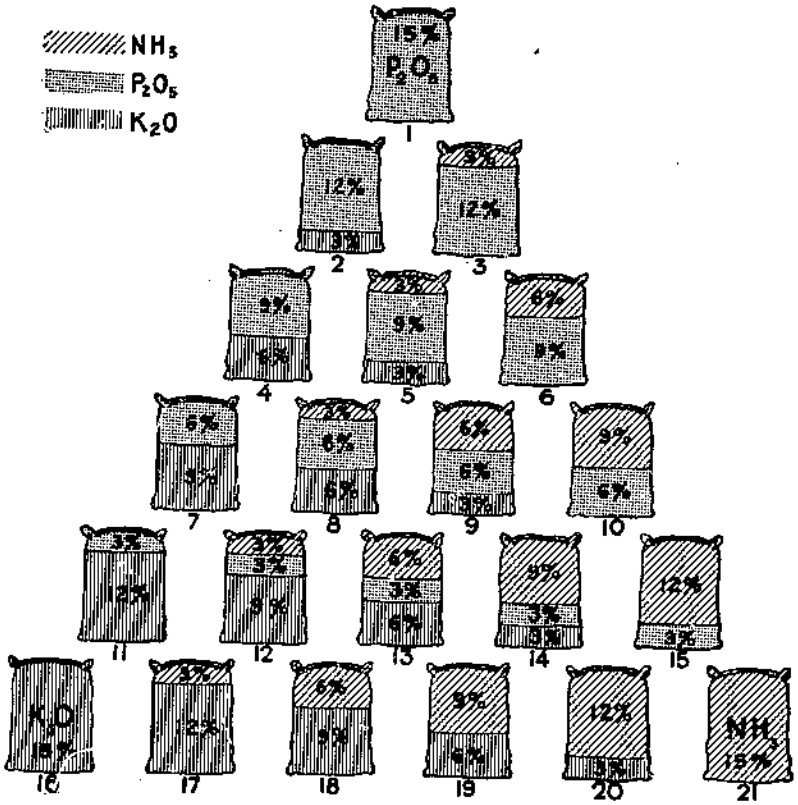


FIGURE 1.—Bags of fertilizers arranged in a triangle, showing percentages of each fertilizer ingredient in the 21 fertilizers used in the sweetpotato experiments

stages. The fertilizers represented by the points at the three angles of the triangle (fig. 2) are single constituents—ammonia, phosphoric acid, and potash. The points on the base of the triangle represent mixtures containing no phosphoric acid; those on the line just above contain 3 per cent phosphoric acid. This progression continues so that the extreme point of the triangle represents a 15 per cent phosphoric acid fertilizer. In the same manner the points on the two sides contain no potash and no nitrogen, and those on the lines parallel to the sides contain from 3 to 15 per cent of these elements.

The fertilizer constituents in each fertilizer total 15 per cent, whether 1, 2, or 3 of the constituents are present. Each plot received

the same number of pounds of plant-food constituents but in different ratios. The ratio of ammonia, phosphoric acid, and potash in each fertilizer is given in Figure 2.[3] The phosphoric acid used in the fertilizer mixtures was derived from superphosphate; the nitrogen from one-third each of sodium nitrate, ammonium sulphate, and cottonseed meal; and the potash from sulphate of potash. All the fertilizer was applied in the furrows and covered about one week before the plants were set. These experiments were planned and conducted to study the effects of different fertilizer ratios on the growth and yield of sweetpotatoes on some of the principal soil types utilized for the production of this crop in North Carolina.

The triangle plan (*15*) of fertilizer experimentation has been used extensively in field investigations, first in a grass experiment (*10*) at the Pennsylvania State College and later with many crops in various sections of the United States. This plan of preparing mixtures proved very useful in fertilizer investigations with cotton and potatoes in

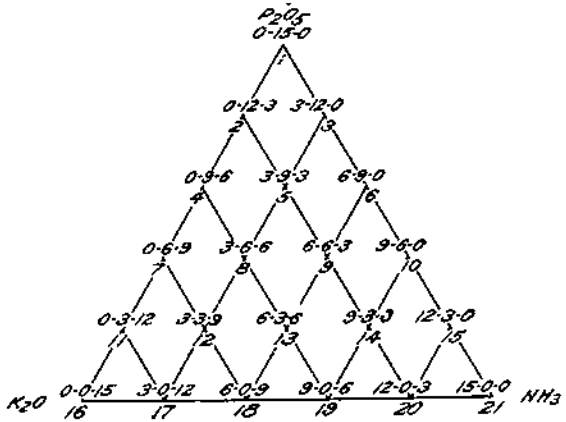


FIGURE 2.—The triangle diagram with numbered points, showing the ratios of ammonia, phosphoric acid, and potash of the 21 fertilizers in the triangle system used in the sweetpotato experiments

North Carolina (*11*) and with cotton in Georgia (*1*). It was used in sweetpotato studies by Schermerhorn in New Jersey (*14*) and Zimmerley (*20*) in Virginia.

SOIL TYPES AND RESULTS OBTAINED

The soil types on which experiments were made in each case are representative of a large area used for growing sweetpotatoes in the State. One-twentieth-acre plots were used for each fertilizer mixture, and check, or no-fertilizer, plots were distributed throughout the series.

The yield data secured in the experiments[4] on the soil types enumerated are given in Table 1 and in Figures 3, 5, 6, and 7. The stand-

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

[4] Assistance and cooperation of T. B. Elliott, county agent of Currituck County; A. H. Harris, former county agent of Carteret County; and J. W. Hendricks, former county agent of Catawba County, in conducting these experiments and in offering helpful suggestions is acknowledged. Credit is due F. R. Reid, Bureau of Chemistry and Soils, and S. K. Jackson and A. S. Olline, former assistant agronomists of the North Carolina Experiment Station, for assistance in obtaining the field data; and to A. R. Anthony, W. S. Boswood, C. G. Gaskell, R. L. Griggs, H. E. Patten, Clyde Mathias, and G. E. Rockett, cooperating growers who furnished land and labor for the experiments.

ard bushel of sweetpotatoes weighs 50 pounds. The fertilizer mixtures, with corresponding yields, are arranged according to their content of ammonia, phosphoric acid, and potash in Tables 2 and 3. These data are discussed for each soil type.

TABLE 1.—*Acre yields of sweetpotatoes* [1] *from fertilizers* [2] *with varying ratios of ammonia, phosphoric acid, and potash on several soil types in North Carolina*

Fertilizer No.	Fertilizer ratio NH_3–P_2O_5–K_2O	Norfolk sandy loam, Carteret County, C. G. Gaskell farm, 1924	Portsmouth fine sandy loam, Craven County, H. E. Patten farm		Cecil sandy loam, Catawba County			Norfolk loamy fine sand, Currituck County		
					G. E. Rockett farm, 1926	A. R. Anthony farm		Clyde Mathias farm, 1925	R. L. Griggs farm	
			1922	1923		1927	1928		1926	1927
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
X	Check.	90	60		69					
1	0–15–0	186	70	56	44	173	240	98	111	71
2	0–12–3	237	95	67	72	176	242	122	107	86
3	3–12–0	212	82	58	71	175	231	170	99	107
X	Check.		60	43		128	197	102	34	50
4	0–9–6	248	117	58	112	148	239	140	103	81
5	3–9–3	248	124	61	96	176	241	171	99	131
6	6–9–0	173	121	67	84	179	237	132	107	113
X	Check.	88	39	48	75					
7	0–6–9	242	101	69	97	188	225	134	113	89
8	3–6–6	246	150	64	130	189	268	177	132	130
9	6–6–3	180	120	62	102	177	255	171	87	128
X	Check.		73	41		148	196	98	39	53
10	9–6–0	166	101	67	71	179	236	159	73	109
11	0–3–12	224	102	65	79	174	269	165	110	77
12	3–3–9	266	157	76	126	191	281	231	115	109
X	Check.	80	52	44	66					
13	0–3–6	253	90	81	115	196	205	223	128	106
14	9–3–3	253	79	65	100	172	229	144	62	91
15	12–3–0	203	69	55	73	150	230	126	44	112
X	Check.		63	38		112	180	108	36	45
16	0–0–15	259	91	67	90	150	255	90	80	65
17	3–0–12	291	112	64	90	180	256	156	69	123
18	6–0–9	331	132	67	81	165	228	174	57	121
X	Check.	95	63	39	82	130	185	92	27	44
19	9–0–6	180	121	67	95	171	185	150	40	91
20	12–0–3	183	88	55	94	153	175	93	33	115
21	15–0–0	169	84	58	72	157	132	96	26	86
X	Check.	85	61	35						
Average of checks		87.6	58.8	41.1	73	129	191	109	34	48

[1] Sweetpotatoes were set in June and dug in November in Carteret, Craven, and Catawba Counties; set in April and dug in August in Currituck County.

[2] Source of fertilizer ingredients: Phosphoric acid from superphosphate, nitrogen one-third each from sodium nitrate, ammonium sulphate, and cottonseed meal; potash from sulphate of potash. Fertilizer applied at rate of 750 pounds per acre in Carteret, Craven, and Catawba Counties; 1,400 pounds per acre in 1925 and 1,800 pounds in 1926 and 1927 in Currituck County experiments.

TABLE 2.—*Effect of percentages of ammonia, phosphoric acid, and potash in fertilizer, on yield of sweetpotatoes on several soil types in North Carolina*

Fertilizer mixture No.[1]	Fertilizer mixtures containing 9 to 15 per cent of—	Average yield per acre on—								
		Norfolk sandy loam, Carteret County, 1924	Portsmouth fine sandy loam, Craven County		Cecil sandy loam, Catawba County			Norfolk loamy fine sand, Currituck County		
			1922	1923	1926	1927	1928	1925	1926	1927
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
10, 14, 15, 19, 20, 21	Ammonia	192	90	61	84	164	193	128	46	101
1, 2, 3, 4, 5, 6	Phosphoric acid.	217	103	61	80	172	238	130	104	98
7, 11, 12, 16, 17, 18	Potash	260	116	68	92	176	252	159	92	97

[1] Fertilizer mixtures as listed in Table 1 and Figures 3, 5, 6, and 7.

TABLE 3.—*Effect of different proportions of ammonia, phosphoric acid, and potash in fertilizers on yield of sweetpotatoes on several soil types in North Carolina*

Fertilizer mixture No.[1]	Fertilizer constituent in mixtures	Average yield per acre on—								
		Norfolk sandy loam, Carteret County, 1924	Portsmouth fine sandy loam, Craven County		Cecil sandy loam, Catawba County			Norfolk loamy fine sand, Currituck County		
			1922	1923	1926	1927	1928	1925	1926	1927
	Per cent	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
AMMONIA GROUP										
1, 2, 4, 7, 11, 16	0	233	98	64	82	170	245	126	105	78
3, 5, 8, 12, 17	3	253	125	65	102	182	256	181	102	120
6, 9, 13, 18	6	236	116	69	96	179	231	175	95	117
10, 14, 19	9	200	109	67	88	174	217	151	58	97
15,20	12	192	78	55	83	152	203	109	39	113
21	15	169	84	58	72	157	132	96	26	86
PHOSPHORIC ACID GROUP										
16, 17, 18, 19, 20, 21	0	235	105	63	87	164	205	127	52	100
11, 12, 13, 14, 15	3	239	99	68	97	177	243	178	91	99
7, 8, 9, 10	6	210	118	66	102	183	246	160	101	114
4, 5, 6	9	223	121	62	97	167	239	148	103	108
2, 3	12	224	88	62	72	177	236	146	103	90
1	15	183	79	56	44	173	240	98	111	71
POTASH GROUP										
1, 3, 6, 10, 15, 21	0	185	89	60	69	169	218	130	77	100
2, 5, 9, 14, 20	3	221	101	62	93	171	228	140	77	110
4, 8, 13, 19	6	232	110	68	115	176	221	172	101	102
7, 12, 18	9	280	130	71	98	181	245	180	95	106
11, 17	12	257	107	65	85	177	263	160	89	100
16	15	259	91	67	90	159	255	96	80	65

[1] Fertilizer mixtures as listed in Table 1 and Figures 3, 5, 6, and 7.

NORFOLK SANDY LOAM

The experiments on Norfolk sandy loam were made in 1924 on the farm of C. G. Gaskill, in Carteret County, east of Beaufort. Porto Rico sweetpotatoes were set in June and dug in November. Fertilizers were applied at the rate of 750 pounds an acre in the furrows and covered one week before the plants were set. The yield data given in Table 1 are charted on the triangle diagram in Figure 3. The results can be better understood by a study of the data given in the figure.

Comparing the single-element fertilizers, potash (fertilizer No. 16) gave a larger yield than did phosphoric acid (fertilizer No. 1) or ammonia (fertilizer 21). This greater response from potash is in keeping with the higher yields obtained from the complete fertilizers containing high percentages of potash, as compared with yields from complete fertilizers containing high percentages of phosphoric acid or high percentages of ammonia. These comparative data are shown for the Norfolk sandy loam in Table 2. The fertilizers containing high percentages of potash are those in Figure 3, included in the subtriangle outlined by mixtures 7, 16, and 18. The fertilizers containing high percentages of phosphoric acid are within the subtriangle formed by

Nos. 1, 4, and 6, and the fertilizers containing high percentages of ammonia are in the subtriangle outlined by Nos. 10, 19, and 21.

The three mixtures producing highest yields are Nos. 12, 17, and 18. These mixtures contain ratios of ammonia, phosphoric acid, and potash as follows: 3–3–9, 3–0–12, and 6–0–9, and the average composition of the three mixtures is 4–1–10. This ratio is charted in the small triangle formed by these three mixtures in Figure 3.

The fertilizer mixtures shown in Figure 3 are arranged in Table 3 according to the amount of ammonia, phosphoric acid, and potash they contain, and the average yield of each group is tabulated.

The fertilizer mixtures containing 3 per cent of ammonia have given the largest average yields of the varying-nitrogen group. The yields decrease as the nitrogen in the fertilizer mixtures increases above this percentage. There is no correlation between yield and the phosphoric acid content of the fertilizer, but there is a correlation between yield and potash content, the yield increasing with increase of potash in the fertilizer up to 9 per cent. Fertilizers having percentages of potash

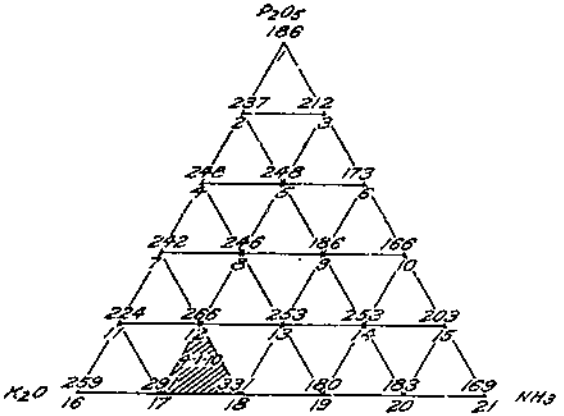


FIGURE 3.—Yield of sweetpotatoes in bushels per acre from fertilizers containing various ratios of ammonia, phosphoric acid, and potash on Norfolk sandy loam in Carteret County, N. C., 1924

higher than this gave lower yields. This compilation of the data shows that the largest yields are obtained with mixtures containing 3 per cent ammonia, no phosphoric acid, and 9 per cent potash. This fertilizer analysis does not differ widely from that derived by averaging the composition of the three mixtures giving highest yields. This average composition is 4 per cent ammonia, 1 per cent phosphoric acid, and 10 per cent potash. From these data it would seem that a fertilizer containing 3 to 4 per cent ammonia, 0 to 1 per cent phosphoric acid, and 9 to 10 per cent potash should give good results on this soil. The data as a whole seem to show that these percentages of nitrogen and potash are the best in a mixture used at the rate of 750 pounds an acre. The phosphoric acid effect is not altogether uniform in the various mixtures.

PORTSMOUTH FINE SANDY LOAM

The experiments on Portsmouth fine sandy loam were made on the farm of H. E. Patten, near New Bern, Craven County, in 1922 and

repeated on an adjoining field in 1923. A soil map of the field showing the layout of the experimental plots is shown in Figure 4. Porto Rico sweetpotatoes were set in June and dug in November. The fertilizers were applied at the rate of 750 pounds an acre. In the plots containing high percentages of ammonia, Nos. 15, 20, and 21, difficulty in maintaining a stand was experienced. Some of the plants died shortly after being set, and it was necessary to reset the plots in which this occurred. The yield data are given in Table 1 and in Figure 5.

In the 2-year experiments the yields from potash (fertilizer No. 16) were higher than from phosphoric acid (fertilizer No. 1) or from am-

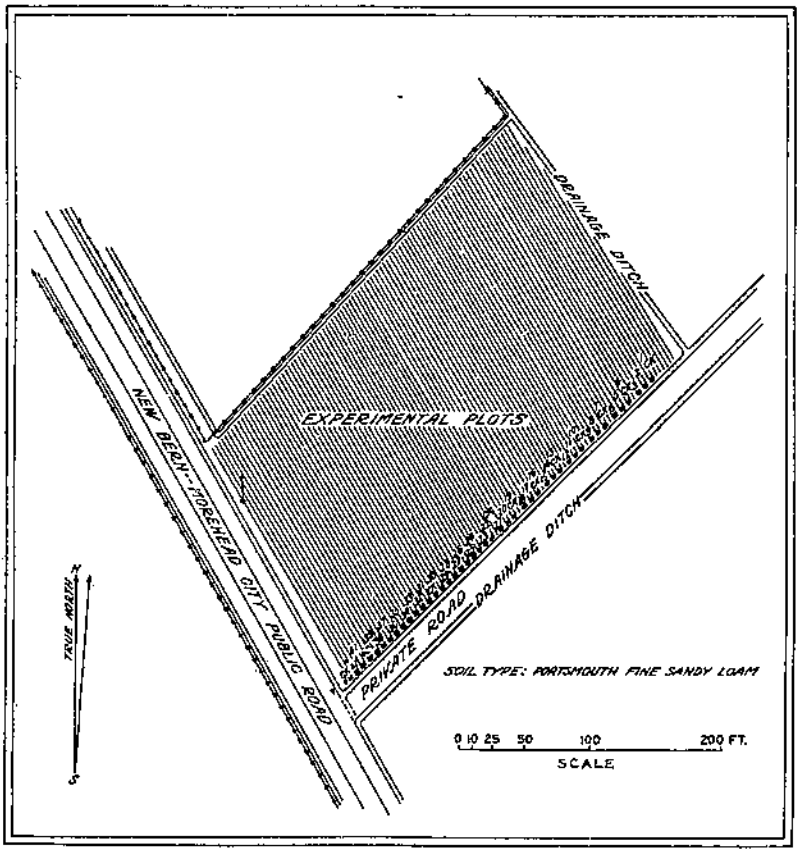


FIGURE 4.—Map of experiment field on Portsmouth fine sandy loam in New Bern, Craven County, N. C., 1923

monia (fertilizer No. 21). This result is in harmony with the higher yields produced by the mixtures containing high percentages of potash as compared with yields produced by the mixtures containing high percentages of phosphoric acid and the mixtures containing high percentages of ammonia. The average yields of these three groups are given in Table 2. The three fertilizers giving the highest yields in 1922 (fig. 5, A) are Nos. 8, 12, and 18. These form an inner triangle shown in the shaded area. The ratio of ammonia, phosphoric acid,

and potash of these three mixtures is, respectively, 3–6–6, 3–3–9, and 6–0–9. Two of these mixtures contain 3 per cent ammonia, and two contain 9 per cent potash. The average analysis of the three fertilizers is 4 per cent ammonia, 3 per cent phosphoric acid, and 8 per cent potash. The three fertilizers producing highest yields in 1923 (fig. 5, B) are Nos. 7, 12, and 13, having the following respective ratios of ammonia, phosphoric acid, and potash: 0–6–9, 3–3–9, and 6–3–6, averaging 3–4–8. This compilation of the 2-year data would indicate

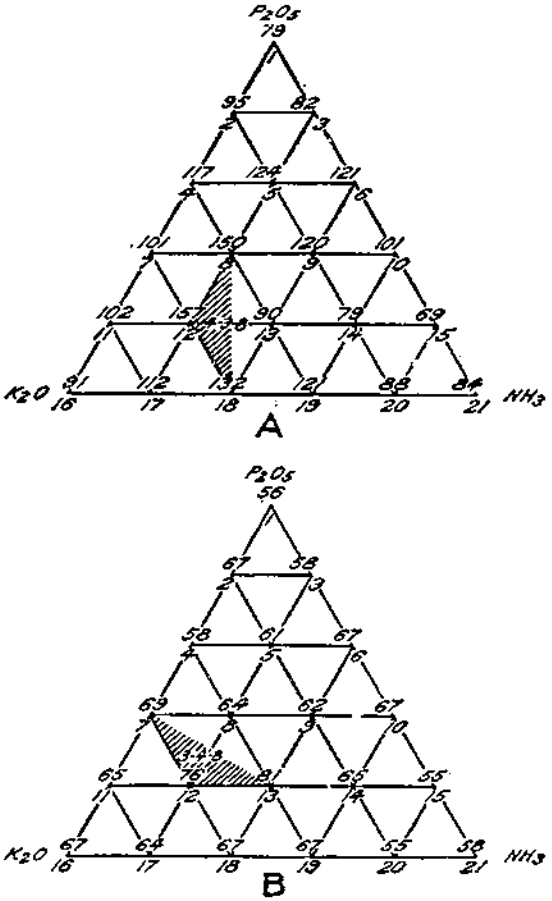


FIGURE 5.—Yield of sweetpotatoes in bushels per acre from fertilizers containing various ratios of ammonia, phosphoric acid, and potash on Portsmouth fine sandy loam in Craven County, N. C.: A, Yields obtained in 1922; B, yields obtained in 1923

that a fertilizer for sweetpotatoes on this soil should contain 3 to 4 per cent ammonia, 3 to 4 per cent phosphoric acid, and 8 to 9 per cent potash.

When the yield data from the fertilizers represented by points along each line of the triangle, that is, according to the percentage of ammonia, phosphoric acid, or potash in the fertilizer, are considered, the result is interesting and in harmony with the deduction discussed

in the preceding paragraph. In Table 3 the average yields for fertilizers containing increasing quantities of ammonia, phosphoric acid, or potash are given. In 1922 the mixtures containing 3 per cent ammonia gave highest average yields of the varying ammonia groups. The yields decreased with increasing percentages of ammonia above 3 per cent. The result in 1923 was somewhat similar, except the largest average yield was obtained from the 6 per cent ammonia group; however, the average yields for the no-ammonia and 3, 6, and 9 per cent ammonia groups do not vary widely. In the phosphoric acid groups there is not a close correlation between yields and phosphoric acid content of the fertilizer.

The mixtures containing 9 per cent potash gave the largest yields of the varying potash groups in each year's experiments. There is an increase in yields with increasing percentages of potash up to this amount. Higher percentages than this gave smaller yields. This compilation of the data indicates that the most effective fertilizer for sweetpotatoes on this type of soil contains about 3 per cent ammonia and 9 per cent potash. This does not vary widely from the former deduction, so far as ammonia and potash are concerned. The phosphoric acid correlation with yield is not clear.

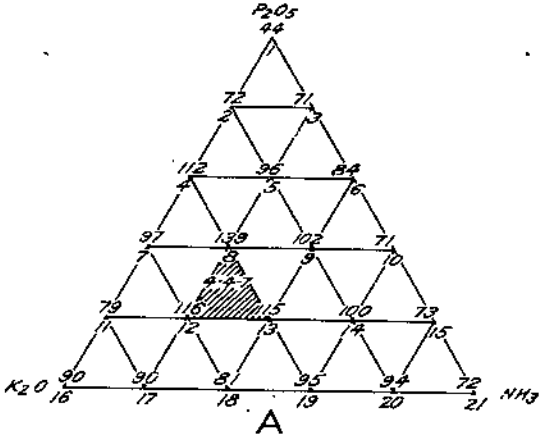
CECIL SANDY LOAM

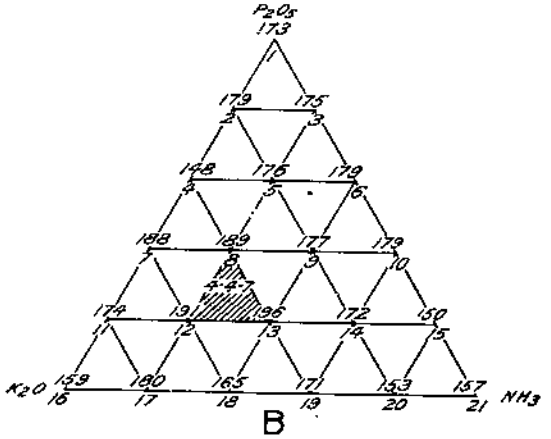
The experiments on Cecil sandy loam were made near Newton in Catawba County, in 1926, 1927, and 1928. The first was on the farm of G. E. Rockett and the others on soil of the same type on the farm of A. R. Anthony. Nancy Hall sweetpotatoes were set in June and dug in October. Fertilizers were applied at the rate of 750 pounds an acre a few days before the plants were set.

The yield data given in Table 1 are charted on triangle diagrams in Figure 6. Potash used alone gave a higher yield than did phosphate alone or ammonia alone in 1926 and 1928, but phosphate was highest in 1927. However, when the group of mixtures containing high percentages of potash is compared to the group containing high percentages of phosphoric acid or the group containing high percentages of ammonia, as compiled in Table 2, the average yields from the potash group are highest in each experiment.

The three mixtures giving highest yields in the first two years are Nos. 8, 12, and 13, which contain the following respective ratios of ammonia, phosphoric acid, and potash: 3–6–6, 3–3–9, and 6–3–6, with an average ratio of 4–4–7. The three mixtures giving highest yields in the third year are Nos. 8, 11, and 12. The average ratio of ammonia, phosphoric acid, and potash, of the three mixtures producing highest yields, is 2–4–9. The points represented by these three mixtures form an inner triangle, shown in the shaded areas in Figure 6.

When the data are considered with respect to the percentage of ammonia, phosphoric acid, or potash in the mixtures, as compiled in Table 3, it is seen that fertilizers containing 3 per cent of ammonia gave highest average yields in the nitrogen group each year. In the varying phosphoric acid groups the mixtures containing 6 per cent phosphoric acid gave the highest yields each year. In the potash group the highest yields were obtained from mixtures containing 6 per cent potash in 1926, 9 per cent in 1927, and 12 per cent in 1928.





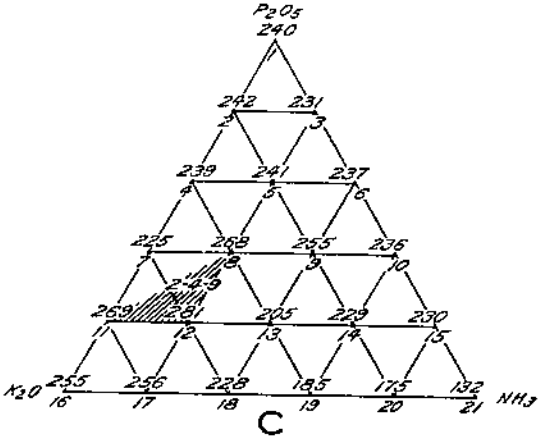


FIGURE 6.—Yield of sweetpotatoes in bushels per acre from fertilizers containing various ratios of ammonia, phosphoric acid, and potash on Cecil sandy loam in Catawba County, N. C.: A, Yields obtained in 1926; B, yields obtained in 1927; C, yields obtained in 1928

From all the data it is apparent that potash is important in fertilizing sweetpotatoes on Cecil sandy loam. Nitrogen appears to be needed, but only in small quantities. The effect of phosphoric acid is variable. It is apparent that a mixture containing 2 to 4 per cent ammonia, 4 to 6 per cent phosphoric acid, and 7 to 9 per cent potash should be selected for this soil.

NORFOLK LOAMY FINE SAND

The experiments on Norfolk loamy fine sand were made in Currituck County in 1925, 1926, and 1927, the first on the farm of Clyde Mathias, and the two later on the farm of R. L. Griggs. The soil conditions on the two farms where the experiments were made are similar and are typical of the Norfolk loamy fine sand occurring in Currituck County. The fertilizer was applied under the plant row about 10 days before the plants were set. It was mixed in the soil and covered by two furrows. Fertilizer was applied at the rate of 1,400 pounds an acre the first year and 1,800 pounds the following two years. Big-Stem Jersey sweetpotatoes were set in April and dug in August.

In the experiments conducted during 1926 and 1927 considerable difficulty was experienced in maintaining a stand of plants. On the plots which received fertilizer containing more than 6 per cent ammonia, there was only 75 to 85 per cent of a stand. Many of the plants in the high-nitrogen plots died within the first two weeks after they were set. About 30 per cent of the plants died in plot 21 which received a 15 per cent ammonia fertilizer. It was noted that the stand of sweetpotato plants was best on the no-fertilizer plots and those plots (Nos. 1, 2, 4, 7, 11, and 16) where fertilizers containing no nitrogen were used. The plots receiving fertilizers containing a high proportion of potash or a high proportion of phosphoric acid had relatively good stands. The season was extremely dry from the time the plants were set until they were dug, which undoubtedly accentuated the fertilizer injury to the young plants. Better stands of sweetpotato plants might have been obtained had the fertilizers containing the higher percentages of ammonia been applied partly before planting and partly as a side application several weeks later.

The yield data for the three years are given in Table 1 and in Figure 7. The Norfolk loamy fine sand in Currituck County is a loose light sand, deficient in plant food. The effect of fertilizers on the growth of sweetpotato vines is shown in Figure 8. Large quantities of commercial fertilizer are required for successful sweetpotato production. This is indicated by the yields from the no-fertilizer plots. The sweetpotatoes dug from the check plots were small and hardly suitable for market as compared with the large prime potatoes produced on the fertilizer plots. Although there is a large increase in yield on most of the complete-fertilizer plots, it is noted that most of the high-nitrogen fertilizer plots produced scarcely as much as the no-fertilizer plots. This is probably due to the fact that many of the sweetpotato plants died or were badly stunted while young and that the surviving plants developed an abundance of vegetation. Small yields were obtained with phosphoric acid, potash, or nitrogen alone. All three fertilizer constituents are apparently necessary for sweetpotatoes on this soil.

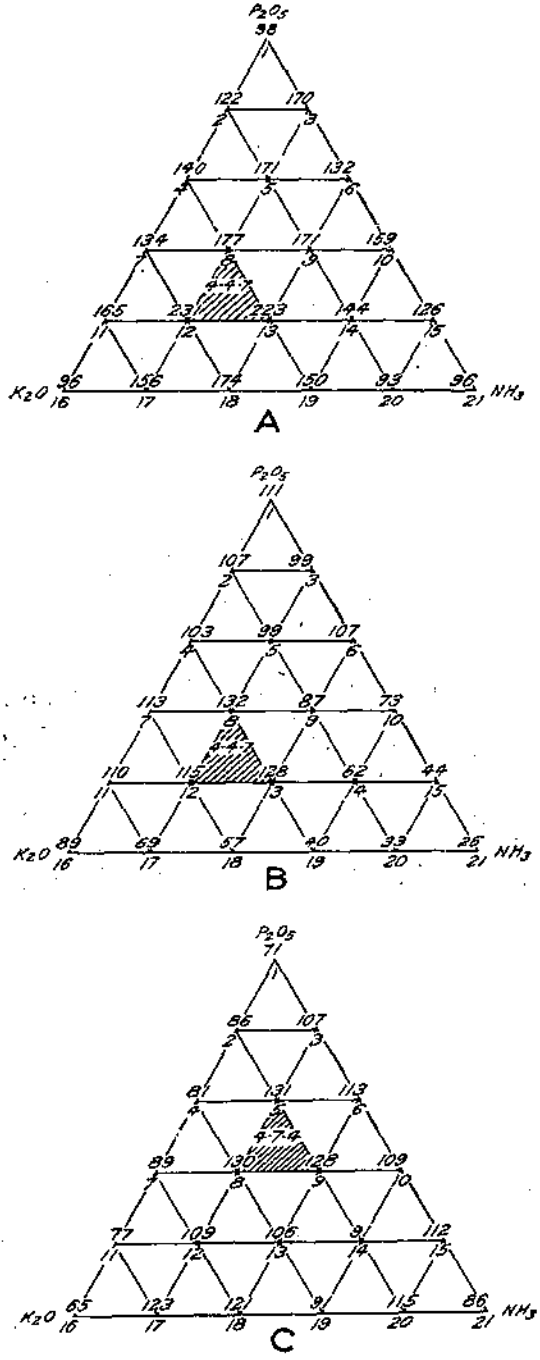


FIGURE 7.—Yield of sweetpotatoes in bushels per acre from fertilizers containing various ratios of ammonia, phosphoric acid, and potash on Norfolk loamy fine sand in Currituck County, N. C.: A, Yields obtained in 1925; B, yields obtained in 1926; C, yields obtained in 1927

In 1925 and 1926 the three fertilizer mixtures producing the highest yields were Nos. 8, 12, and 13. (Fig. 7, A and B.) These have ratios of ammonia, phosphoric acid, and potash, respectively, of 3–6–6, 3–3–9, and 6–3–6, with an average of 4–4–7. In 1927 the three mixtures giving the highest yields were Nos. 5, 8, and 9, as charted in the small inner shaded triangle in Figure 7, C. The composition of these three mixtures in ammonia, phosphoric acid, and potash is, respectively, 3–9–3, 3–6–6, and 6–6–3, with an average of 4–7–4. This result is considerably at variance with that obtained the first two years.

The data are interesting in respect to the yields from the fertilizers containing high percentages of ammonia, high percentages of phosphoric acid, and high percentages of potash as given in Table 2. In 1925 the average yields from the mixtures containing high percentages of potash were greater than the average yields from mixtures containing high percentages of ammonia or high percentages of phos-

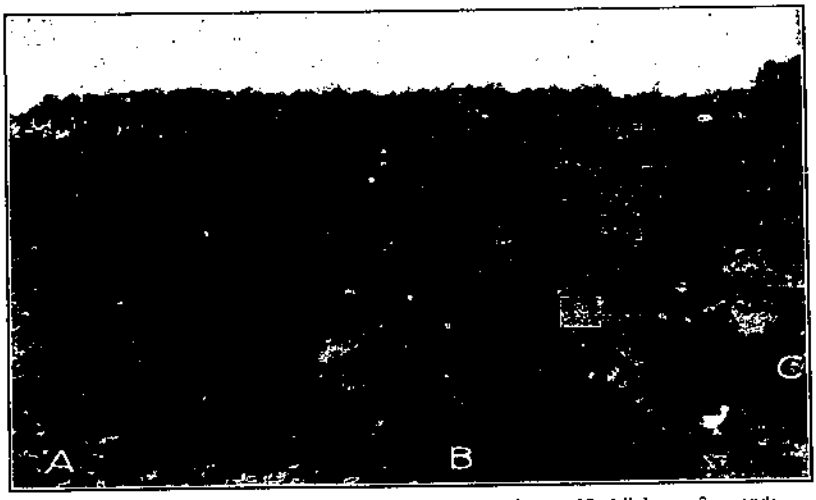


FIGURE 8.—Effect of fertilizers on growth of sweetpotato vines on Norfolk loamy fine sand: A, Fertilizer analysis, 3–6–6; B, fertilizer analysis, 6–3–6; C, no fertilizer

phoric acid. In 1926 the average yields from mixtures containing high percentages of phosphoric acid were higher and in 1927 yields from the three groups were similar, with yields from the mixtures containing high percentages of ammonia leading.

The data are compiled in Table 3, according to the percentages of ammonia, phosphoric acid, and potash the mixtures contain. In 1925 the mixtures containing 3 per cent ammonia gave the largest yields of the varying ammonia groups. In 1926, however, the mixtures containing no ammonia gave the highest yields, which were closely followed by the 3 per cent ammonia group. Again in 1927 the 3 per cent ammonia fertilizers led.

There seems to have been no consistent correlation between yield and phosphoric acid content of the fertilizers, although the results indicate that phosphoric acid is required.

Considering the varying potash fertilizers, the largest average yields of sweetpotatoes were produced in 1925 with the 9 per cent potash

mixtures, in 1926 with the 6 per cent potash mixtures, and in 1927 with the 3 per cent potash mixtures.

Judging by this compilation of data the best fertilizer analysis for this soil would be a mixture containing about 3 per cent ammonia, 3 to 6 per cent phosphoric acid, and 6 to 9 per cent potash. This deduction does not differ widely from the 4–4–7 ratio derived by averaging the composition of the three mixtures producing the highest yields.

The results obtained in each of the three years' experiments are not in close harmony, and to further study the influence of potash on Norfolk loamy fine sand another experiment was made on the Griggs farm in 1928. The results are given in Table 4.

TABLE 4.—*Effect of fertilizer* [1] *containing varying percentages of potash on yield of sweetpotatoes on Norfolk loamy fine sand, 1928*

Fertilizer analysis			Yield per acre
NH_3	P_2O_5	K_2O	
Per cent	*Per cent*	*Per cent*	*Bushels*
4	8	0	104
4	8	4	128
4	8	6	144
4	8	8	175
4	8	10	166
4	8	12	162
0	0	0	[2] 56

[1] Nitrogen in fertilizer derived equally from sodium nitrate and cottonseed meal, phosphoric acid from superphosphate, and potash from sulphate of potash. Fertilizer applied at rate of 1,400 pounds an acre

[2] Small, nonmarketable sweetpotatoes.

In the 1928 experiment the yields increased with an increase of potash up to 8 per cent in the mixture. There was a slight decrease with increase of potash above 8 per cent.

DISCUSSION

The results of experiments reported in the foregoing pages are rather consistent in showing that relatively small percentages of nitrogen in fertilizers are required for best results on the soils used in the sweetpotato experiments in North Carolina. The data are also consistent in showing that relatively high percentages of potash are required for best results on these soils. Phosphate appears to be needed, especially on the thin, loose, sandy soils of the northern coastal-plain section of the State, but there is no close correlation of the phosphoric acid content of the fertilizer with the yield of sweetpotatoes.

The fertilizer requirements of Norfolk sandy loam, Portsmouth fine sandy loam, Cecil sandy loam, and Norfolk loamy fine sand, for sweetpotatoes, do not differ widely. In most of the experiments the largest yields were obtained with fertilizers containing 3 to 6 per cent ammonia, a moderate percentage of phosphoric acid, and 8 to 10 per cent potash. From consideration of all the data it is concluded that the best fertilizer for sweetpotatoes is one containing 3 to 4 per cent ammonia, about 6 per cent phosphoric acid, and 8 to 10 per cent potash. The 4–8–8, 3–8–8, 3–8–10, and 4–8–10 mixtures are generally used for sweetpotatoes in North Carolina on the soils discussed above.

The results of the experiments reported in this bulletin, so far as yield is concerned, indicate that a ratio lower than 8 per cent phosphoric acid to 4 per cent of ammonia and 8 per cent of potash is most effective. The experiments were made on soils which in previous years had been liberally supplied with fertilizers containing high percentages of phosphoric acid, and the soils no doubt contained considerable residual phosphate. The effect of phosphoric acid on most of the soils was variable, and it was not indicated that large percentages were essential in growing sweetpotatoes so far as the yield alone is concerned. For virgin soils and soils previously tilled to crops on which no, or very little, phosphoric-acid fertilizer was used, a fertilizer for sweetpotatoes should probably contain 8 per cent phosphoric acid with 4 per cent ammonia and 8 per cent potash. A sufficient supply of available phosphoric acid is necessary for sweetpotatoes grown on thin sandy soils if they are to develop strong, stocky plants which can withstand unfavorable weather conditions in early spring.

The results of fertilizer experiments on other soil types in various sections of the United States are of interest in connection with these studies. Results of a fertilizer-ratio experiment, in which Big-Stem Jersey sweetpotatoes were grown on Sassafras sandy loam on the Eastern Shore branch of the Virginia Truck Experiment Station (*7*, *20*) were reported in 1929. A fertilizer high in potash, with low phosphoric acid and nitrogen plant-food ratios proved most effective. There was a uniform rise in yield coincident with increases in the potash content up to 15 per cent. There was a downward trend when the nitrogen was increased beyond 6 per cent. A 3–3–15 mixture gave the largest yields and the best quality of potatoes on the Sassafras sandy loam.

Schermerhorn (*13*, *14*) conducted fertilizer-ratio experiments with Yellow Jersey sweetpotatoes on coarse sandy soils in southern New Jersey and found that a 3-8-8 mixture gave best results. Under average conditions an application ranging from 1,000 to 1,500 pounds of fertilizer per acre was most economical. Fertilizers containing more than 8 per cent of potash were not profitable. Organic nitrogen of vegetable and animal origin was superior to mineral nitrogen, but, owing to the cost of organic nitrogen, it is recommended that for sweetpotato fertilizers the nitrogen be derived one-half from mineral sources and one-half from organic sources. Former work (*19*, conducted at the New Jersey station had shown that kainit was detrimental to sweetpotatoes, not, perhaps, because of the form of potash, but because of the very large quantity of salt necessarily applied in order to obtain the desired quantity of potash. Potassium chloride gave slightly better results than potassium sulphate. It is pointed out that nitrogen and potassium influence the shape and size of sweetpotatoes.

Experiments with Big-Stem Jersey sweetpotatoes on the western and eastern shores of Chesapeake Bay, in Maryland, on Norfolk sand and Sassafras loam, made by Geise (*3*, *4*) show a need for fertilizers containing high percentages of potash. A 2–8–10 fertilizer gave an increase over a 2–8–8 mixture, and the yield from a 3–8–10 exceeded that from a 3–8–8 mixture. Houghland (*6*) also found that Big-Stem Jersey sweetpotatoes responded to potash fertilizers on Norfolk sandy loam in Maryland.

The fertilizer requirements of Triumph sweetpotatoes on Florida sand were studied by Scott (*16*). He found that nitrogen, phosphoric acid, and potash were required. The omission of potash resulted in depressed yields. Potassium chloride gave somewhat better results than potassium sulphate. Stuckey (*17*) of the Georgia Agricultural Experiment Station, has reported results of fertilizer experiments with Pumpkin (yam) sweetpotatoes made on Cecil clay loam in which larger yields resulted from the application of potassium sulphate than from applying nitrogen or superphosphate. A mixture containing all three of these fertilizer constituents gave larger yields than any one material.

From the results obtained in these experiments it would seem that the coastal-plain soils bordering the Atlantic seaboard appear to need a complete fertilizer for the successful production of sweetpotatoes. A high ratio of potash to nitrogen and phosphorus is apparently required for best results. Results of experiments on the coastal-plain soils in New Jersey, Maryland, Virginia, North Carolina, and Florida are generally in harmony in that they show that best results may be obtained with fertilizers containing a comparatively low percentage of nitrogen and phosphoric acid and a high percentage of potash. On most of the coastal-plain soils the experiments apparently indicate a fertilizer of 3 to 4 per cent nitrogen, 4 to 8 per cent phosphoric acid, and 8 to 10 per cent potash for best results with sweetpotatoes, although on some of the soils the need for fertilizer containing a higher percentage of potash is indicated.

In southern Mississippi (*2*), on sandy loam soils, Porto Rico sweetpotatoes responded to fertilizers containing nitrogen, phosphoric acid, and potash. The results are somewhat similar to those obtained on the sandy loam soils of the Atlantic seaboard. Generally yields increased with the increase of potash up to 8 per cent in the fertilizer. Fertilizers containing more than 4 per cent nitrogen gave reduced yields.

Sweetpotatoes remove from the soil more potash than nitrogen and phosphorus, as shown by Keitt (*8*) in his work with a number of varieties grown on a sandy loam soil in South Carolina. Nitrogen, phosphoric acid, and potash were removed in the ratio of 31–8–61, respectively.

Soils on which sweetpotato experiments have been made in the Central and Western States appear to have a fertilizer requirement different from those already discussed. On Susquehanna fine sandy loam in eastern Texas, Hotchkiss (*5*) found that there was less response by Dooley (yam) sweetpotatoes to potash than to other fertilizer materials. Superphosphate consistently produced larger yields in these experiments. Experiments in Arkansas (*9*) with Nancy Hall and Porto Rico sweetpotatoes are reported showing good results from a 3–8–2 mixture, and negative results from the use of additional quantities of potash. Quinn (*12*) working with Porto Rico sweetpotatoes on a silt loam soil in the eastern part of northern Missouri found that only slight gains were effected by using a fertilizer containing all three constituents. The yields from the mixture were only slightly better than from potash alone.

DIFFERENT QUANTITIES OF FERTILIZERS

The results of nine experiments made on four soil types with different quantities of fertilizers are given in Table 5. In each experiment two fertilizer mixtures were used, one relatively low in potash and the other relatively high. On Portsmouth fine sandy loam and Norfolk sandy loam, mixtures analyzing 3 per cent ammonia, 7 per cent phosphoric acid, and 5 per cent potash were used. The second mixture contained the same percentages of ammonia and phosphoric acid and 10 per cent of potash. On Cecil sandy loam and Norfolk loamy fine sand, 4–8–4 and 4–8–8 mixtures were used. The phosphoric acid in the mixtures was derived from superphosphate, the nitrogen from one-half mineral and one-half organic sources, and the potash from potassium sulphate. The fertilizer was applied in the plant row, mixed in the soil, and covered by two furrows, from 10 days to 2 weeks before the plants were set.

TABLE 5.—*Results of sweetpotato experiments with different quantities of fertilizers containing low and high percentages of potash*

Soil type and location	Year	Fertilizer per acre	Yield of sweetpotatoes per acre		
			Fertilizer 3-7-5 [1]	Fertilizer 3-7-10 [1]	No fertilizer
		Pounds	*Bushels*	*Bushels*	*Bushels*
Portsmouth fine sandy loam, H. E. Patten farm, Craven County	1922	500	126	149	
		750	146	181	
		1,000	154	208	
		None.			91
	1923	500	53	70	
		750	64	78	
		1,000	76	79	
		None.			41
Norfolk sandy loam, C. G. Gaskell farm, Carteret County	1924	500	150	135	
		750	162	169	
		1,000	165	175	
		None.			89
			Fertilizer 4-8-4 [1]	Fertilizer 4-8-8 [1]	
			Bushels	*Bushels*	
Cecil sandy loam, G. E. Rockett farm, Catawba County	1925	500	54	107	
		750	65	82	
		1,000	70	94	
		None.			46
	1926	500	80	93	
		750	92	99	
		1,000	95	94	
		None.			77
Cecil sandy loam, A. R. Anthony farm, Catawba County	1927	500	148	178	
		750	166	185	
		1,000	166	189	
		None.			109
	1928	500	205	224	
		750	205	277	
		1,000	227	222	
		None.			168
Norfolk loamy fine sand, Clyde Mathias farm, Currituck County	1925	1,000	193	221	
		1,200	195	220	
		1,400	200	219	
		None.			110
Norfolk loamy fine sand, R. L. Griggs farm, Currituck County.	1926	1,000	88	126	
		1,500	91	129	
		1,800	110	121	
		2,000	116	117	
		None.			34

[1] Percentages of ammonia, phosphoric acid, and potash, respectively. Fertilizer prepared from superphosphate, potassium sulphate, sodium nitrate, ammonium sulphate, and cottonseed meal.

In all except three cases the fertilizers containing the larger quantities of potash gave a larger yield than did corresponding applications of fertilizers containing less potash.

PORTSMOUTH FINE SANDY LOAM

In experiments on Portsmouth fine sandy loam the yield increased with increased quantities of fertilizers used. However, the results as a whole indicate that 750 pounds an acre is more economical than 1,000 pounds an acre. In three of the tests the yield from 1,000 pounds an acre was only slightly increased over that from 750 pounds. It is interesting that 750 pounds of 3–7–5 fertilizer produced a yield not quite so large as that from 500 pounds of 3–7–10, and that 1,000 pounds of 3–7–5 fertilizer did not produce so large a yield as did 750 pounds of 3–7–10 fertilizer. The yields of sweetpotatoes produced by different quantities of fertilizers are shown in Figure 9.

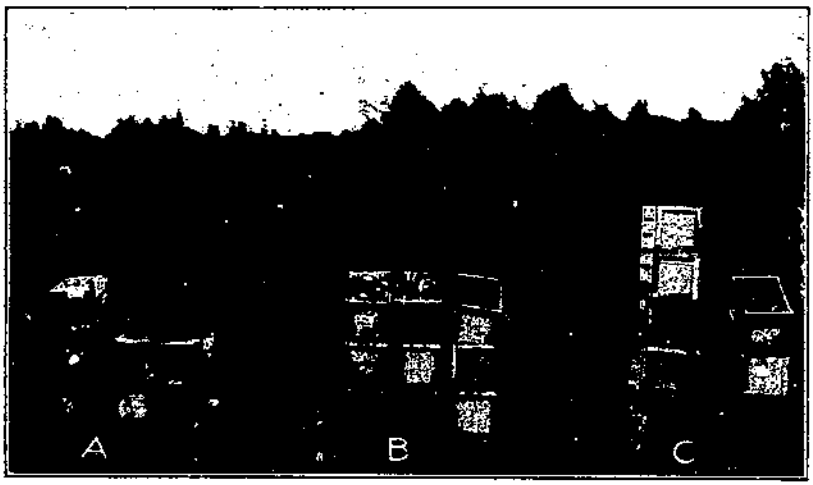


FIGURE 9.—Yield of sweetpotatoes on Portsmouth fine sandy loam from 1/20-acre plots fertilized with a mixture analyzing 3 per cent ammonia, 7 per cent phosphoric acid, and 5 per cent potash: A, With 500 pounds per acre, 3 crates of primes, 2 crates of seconds, 2 crates of culls; B, with 750 pounds per acre, 3 crates of primes, 3 crates of seconds, 3 crates of culls; C, with 1,000 pounds per acre, 5 crates of primes, 1 crate of seconds, 3 crates of culls

NORFOLK SANDY LOAM

In the experiment on Norfolk sandy loam, yields from increasing amounts of fertilizer did not vary widely. There was only a slight increase in yield from 1,000 pounds an acre over 750 pounds.

CECIL SANDY LOAM

Seven hundred and fifty pounds of fertilizer an acre gave a larger yield than 500 pounds in all the experiments except one on Cecil sandy loam. There was a slight increase in yield with 1,000 pounds over 750 pounds in four cases, but this was not true in four other cases, and the increases were not sufficiently large to justify the use of the larger quantities. In three years, 500 pounds of 4–8–8 fertilizer gave a larger yield than did 750 pounds of 4–8–4 fertilizer.

The influence of fertilizers containing various quantities of potash on yield of sweetpotatoes is shown in Figure 10.

NORFOLK LOAMY FINE SAND

In the experiments on Norfolk loamy fine sand the fertilizer applications ranged from 1,000 to 1,400 pounds an acre in 1925, and from 1,000 to 2,000 pounds in 1926. In each year 1,000 pounds of 4–8–8 fertilizer gave almost as good yields as larger quantities. However, where 4–8–4 fertilizer was used, the highest yields were obtained with 1,400 pounds an acre in 1925 and with 2,000 pounds in 1926. These were the maximum quantities used. In each case the yields from smaller quantities were nearly as large.

The yields of sweetpotatoes from different quantities of fertilizers and from no fertilizer are shown graphically in Figure 11 for each soil type used in the experiments.

NITROGEN SOURCES

To study the effect of nitrogen sources in sweetpotato fertilizers, experiments were made in which two mineral salts and two organic materials were used, each as the sole source of nitrogen in fertilizers containing superphosphate and potash. A mixture was included in which the nitrogen was derived, one-third each, from sodium nitrate, ammonium sulphate, and cottonseed meal. The results of experiments on four soil types are given in Table 6.

TABLE 6.—*Results of sweetpotato experiments with fertilizers* [1] *containing nitrogen from various sources, phosphoric acid, and potash on several soil types in North Carolina*

Soil type	Location	Year	Yield of sweetpotatoes per acre with—				
			Sodium nitrate	Ammonium sulphate	Cottonseed meal	Fish scrap	One-third from sodium nitrate, one-third from ammonium sulphate, and one-third from cottonseed meal
			Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Portsmouth fine sandy loam.	H. E. Patten farm, Craven County.	1922	137	.....	121	153	120
		1923	92	.....	102	100	100
Norfolk sandy loam.	C. G. Gaskell farm, Carteret County.	1924	198	.....	171	146	186
Cecil sandy loam	G. E. Rockett farm, Catawba County.	1925	86	60	73	77	.....
		1926	88	104	116	115	122
	A. R. Anthony farm, Catawba County.	1927	170	163	189	178	181
		1928	291	293	274	263	277
Norfolk loamy fine sand.	Clyde Mathins farm, Currituck County.	1925	95	108	130	130	170
	R. L. Griggs farm, Currituck County.	1926	63	77	108	95	93
		1927	86	99	107	108	142
Average	.....	.....	130.6	.....	130.1	137	154.5

[1] Fertilizer containing 4 per cent ammonia, 8 per cent phosphoric acid, and 8 per cent potash applied at rate of 750 pounds an acre in all experiments except on Norfolk loamy fine sand, where 1,400 pounds an acre were used in 1925 and 1,800 pounds in 1926 and 1927.

FIGURE 10.—Effect of fertilizers containing various percentages of potash on yield of sweetpotatoes on Cecil sandy loam. Yield from 1/20-acre plots: A, No fertilizer, yield equivalent to 100 bushels per acre; B, yield from 750 pounds of fertilizer containing 4 per cent ammonia, 8 per cent phosphoric acid, and 4 per cent potash, equivalent to 166 bushels per acre; C, yield from 750 pounds of fertilizer containing 4 per cent ammonia, 8 per cent phosphoric acid, and 8 per cent potash, equivalent to 185 bushels per acre

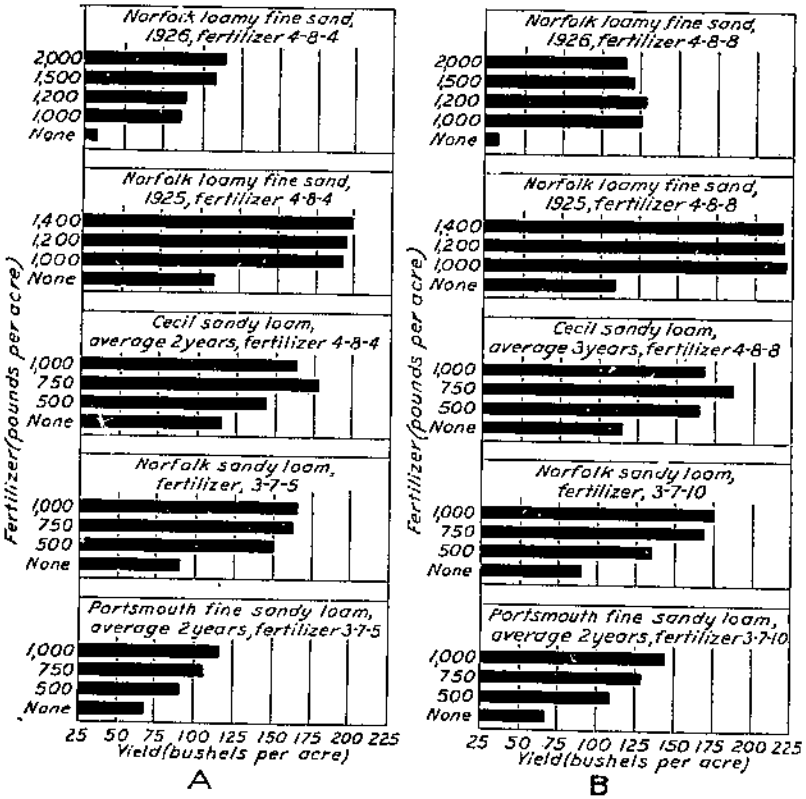


FIGURE 11.—Effect of varying quantities of several fertilizers on yield of sweetpotatoes on four soil types. A, Relatively low potash fertilizers; B, relatively high potash fertilizers

There was not a great difference in yield from the use of fertilizers containing nitrogen from various sources in the experiments on Portsmouth fine sandy loam, Norfolk sandy loam, and Cecil sandy loam. The fertilizer application was 750 pounds an acre, and no injury to young plants was noted from any of the treatments on these soils.

In the Currituck County experiments on Norfolk loamy fine sand, on which 1,400 and 1,800 pounds an acre of fertilizer were used, sodium

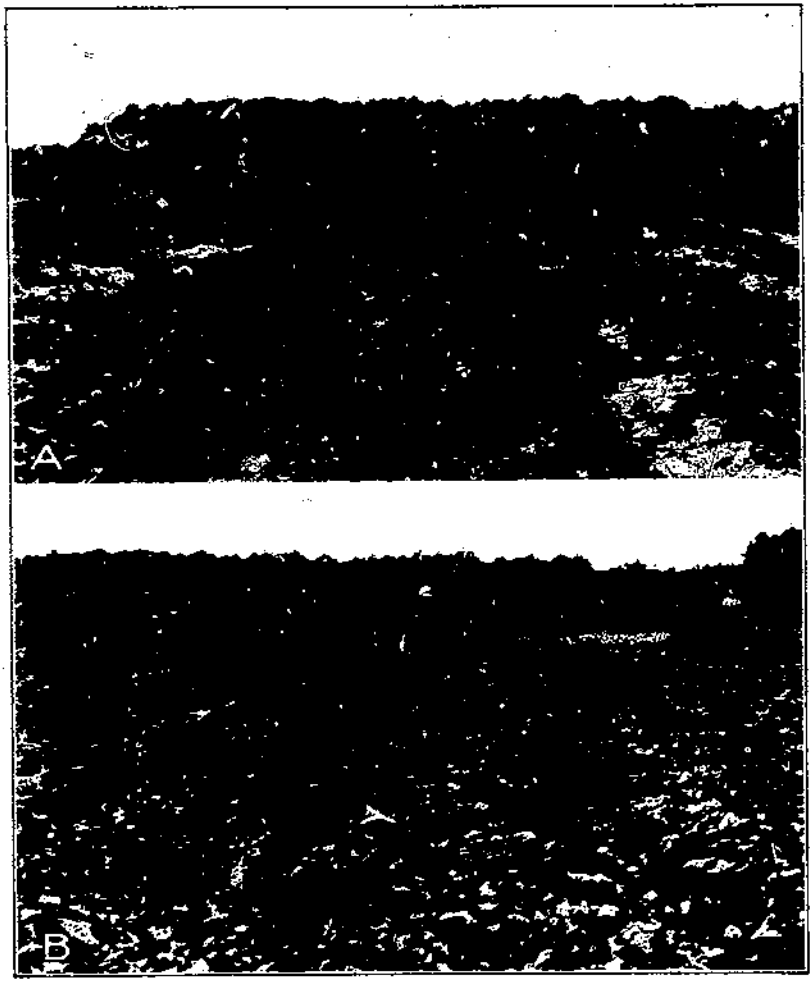


FIGURE 12.—Sweetpotatoes on Norfolk loamy fine sand fertilized with a 4-8-8 fertilizer applied at the rate of 1,000 pounds per acre before the plants were set: A, Nitrogen in the fertilizer derived from inorganic sources; B, nitrogen in the fertilizer derived two-thirds from mineral sources and one-third from organic sources of vegetable and animal origin

nitrate mixtures and ammonium sulphate mixtures gave smaller yields than did organic nitrogen mixtures. However, a mixture containing two-thirds mineral nitrogen and one-third organic nitrogen produced as large or larger yields than did organic nitrogen. Where sodium nitrate and ammonium sulphate were used the stands of sweetpotatoes were slightly poorer, which undoubtedly influenced the yields.

Approximately 20 per cent of the plants died in the sodium nitrate plots and 12 per cent in the ammonium sulphate plots. These plots were reset, but the late plants produced few sweetpotatoes. A perfect stand resulted where cottonseed meal and fish scrap were used, and there was no plant injury from the fertilizer deriving its nitrogen from a mixture of sodium nitrate, ammonium sulphate, and cottonseed meal. Figure 12, A, shows the results on stands of sweetpotatoes of fertilizer deriving all its nitrogen from inorganic sources, and in Figure 12, B, the results from fertilizer deriving nitrogen, two-thirds from inorganic sources and one-third from organic sources of vegetable and animal origin, are shown. Subsequent experiments revealed that mineral nitrogen, when used under certain conditions, may cause injury to newly set sweetpotato sprouts. It was difficult to maintain a stand where fertilizers containing 4 per cent of ammonia, derived from sodium nitrate and applied at the rate of 1,000 to 1,600 pounds an acre, were used. Experiments which give additional data on probable injury by fertilizer salts to young sweetpotato sprouts are reported and discussed in another section of this bulletin.

The results of experiments in which synthetic nitrogen salts were used as the sole source of nitrogen in mixed fertilizers, are given in Table 7 and are compared with results from sodium nitrate and ammonium sulphate. When the averages are considered, the yields from urea are somewhat lower than those from mineral nitrogen or other synthetic nitrogen salts. Experimental work reported in the following pages shows that better results are obtained when the nitrogen in a 4 per cent ammonia fertilizer is derived in part from mineral sources and in part from organic materials such as dried blood, fish scrap, tankage, and cottonseed meal. Experiments are in progress to determine the best ratio of mineral to organic nitrogen in mixed fertilizers for sweetpotatoes.

TABLE 7.—*Results of sweetpotato experiments with synthetic nitrogen salts as sources of nitrogen in fertilizers,*[1] *with phosphoric acid and potash*

Soil type and location	Year	Yield of sweetpotatoes per acre, with—				
		Sodium nitrate	Ammonium sulphate	Urea	Ammonium phosphate	Leuna-salpeter
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Cecil sandy loam, A. R. Anthony farm, Catawba County	1927	170	163	155	133	140
	1928	291	293	228	270	226
Norfolk loamy fine sand, R. L. Griggs farm, Currituck County	1927	86	99	166	102	121
	1928	67	69	58	68	71
Average		153.5	156	136	143	141

[1] Fertilizer analyzing 4 per cent ammonia, 8 per cent phosphoric acid, and 8 per cent potash, applied at the rate of 750 pounds an acre on Cecil sandy loam and 1,800 pounds on Norfolk sandy loam.

POTASH SOURCES

The effect of potash from several sources in mixtures with nitrogen and superphosphate was studied in experiments on four soil types. The fertilizers were applied at the rate of 750 pounds an acre on all soils used in the experiments, except Norfolk loamy fine sand, in Currituck County, on which the rate of application was 1,400 and 1,800 pounds an acre. The results are given in Table 8.

TABLE 8.—*Results of sweetpotato experiments with potash from various sources in complete fertilizers,*[1] *with phosphoric acid and nitrogen, on several soil types in North Carolina*

Soil type and location	Year	Yield of sweetpotatoes per acre, with—		
		Potassium sulphate	Potassium chloride	Kainit
		Bushels	*Bushels*	*Bushels*
Portsmouth fine sandy loam, H. E. Patten farm, Craven County	1922	150	156	110
Norfolk sandy loam, C. G. Gaskell farm, Carteret County	1923	64	70	48
	1924	190	185	105
Cecil sandy loam, G. E. Rockett farm, Catawba County	1925	71	69	43
	1926	126	129	83
Cecil sandy loam, A. R. Anthony farm, Catawba County	1927	181	177	160
	1928	268	272	176
Norfolk loamy fine sand, Clyde Mathins farm, Currituck County	1925	162	138	99
Norfolk loamy fine sand, R. L. Griggs farm, Currituck County	1926	132	92	35
	1927	133	136	78
Average		147.7	142.4	93.7

[1] Fertilizer analyzing 4 per cent ammonia, 8 per cent phosphoric acid, and 6 per cent potash applied at rate of 750 pounds an acre, except in Currituck County experiments, which received 1,400 pounds in 1925 and 1,800 pounds in 1926 and 1927.

The outstanding result in these experiments, in which one form of potash was used as the entire source of that constituent, was the poor showing made by kainit. The yields from kainit were lower in each experiment than those from potassium sulphate or potassium chloride; the last two produced about the same result. In five experiments potassium chloride led and in five potassium sulphate led. The average yield in all the experiments is slightly higher with potassium sulphate. The effect of the potash sources on the growth of sweetpotato vines is shown in Figure 13.

FIGURE 13.—Effect of several potash sources, in mixed fertilizers with nitrogen and superphosphate, on stand and growth of sweetpotato vines on Norfolk loamy fine sand: A, Potassium sulphate, yield 133 bushels per acre; B, potassium chloride, yield 136 bushels per acre; C, kainit, yield 78 bushels per acre

The reduced yields from kainit may be attributed to its injurious effect on young sweetpotato plants. Considerable plant injury was observed in the kainit plots, especially on Norfolk loamy fine sand, on which it was necessary to reset the plants. The large percentage of readily soluble salts in fertilizers containing 8 per cent potash, derived from kainit, is apparently the cause of the plant injury observed. Reports on subsequent work give results of fertilizer-placement experiments, and detailed data on the salt content of the soil near the roots of plants, where fertilizers of different composition were used.

Potassium chloride and potassium sulphate have about equal value for sweetpotatoes on the soils used in the experiments. Kainit seems unsuitable as the sole source of potash, where a 6 to 8 per cent potash fertilizer is used, unless precautions are taken in applying the fertilizer.

FERTILIZER PLACEMENT AND TIME OF APPLICATION

On Norfolk loamy fine sand, injury to sweetpotato plants attributed to fertilizers has resulted in poor stands and delayed maturing of the crop. Loss of plants in the early part of the season can be reduced by methods of placing fertilizers in relation to the position of newly set plants, and timing application of fertilizers in relation to time of setting the plants. Results of experiments, made from 1928 to 1931, on this soil type are interesting in connection with placement of fertilizers, time of applying fertilizer mixtures, and time of applying separate fertilizer ingredients, nitrogen and potash.

Results of experiments with a fertilizer mixture containing 4 per cent ammonia, 8 per cent phosphoric acid, and 8 per cent potash, used at the rate of 1,000 and 1,600 pounds an acre are given in Table 9.

TABLE 9.—*Effect of applying fertilizers* [1] *at different locations, in relation to plants and time of application, on sweetpotatoes on Norfolk loamy fine sand, Boswood farm, Currituck County, N. C., 1928*

Method and time of application	Plants living when—		Yield per acre when—	
	1,000 pounds of fertilizer per acre were applied	1,600 pounds of fertilizer per acre were applied	1,000 pounds of fertilizer per acre were applied	1,600 pounds of fertilizer per acre were applied
	Per cent	*Per cent*	*Bushels*	*Bushels*
Fertilizers applied in plant row, mixed in soil and bedded on, 10 days before plants were set	90	92	85	97
Fertilizers applied in plant row, not mixed in soil and bedded on, 10 days before plants were set	92	87	87	92
Fertilizers applied to side of plant row, 3 inches from plants, 2 weeks after plants were set	100	100	93	100
Fertilizers applied broadcast on top of plant row, 2 weeks after plants were set	100	100	101	106
	Per cent		*Bushels*	
No fertilizer	100		28	

[1] Fertilizer containing 4 per cent ammonia, 8 per cent phosphoric acid, and 8 per cent potash, made from sodium nitrate, cottonseed meal, superphosphate, and potassium sulphate.

There was some injury to the young sweetpotato plants from the fertilizer applied in the row under the plants, as indicated by the percentage of plants which failed to survive and grow. Fertilizers

applied to the side of the plants or broadcast on top of the row after the plants had become established caused no injury and all plants survived. The plots having the best stands produced the largest yields.

Results of experiments with potassium chloride and kainit in a mixture with superphosphate, sodium nitrate, and cottonseed meal are given in Table 10. Kainit proved more injurious to young plants than the potassium chloride, possibly because of the amount of readily soluble salts in the mixture supplied in kainit. The kainit contained 12.5 per cent and the potassium chloride 50 per cent potash. Four times as much kainit as muriate of potash was required to make the 8 per cent potash mixture.

TABLE 10.—*Effect on sweetpotato growth and yield of time of applying potash on Norfolk loamy fine sand, Boswood farm, Currituck County, N. C., 1928* [1]

Method and time of application	Plants living when—			
	1,000 pounds of fertilizer per acre were used (potassium chloride source of potash)	1,600 pounds of fertilizer per acre were used (potassium chloride source of potash)	1,000 pounds of fertilizer per acre were used (kainit source of potash)	1,600 pounds of fertilizer per acre were used (kainit source of potash)
	Per cent	*Per cent*	*Per cent*	*Per cent*
All potash applied with mixture when plants were set	95	92	82	70
All potash applied with mixture 2 weeks before plants were set	98	97	85	78
One-fourth of the potash applied with mixture 2 weeks before plants were set, one-half 3 weeks after plants were set, and one-fourth 6 weeks after plants were set	100	100	97	96
One-half of the potash applied with mixture 3 weeks after plants were set and one-half 6 weeks after plants were set	98	95	95	90
No fertilizer	*Per cent* 97			

Method and time of application	Yields per acre when—			
	1,000 pounds of fertilizer per acre were used (potassium chloride source of potash)	1,600 pounds of fertilizer per acre were used (potassium chloride source of potash)	1,000 pounds of fertilizer per acre were used (kainit source of potash)	1,600 pounds of fertilizer per acre were used (kainit source of potash)
	Bushels	*Bushels*	*Bushels*	*Bushels*
All potash applied with mixture when plants were set	88	78	69	62
All potash applied with mixture 2 weeks before plants were set	114	122	98	98
One-fourth of the potash applied with mixture 2 weeks before plants were set, one-half 3 weeks after plants were set, and one-fourth 6 weeks after plants were set	136	123	95	99
One-half of the potash applied with mixture 3 weeks after plants were set and one-half 6 weeks after plants were set	100	126	95	100
No fertilizer	*Bushels* 29			

[1] 4-8-8 fertilizer was used in experiment. Phosphoric acid and nitrogen applied before plants were set. Phosphoric acid in mixture derived from superphosphate; nitrogen one-half from sodium nitrate and one half from cottonseed meal

Where potash was applied with the fertilizer mixture immediately before the plants were set, a high percentage of plants died following the use of kainit, and there was some loss of plants when potassium chloride was used. The loss was greater in each case with the larger quantity of fertilizer employed. It was less when the fertilizers were applied two weeks before planting. Between the time the fertilizers were applied and the time the plants were set there was sufficient rainfall to thoroughly wet the soil and diffuse the fertilizer. There was but slight loss of plants where kainit mixtures were used and practically no loss where potassium chloride mixtures were used, where one-fourth the potash was applied before the plants were set and the remainder as a side application after the plants had become established. The yields are generally in harmony with the stands on the plots.

Results of experiments with fertilizers containing superphosphate, potassium sulphate, and sodium nitrate in which sodium nitrate was the sole source of nitrogen in one case and a mixture of sodium nitrate and cottonseed meal was the source of nitrogen in another are given in Table 11. In one case the fertilizer containing all the nitrogen was applied before setting the plants, and in the other the nitrogen was applied after the plants had become established. The experiment was planned to study the effect of the application of nitrogen on the growth of young sweetpotato plants and subsequently on yield.

TABLE 11.—*Effect on sweetpotato growth and yield of time of applying nitrogen, on Norfolk loamy fine sand, Boswood farm, Currituck County, N. C., 1928* [1]

Method and time of application	Plants living when—			
	1,000 pounds of fertilizer per acre, having one-half the nitrogen from sodium nitrate and one-half from cottonseed meal, were used	1,600 pounds of fertilizer per acre, having one-half the nitrogen from sodium nitrate and one-half from cottonseed meal, were used	1,000 pounds of fertilizer per acre, having sodium nitrate as the source of all the nitrogen, were used	1,600 pounds of fertilizer per acre, having sodium nitrate as the source of all the nitrogen, were used
	Per cent	*Per cent*	*Per cent*	*Per cent*
All nitrogen applied with mixture 2 weeks before plants were set	95	92	86	78
One-fourth nitrogen applied with mixture 2 weeks before plants were set, one-half 3 weeks after plants were set, and one-fourth 6 weeks after plants were set	95	99	92	90
One-half nitrogen applied with mixture 3 weeks after plants were set and one-half 6 weeks after plants were set	97	95	94	96
All nitrogen applied 3 weeks after plants were set	94	97	96	94
No fertilizer	*Per cent* 97			

[1] A 4-8-8 fertilizer was used in the experiment. Phosphoric acid and potash applied 2 weeks before plants were set. Phosphate in fertilizer derived from superphosphate; potash from sulphate of potash.

Method and time of application	Yield per acre when—			
	1,000 pounds of fertilizer per acre, having one-half the nitrogen from sodium nitrate and one-half from cottonseed meal, were used	1,600 pounds of fertilizer per acre, having one-half the nitrogen from sodium nitrate and one-half from cottonseed meal, were used	1,000 pounds of fertilizer per acre, having sodium nitrate as the source of all the nitrogen, were used	1,600 pounds of fertilizer per acre, having sodium nitrate as the source of all the nitrogen, were used
	Bushels	*Bushels*	*Bushels*	*Bushels*
All nitrogen applied with mixture 2 weeks before plants were set	73	82	64	53
One-fourth nitrogen applied with mixture 2 weeks before plants were set, one-half 3 weeks after plants were set, and one-fourth 6 weeks after plants were set	88	92	89	91
One-half nitrogen applied with mixture 3 weeks after plants were set and one-half 6 weeks after plants were set	77	93	95	83
All nitrogen applied 3 weeks after plants were set	73	90	83	91
No fertilizer	*Bushels* 29			

When applied before the plants were set, fertilizers containing 4 per cent ammonia, of which the nitrogen was derived from sodium nitrate, caused injury to the crop as evidenced by the comparatively small percentage of plants that survived. A larger percentage of the plants survived when only one-fourth or one-half the nitrogen was contained in the fertilizer mixture used in the preplanting application. There was only a small loss of young plants where the 4 per cent ammonia fertilizer, having the nitrogen derived equally from sodium nitrate and cottonseed meal was used. A loss of 8 per cent of the plants where 1,600 pounds of the 4–8–8 fertilizer was used in the preplanting application may be attributed in part to the fertilizer. The loss of plants was small, about the same percentage as in the no-fertilizer plot, where the smaller application of sodium nitrate or of a mixture of sodium nitrate and cottonseed meal was used. The yields from the two fertilizers did not differ widely when the nitrogen was applied after the plants had become established. The data indicate that equally good yields can be produced from fertilizer deriving its nitrogen entirely from sodium nitrate as from a mixture deriving its nitrogen from sodium nitrate and an organic material, if application can be so made as not to injure young plants. The effect of fertilizer on the stand of sweetpotatoes when fertilizers are applied before and after plants are set is shown in Fig. 14.

From the data in Tables 10 and 11, it is apparent that readily soluble salts in fertilizers, such as sodium nitrate and kainit, are harmful to young sweetpotato plants when the fertilizer is placed in the plant row on Norfolk loamy fine sand in Currituck County. In experiments in 1929, 1930, and 1931, the soil around the roots of the plants was examined for soluble salts several weeks after the fertilizer applications were made. Attempts have been made to correlate the quantity of soluble salts in the soil, where several fertilizers were used,

with the percentage of plants dying and with yields. These experiments were made on Norfolk loamy fine sand at Coinjock, N. C. The soil is of the same type as that used in the production of early sweet-

FIGURE 14.—Effect of applying fertilizers before and after sweetpotato plants are set on Norfolk loamy fine sand: 1,000 pounds per acre of a 4-8-8 fertilizer, composed of sodium nitrate, superphosphate, and potassium sulphate were used and applied in plant row before plants were set (A) and as a side dressing two weeks after plants were set (B)

potatoes in Currituck County. The experiments were repeated on the same plots each year. Three years' data are given in Table 12.

TABLE 12.—*Effect of time of application and placement of fertilizers of different compositions on accumulation of water-soluble salts in soil around roots of sweetpotato plants, on survival of plants, and on yield of sweetpotatoes. Norfolk loamy fine sand, Boswood farm, Coinjock, N. C., 1929, 1930, and 1931*

Composition of fertilizers	Rate of application per acre	Data recorded	Placement and time of fertilizer application								
			In furrows, mixed in soil and ridged before plants were set			In furrows, not mixed in soil and ridged before plants were set			In furrows, one-half mixed in soil and ridged before plants were set, one-half 3 weeks after plants were set		
			1929	1930	1931	1929	1930	1931	1929	1930	1931
	Pounds										
(A) 4-8-8, P_2O_5 from superphosphate, K_2O from potassium chloride, N one-half from nitrate soda, one-half from cottonseed meal.	1,000	Soluble salts in soil [1] parts per million	165.0	275.0	200	215.0	390.0	500	160.0	200.0	200
		Plants living [2] per cent	95.0	82.0	98	92.9	84.0	94	93.4	93.0	99
		Yield per acre bushels	129.0	115.0	135	126.0	118.0	110	139.0	124.0	127
Do	1,600	Soluble salts in soil parts per million	165.0	300.0	300	290.0	410.0	600	235.0	300.0	200
		Plants living per cent	92.2	82.0	97	86.4	84.0	94	95.7	94.0	99
		Yield per acre bushels	154.0	119.0	148	167.0	95.0	130	165.0	125.0	136
(B) 4-8-8, P_2O_5 from superphosphate, K_2O from potassium chloride, N from nitrate soda.	1,000	Soluble salts in soil parts per million	245.0	340.0	200	360.0	385.0	700	185.0	335.0	200
		Plants living per cent	90.7	70.0	97	87.2	59.0	96	87.2	90.0	98
		Yield per acre bushels	62.0	96.0	136	103.0	80.0	88	104.0	112.0	133
Do	1,600	Soluble salts in soil parts per million	430.0	490.0	500	520.0	740.0	900	200.0	515.0	300
		Plants living per cent	80.0	48.0	95	80.0	79.0	90	90.6	89.0	97
		Yield per acre bushels	97.0	62.0	115	122.0	60.0	75	140.0	112.0	127
(C) 4-8-8, P_2O_5 from superphosphate, K_2O from kainit, N one-half from nitrate soda and one-half from cottonseed meal.	1,000	Soluble salts in soil parts per million	1,185.0	480.0	250	1,210.0	600.0	900	1,280.0	396.0	200
		Plants living per cent	82.2	45.0	98	73.9	21.0	81	85.0	76.0	93
		Yield per acre bushels	121.0	60.0	133	104.0	57.0	70	91.0	112.0	133
Do	1,600	Soluble salts in soil parts per million	1,445.0	915.0	300	1,535.0	950.0	1,500	330.0	415.0	200
		Plants living per cent	66.5	21.0	96	80.0	11.0	51	69.8	76.0	96
		Yield per acre bushels	154.0	44.0	142	163.0	41.0	62	133.0	104.0	101
(D) 16-32-32, P_2O_5 from ammonium phosphate, K_2O from potassium chloride, N from ammonium phosphate and urea.	250	Soluble salts in soil parts per million	145.0	430.0	200	195.0	230.0	500	120.0	210.0	200
		Plants living per cent	93.7	90.0	96	94.3	78.0	92	94.3	70.0	98
		Yield per acre bushels	97.0	151.0	106	101.0	143.0	121	130.0	149.0	104
Do	400	Soluble salts in soil parts per million	175.0	600.0	250	210.0	245.0	650	180.0	470.0	200
		Plants living per cent	90.0	78.0	94	97.9	64.0	74	92.0	82.0	97
		Yield per acre bushels	136.0	136.0	140	139.0	130.0	111	144.0	171.0	154
Average (4 fertilizers)		Yield per acre bushels	119.0	97.9	132	129.0	90.5	96	131.0	126.2	138

Composition of fertilizers	Rate of application per acre	Data recorded	Placement and time of fertilizer application: Side dressing, 3 weeks after plants were set			One-half as side dressing 3 weeks after plants were set, one-half 6 weeks after plants were set			Broadcast on top of rows, 3 weeks after plants were set			Average		
			1929	1930	1931	1929	1930	1931	1929	1930	1931	1929	1930	1931
	Pounds													
(A) 4-8-8, P_2O_5 from superphosphate, K_2O from potassium chloride, N one-half from nitrate soda, one-half from cottonseed meal.	1,000	Soluble salts in soil [1]—parts per million	30	55.0	60	45	45.0	45	45	50	50			
		Plants living [2]—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	126	108.0	115	152	109.0	111	146	96	120	136	112	120
Do	1,600	Soluble salts in soil—parts per million	45	50.0	60	40	50.0	50	50	55	50			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	136	101.0	163	170	108.0	140	167	115	139	160	111	143
(B) 4-8-8, P_2O_5 from superphosphate, K_2O from potassium chloride, N from nitrate soda.	1,000	Soluble salts in soil—parts per million	25	45.0	45	50	50.0	50	70	40	45			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	129	116.0	85	136	114.0	85	115	157	101	109	113	105
Do	1,600	Soluble salts in soil—parts per million	35	55.0	50	60	45.0	50	45	60	60			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	110	130.0	121	166	116.0	116	131	168	142	128	108	116
(C) 4-8-8, P_2O_5 from superphosphate, K_2O from kainit, N one-half from nitrate soda and one-half from cottonseed meal.	1,000	Soluble salts in soil—parts per million	60	60.0	50	70	45.0	60	60	40	50			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	97	131.0	127	139	120.0	149	113	110	153	111	98	128
Do	1,600	Soluble salts in soil—parts per million	75	50.0	60	60	60.0	60	60	50	50			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	139	118.0	185	179	122.0	134	114	130	181	147	93	149
(D) 16-32-32, P_2O_5 from ammonium phosphate, K_2O from potassium chloride, N from ammonium phosphate and urea.	250	Soluble salts in soil—parts per million	60	50.0	50	50	60.0	45	70	45	60			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	124	139.0	109	128	131.0	72	130	124	78	118	140	98
Do	400	Soluble salts in soil—parts per million	65	50.0	50	55	55.0	50	55	50	50			
		Plants living—per cent	100	100.0	100	100	100.0	100	100	100	100			
		Yield per acre—bushels	127	152.0	145	148	146.0	130	151	148	133	141	147	136
Average (4 fertilizers)		Yield per acre—bushels	124	124.4	131	152	120.8	117	133	131	131			

	Results from no fertilizer: Section A			Section B			Section C			Section D		
Soluble salts in soil—parts per million	50	50	50	60	50	50	55	50	60	60	50	50
Plants living—per cent	100	100	100	100	100	100	100	100	100	100	100	100
Yield per acre—bushels	33	56	27	38	62	22	34	60	22	29	47	20

[1] Water-soluble salts in soil around the roots of the plants determined on samples collected 3 weeks after plants were set and before the delayed applications of fertilizers were made.
[2] Percentage of plants living was determined by making counts of living plants in each plot 3 weeks after plants were set and before delayed applications of fertilizers were made.

Comparison is made of a fertilizer containing 4 per cent ammonia, 8 per cent phosphoric acid, and 8 per cent potash, having its nitrogen derived entirely from sodium nitrate, and of one having the nitrogen derived equally from sodium nitrate and cottonseed meal. Kainit and potassium chloride as sources of potash are also compared. A mixture made from synthetic concentrated materials was also used. The fertilizers were used at the rate of 1,000 and 1,600 pounds an acre, with different methods of application.

There was less accumulation of water-soluble salts in the soil around the roots of the plants three weeks after the fertilizers were applied where a 4–8–8 fertilizer having its nitrogen derived equally from sodium nitrate and cottonseed meal was used, than where a fertilizer of the same analysis but having all its nitrogen from sodium nitrate was used. There was a greater soluble-salt content in the soil near the plant roots where an 8 per cent potash mixture containing kainit was used than where one containing potassium chloride was used. The results with a concentrated fertilizer mixture are not definite. In the first year's experiments the soluble salts in the soil were less than where the commercial mixture A was used, in the second year the accumulation of the salts in the surface soil was greater from the concentrated fertilizer, and in the third year the salt content of the plots receiving the two fertilizers was about the same.

In most cases the amount of salts accumulated in the soil around the roots of the plants correlates in a general way with the survival of the young plants. There was only a moderate accumulation of salts in the soil near the plant roots where mixture A, deriving its nitrogen partly from sodium nitrate and partly from cottonseed meal, was used. However, the quantity concentrating in the soil was sufficient to cause death to a small percentage of the plants in this sandy soil when 1,000 and 1,600 pounds of fertilizer an acre were applied in the furrow before the plants were set. Where only half the nitrogen was applied with the mixture before the plants were set, the accumulation of salts was generally less, but sufficient to be fatal to a small percentage of the plants. There was a greater accumulation of salts within the root zone of the young plants where fertilizer B was used, and many plants died. This occurred whether the fertilizer was not mixed or was well mixed in the soil. Applying only half the nitrogen with the mixture before planting did not entirely alleviate the harmfulness of the mixture.

Mixture C, which contained 8 per cent of potash derived from kainit, was more severe on the young sweetpotato plants than was mixture A, which contained potassium chloride. The amount of soluble salts within the root zone of the plants was much greater (in mixture C than in mixture A) in the 1929 experiments and somewhat greater in the 1930 and 1931 experiments. The percentage of plants surviving was generally in harmony with the percentage of salts in the soil within the root zone of the plants. Plants which survived where mixture C was used produced well, and the yields generally compare favorably with those made with mixtures containing other potash salts.

The survival of plants where the concentrated mixture D was used was as great as with mixture A in the 1929 experiment. However, in

1930 the results were not so clear. Where the fertilizer was left unmixed with the soil, there was a greater accumulation of salts in the plant-root zone, accompanied by a greater fatality of plants in 1930. The salt accumulation the first year was not sufficient to injure the young plants severely. In the third year, there was considerable injury where the fertilizer was not mixed in the soil and a slight injury where it was well mixed in the soil.

It should be noted that where each of the four fertilizers was applied as a side dressing or broadcast on top of the plant row after the plants had become established in the soil, all plants survived and a perfect stand was maintained.

In all three years of the experiments there were more water-soluble salts in the soil within the root zone of the newly set plants (with the exception of two instances) where the fertilizers were left unmixed in the plant row before ridging than where the fertilizers were well mixed before ridging. Generally there was a greater loss of plants with a greater concentration of salts in the surface soil. The thorough mixing of the fertilizers in the soil is important in sweetpotato growing on sandy soils, especially when using fertilizers containing large percentages of readily soluble salts.

A comparison of yield of sweetpotatoes from the four fertilizers used on Norfolk loamy fine sand, is interesting. When the fertilizers were applied before planting, as is the general custom on this soil type in North Carolina, mixture A gave larger yields than mixture B or C. The fertilizer having both mineral and organic nitrogen proved better than that containing only mineral nitrogen, and the fertilizer containing potassium chloride proved better than the mixture containing kainit. The general relation between these fertilizers also held when half the fertilizer was used at the preplanting application and the remainder later as a side application. When the fertilizers were applied as a side dressing or broadcast on top of the ridge after the plants had become established, this relation did not hold and there was not a wide variation in yields from the different mixtures.

In 1929 and 1931 the yields from the use of concentrated mixture C were generally smaller than the yields from the use of mixture A. However, in 1930 use of the concentrated mixture generally resulted in higher yields.

When the yield data are considered with respect to placement of the fertilizers and time of application, it is apparent that the delayed applications have generally given best results. However, these differed with the composition of the fertilizer and the quantity applied. The yields from the mixture containing kainit and from that containing sodium nitrate as the sole source of nitrogen were in most cases decidedly better where the fertilizers were applied after the plants had become well rooted. The results do not show conclusively whether best results can be expected from applying the fertilizer broadcast on top of the plant row or from applying it as a side dressing after the plants have become established.

Results are given in Table 13 of 12 experiments in which a 4–8–8 mixture was applied under the plant row two weeks before the plants were set, as compared with those obtained by broadcast application

on top of the ridge two weeks after the plants were set. These results are generally in favor of broadcasting on top of the row after the plants have become established. The average yield in the 12 experiments where the fertilizers were applied under the row before planting was 109 bushels an acre, as compared with 118 bushels where the fertilizer was applied broadcast on the row after the plants had become rooted.

TABLE 13.—*Effect on growth and yield of sweetpotatoes of broadcasting a 4–8–8* [1] *fertilizer mixture on top of row after plants were set, as compared to applying the same mixture under plants before plants were set*

Year	Fertilizer application per acre	Yield per acre with—		Year	Fertilizer application per acre	Yield per acre with—	
		Fertilizer under plant row, 2 weeks before plants were set	Fertilizer broadcast on top of row, 2 weeks after plants were set			Fertilizer under plant row, 2 weeks before plants were set	Fertilizer broadcast on top of row, 2 weeks after plants were set
	Pounds	*Bushels*	*Bushels*		*Pounds*	*Bushels*	*Bushels*
1928	1,000	85	101	1930	1,200	74	97
1928	1,600	97	107	1930	1,200	97	117
1929	1,000	129	146	1931	1,000	94	100
1929	1,600	154	157	1931	1,600	110	139
1930	1,000	115	90	1931	1,200	120	146
1930	1,600	119	115				

[1] Percentages, respectively, of ammonia, phosphoric acid, and potash.

CONCENTRATED FERTILIZERS

In a preceding section of this bulletin, are reported experiments comparing the effects of several synthetic nitrogen and mineral salts. In these experiments the salts were used in a complete fertilizer containing 20 per cent of plant food and 80 per cent of a filler, either natural or added. In order to study the effects of concentrated fertilizer on sweetpotatoes, field experiments were made on Norfolk loamy fine sand in Currituck County, and the results are here reported.

The materials used in preparing the concentrated fertilizer mixtures were ammonium phosphate, monopotassium phosphate, potassium nitrate, potassium sulphate, ammonium nitrate, ammonium chloride, urea, ammonium sulphate, and sodium nitrate. The ammonium phosphate was a commercial product, containing 14 per cent ammonia and 60 per cent phosphoric acid. The monopotassium phosphate was made in the fertilizer and fixed nitrogen laboratory of the Bureau of Chemistry and Soils at the Arlington Experiment Farm, Rosslyn, Va., from volatilized phosphoric acid and commercial potassium hydroxide. It analyzed 52 per cent phosphoric acid and 44 per cent potash. The potassium nitrate and potassium sulphate were commercial products purchased on the market, the former containing 16 per cent ammonia and 44 per cent potash, and the latter containing 50 per cent potash. The ammonium nitrate had a nitro-

gen content of 42 per cent ammonia, the urea 56 per cent, and the ammonium chloride 31.5 per cent.

Potassium ammonium phosphate, a mixture of monoammonium and monopotassium phosphates, made in the fertilizer and fixed nitrogen laboratory, was also used. The steps in preparing this mixture are the treatment of potassium chloride with two equivalents of phosphoric acid at a temperature high enough to expel hydrochloric acid and form a solution of monopotassium phosphate in phosphoric acid. The excess phosphoric acid is then neutralized with ammonia. Potassium ammonium phosphate is a complete fertilizer in itself and possesses excellent physical and mechanical properties making it suitable for fertilizer use. It contains 6.5 per cent ammonia, 56 per cent phosphoric acid, and 17 per cent potash.

In 1926 cottonseed meal was used, to the extent of 10 per cent of the total weight of the fertilizer mixture, as a partial source of nitrogen, to insure satisfactory drillability. Many of the mixtures made in 1925 had caked and proved difficult to handle and distribute in the field. In 1927 the cottonseed meal employed as a conditioner was, however, reduced to 5 per cent of the total weight of the mixtures, as it had been found that this quantity was sufficient to keep them in good drillable condition.

In the investigation with concentrated fertilizers, two mixtures were used in the first year's experiments. A commercial fertilizer containing 6 per cent ammonia, 9 per cent phosphoric acid, and 6 per cent potash was used at the rate of 1,400 pounds an acre, and equivalent quantities of the concentrated fertilizer were used. The so-called commercial fertilizer was composed of materials used in commercial-fertilizer mixtures for many years, and its composition differed slightly in the different experiments reported. In the discussion this mixture is referred to as the older fertilizer, or ordinary commercial fertilizer.

The fertilizers were prepared early in February and stored until April. The two concentrated mixtures absorbed moisture and became gummy. The physical condition of both mixtures was such that they could not be applied with a fertilizer distributor. The concentrated mixtures which were diluted with sand were also slightly moist, and their distribution by means of a machine was difficult.

The fertilizers were distributed by hand in the seed furrow, mixed with the soil by running a plow in the row, then bedded on, and sweetpotato plants were set 10 days later.

A good stand of plants was obtained, although the season from the time of setting the sprouts until the sweetpotatoes were dug on August 30 was unusually dry. The vines grew normally and the differences in vegetative growth in the different plots were slight. The yields are given in Table 14.

TABLE 14.—*Effect of concentrated fertilizers*[1] *on yield of sweetpotatoes on Norfolk loamy fine sand*

Fertilizer mixture	Ingredients in fertilizer mixture	Ingredients applied per acre	Yield per acre
		Pounds	*Bushels*
A	Ammonium phosphate	183.4	
	Ammonium nitrate	162.6	
	Potassium phosphate	24.5	
	Potassium nitrate	51.5	
	Total	422.0	115.1
A–1	Same as A diluted with sand	1,400	117.0
B	Ammonium phosphate	210.0	
	Urea	97.0	
	Potassium sulphate	168.0	
	Total	475.0	100.8
B–1	Same as B diluted with sand	1,400	110.2
C	Superphosphate	787.5	
	Potassium sulphate	108.0	
	Sodium nitrate	147.0	
	Ammonium sulphate	112.0	
	Dried blood	175.0	
	Filler	10.5	
	Total	1,400.0	123.0
	No fertilizer		72.0

[1] Fertilizer used at the rate of 1,400 pounds per acre, 6–9–6 basis.

In 1926, 1927, and 1928 experiments were made on the same soil type and on the same farm as in 1925. Eighteen hundred pounds an acre on the basis of 6–9–6 fertilizer was used in 1926 and 1927, and 1,600 pounds of a 4–8–8 mixture in 1928 was used on ¼-acre plots. The experiments were extended to include six mixtures in 1926 and eight in 1927 and 1928. The composition of each fertilizer is given in connection with the yield data in Table 15.

TABLE 15.—*Effect of concentrated and commercial fertilizers on sweetpotatoes on Norfolk loamy fine sand*

Fertilizer mixture	Ingredients in fertilizer mixture	Ingredients in fertilizer to make—		Yield per acre		
		1,800 pounds of 6–9–6 used in 1926 and 1927	1,600 pounds of 4–8–8 used in 1928	1926	1927	1928
		Pounds	*Pounds*	*Bushels*	*Bushels*	*Bushels*
A	Ammonium phosphate	265.0	267.0			
	Ammonium nitrate	68.0	64.7			
	Potassium ammonium phosphate	93.0				
	Potassium nitrate	221.0				
	Potassium sulphate		249.5			
	Cottonseed meal	168.0	31.2			
	Total	685.0	612.4	190	132	163
B	Ammonium phosphate	338.0	67.0			
	Urea	105.0	48.0			
	Potassium sulphate	216.0	249.5			
	Cottonseed meal	172.0	30.5			
	Total	731.0	395.0	200	138	176

TABLE 15.—*Effect of concentrated and commerical fertilizers on sweet potatoes on Norfolk loamy fine sand*—Continued

Fertilizer mixture	Ingredients in fertilizer mixture	Ingredients in fertilizer to make—		Yield per acre		
		1,800 pounds of 6-9-6 used in 1926 and 1927	1,600 pounds of 4-8-8 used in 1928	1926	1927	1928
		Pounds	*Pounds*	*Bushels*	*Bushels*	*Bushels*
C	Superphosphate	1,013.0	800.0			
	Potassium sulphate	216.0	249.5			
	Sodium nitrate	189.0	89.0			
	Ammonium sulphate	144.0	64.0			
	Dried blood	225.0	155.0			
	Filler	13.0	243.0			
	Total	1,800.0	1,600.5	179	158	184
D	Ammonium phosphate	338.0	267.0			
	Ammonium chloride	183.0	85.5			
	Potassium sulphate	216.0	249.5			
	Cottonseed meal	81.0	32.0			
	Total	818.0	634.0	120	113	102
E	Ammonium phosphate	338.0	267.0			
	Ammonium sulphate	236.0	106.0			
	Potassium sulphate	216.0	249.5			
	Cottonseed meal	[1] 86.0	33.5			
	Total	870.0	656.0	118	131	170
F	Triple phosphate	360.0	276.0			
	Urea	181.0	109.5			
	Potassium sulphate	216.0	249.5			
	Cottonseed meal	[1] 83.0	33.5			
	Total	840.0	668.5	140	136	110
G	Potassium ammonium phosphate	290.0	229.0			
	Urea	117.5	26.0			
	Potassium nitrate	134.0	202.0			
	Cottonseed meal	28.5	24.0			
	Total	570.0	481.0	150	137	
H	Potassium ammonium phosphate	290.0	229.0			
	Ammonium sulphate	260.0	58.5			
	Potassium nitrate	134.0	200.5			
	Cottonseed meal	36.0	25.5			
	Total	720.0	513.5	136	139	
I	Ammonium phosphate	338.0	267.0			
	Sodium nitrate	317.0	145.0			
	Potassium sulphate	228.0	240.5			
	Cottonseed meal	47.0	35.5			
	Total	930.0	697.0	180	138	
	No fertilizer			53	31	35

[1] Half this amount of cottonseed meal was used in 1927.

In 1926 cottonseed meal was added in quantities amounting to 10 per cent of the weight of the mixture in each concentrated fertilizer, and in 1927 and 1928 cottonseed meal amounting to 5 per cent of the weight of the mixture was added to keep it in a desirable physical condition. The fertilizers were mixed early in February of each year and stored until applied in April. A desirable physical condition of the mixtures was maintained in most of the fertilizers. The treble phosphate mixture with urea (F) became gummy and the mixture of

urea and ammonium phosphate (B) was slightly moist but its condition was not undesirable. The other fertilizer did not absorb moisture or become caked. All the fertilizers except the treble phosphate-urea mixture were applied without difficulty by a fertilizer distributor. The application was made 14 days before the plants were set, and the fertilizer was well mixed in the soil.

In 1926 the season was again very dry, but no severe injury to the sweetpotatoes was noted. Growth was very slow in the early part of the summer, and the vines where fertilizer D, containing ammonium chloride, was used did not make a good growth, nor did they have a desirable green color at any time during the summer.

In 1927 and 1928 the plants again grew well and appeared thrifty in most of the plots. Early in the summer of 1927 it was noted that the plants on plot D, where the fertilizer contained ammonium chloride, had a pale-yellow color and were growing only slightly better than those on the no-fertilizer plots. A few plants died. Notes made on July 25 show the relative stand and condition of the crop. The data are given in Table 16.

TABLE 16.—*Condition of sweetpotato vines on July 25, 1927 and 1928, grown with concentrated and commercial fertilizers*

Fertilizer mixture	Color of vines	Area covered by vines	1927		1928	
			Relative condition considering stand and appearance	Stand	Relative condition considering stand and appearance	Stand
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
A	Dark green	92	90	90	95	100
B	do	90	98	95	92	100
C	do	98	100	95	100	100
D	Pale green	85	85	80	92	100
E	Dark green	96	97	95	96	100
F	do	92	95	90	94	100
G	do	98	100	98	95	100
H	do	93	92	98	95	100
I	do	90	90	92	95	100
No fertilizer	Pale green	85	40	98	25	100

In 1926 the largest yields were obtained from the use of concentrated fertilizers A and B, which produced 11 and 21 bushels more, respectively, than fertilizer C. The yields from the use of fertilizers D, E, and F were smaller.

In 1927 the commercial mixture C gave larger yields than seven of the concentrated mixtures. Concentrated mixture I gave the largest yield, but this relation did not hold the following year. In 1928 the largest yielding plot was that fertilized with the commercial mixture C.

In 1926 and 1928 concentrated mixture F, which contained triple phosphate and urea, gave a smaller yield by 60 and 57 bushels, respectively, than did mixture B which had its phosphate derived from ammonium phosphate and its nitrogen partly from ammonium phosphate and partly from urea. In 1927 the yields from the two fertilizers were very close but slightly in favor of mixture B.

Fertilizer D, containing ammonium phosphate, ammonium chloride, and potassium sulphate, gave a comparatively low yield each

year. This was more marked in 1926 and 1927. The disturbing factor in this mixture is undoubtedly ammonium chloride. In 1928 a lower nitrogen fertilizer was used and the amount of ammonium chloride was probably not sufficient to exert a retarding effect. It was noted that there was no detrimental effect that year on the young plants when first set, but there was some retardation of vine growth. This was overcome in the late season, and the yields of sweetpotatoes fertilized by mixture D compared favorably with yields from some of the other concentrated mixtures but were not so good as yields from the commercial fertilizer.

In 1927 an experiment on a somewhat larger scale was made in addition to those reported in Table 15. The test was carried out on two ½-acre plots, one of which was treated with a fertilizer made from older commercial materials and the other with a mixture of concentrated materials. The fertilizer used in each case analyzed 4–8–8 and was applied at the rate of 1,800 pounds an acre. The fertilizer was supplied to the cooperating farmer and applied by him with the fertilizer distributor used in applying fertilizers to his commercial crop.

A good stand was obtained in each ½-acre plot, and a healthy growth of vines was produced. The vines retained a desirable dark-green color throughout the growing season. Ninety-eight per cent of the plants lived on the half acre fertilized with the commercial mixture and 95 per cent on the half acre treated with the concentrated fertilizer.

The sweetpotato yields and the composition of the two fertilizers are given in Table 17. The commercial mixture produced a larger yield by 16.5 bushels than did the concentrated.

TABLE 17.—*Yields from two ½-acre plots of sweetpotatoes fertilized [1] with a commercial and a concentrated mixture, on Norfolk loamy fine sand, Currituck County, N. C., 1927*

Kind of fertilizer	Composition of fertilizer	Quantity applied per acre	Yield of sweetpotatoes per acre
		Pounds	*Bushels*
Concentrated	Ammonium phosphate	300	
	Urea	58	
	Potassium sulphate	306	
	Cottonseed meal	70	
	Total	734	148.5
Commercial	Superphosphate	900	
	Sodium nitrate	100	
	Ammonium sulphate	72	
	Fish scrap	152	
	Cottonseed meal	224	
	Potassium sulphate	306	
	Filler	46	
	Total	1,800	165.0

[1] Fertilizer applied at a rate to equal 1,800 pounds per acre of a 4–8–8 analysis.

The addition of sodium nitrate and ammonium sulphate or of cottonseed meal and tankage to some of the concentrated mixtures used in the preceding experiments did not appreciably improve them for sweetpotato production. In the experiments reported in Table 18,

one-fourth of the nitrogen from the synthetic salts in three mixtures, namely, A, B, and F, was replaced by mineral nitrogen in one case and by organic nitrogen of vegetable and animal-waste origin in another. There was no consistent increase in sweetpotato yield from mixtures containing the substitutes over the yield from the mixture deriving its nitrogen entirely from the more concentrated synthetic salts. This was generally the case whether the fertilizer was all applied before the plants were set or whether only half the quantity was applied before planting and half as a side dressing 30 days after planting. The yields from the concentrated mixtures were not so great as from mixture C which was composed entirely of the commercial fertilizer materials.

TABLE 18.—*Effect on sweetpotatoes of concentrated fertilizer containing small quantities of mineral and organic nitrogen, on Norfolk loamy fine sand, Currituck County, N. C.*

Plot No.	Composition of fertilizer	Fertilizer per acre [1]	Yield per acre with—								Average yield
			Fertilizer applied before planting				Fertilizer applied one-half before planting and one-half 30 days after plants were set				
			1929	1930	1931	Average	1929	1930	1931	Average	
		Pounds	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
A–1	Ammonium phosphate, ammonium nitrate, and potassium sulphate	626	96	152	119	122.3	129	150	123	134.0	128.1
A–2	Same as A–1, except one-fourth of nitrogen was from sodium nitrate and ammonium sulphate	667	110	151	113	124.7	124	129	125	126.0	125.3
A–3	Same as A–1, except one-fourth of nitrogen was from cottonseed meal and tankage	751	107	184	128	139.7	126	132	132	130.0	134.8
B–1	Ammonium phosphate, urea, and potassium sulphate	604	88	165	121	124.7	116	137	132	128.3	126.5
B–2	Same as B–1, except one-fourth of nitrogen was from sodium nitrate and ammonium sulphate	657	93	161	108	120.7	109	162	109	126.6	123.6
B–3	Same as B–1, except one-fourth of nitrogen was from cottonseed meal and tankage	741	98	147	123	122.7	107	138	137	127.3	125.0
F–1	Treble superphosphate, urea, and potassium sulphate	713	92	149	119	120.0	112	157	115	128.0	124.0
F–2	Same as F–1, except one-fourth of nitrogen was from sodium nitrate and ammonium sulphate	732	117	----	----	----	100	----	----	----	----
F–3	Same as F–1, except one-fourth of nitrogen was from cottonseed meal and tankage	875	117	----	----	----	112	----	----	----	----
C	Superphosphate, potassium sulphate, sodium nitrate, ammonium sulphate, cottonseed meal, and tankage	1,600	129	157	135	140.3	132	167	138	145.7	143.0
	No fertilizer	0	37	62	27	42.0	----	----	----	----	----

[1] Equivalent to 1,600 pounds per acre of 4–8–8 fertilizer.

Experiments with concentrated fertilizers containing dolomitic limestone and minor essential plant foods, such as manganese, copper, zinc, nickel, and boron did not give consistent results, as shown in Table 19. Their use resulted in some increases over the use of concentrated mixtures, but in no case was the yield so large as in plot C, containing the commercial materials. The soil of the plots where no limestone was used was acid, having a pH of 5.8 to 6.0. The minor chemicals were mixed in the fertilizer and applied with the mixture. Manganese sulphate alone, with the concentrated fertilizer, and in concentrated fertilizers with zinc sulphate, copper sulphate, nickel sulphate, and boron, gave some minor increases over its check when divided fertilizer application was made but practically no increase when the fertilizer was all applied before planting.

TABLE 19.—*Effect of concentrated fertilizers, containing minor essential chemicals, on sweetpotatoes on Norfolk loamy fine sand, Currituck County, N. C.*

Plot No.	Fertilizer treatment	Fertilizer per acre [1]	Yield per acre with—						Average yield
			Fertilizers applied before planting			One-half fertilizer applied before planting and one-half 30 days after plants were set			
			1930	1931	Average	1930	1931	Average	
		Pounds	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
B–1	Ammonium phosphate, urea, and potassium sulphate	604	147	121	134.0	137	132	134.5	134.2
B–4	Same as B–1, plus manganese sulphate [2]	654	143	116	129.5	152	130	141.0	135.2
B–5	Same as B–1, plus manganese sulphate, copper sulphate, zinc sulphate, nickel sulphate, and boron [3]	672	151	120	135.5	145	137	141.0	138.2
B–6	Ammonium phosphate, urea, potassium sulphate, and limestone [4]	604	135	118	126.5	140	120	130.0	128.2
B–7	Same as B–6, plus manganese sulphate [2]	654	136	124	130.0	149	130	139.5	134.8
B–8	Same as B–6, plus manganese sulphate, zinc sulphate, nickel sulphate, and boron [3]	672	145	128	136.5	150	137	143.5	140.0
C	Superphosphate, potassium sulphate, sodium nitrate, ammonium sulphate, cottonseed meal, and tankage	1,600	157	135	146.0	167	138	152.5	149.2
	No fertilizer	0	63	27	45				

[1] Equivalent to 1,600 pounds per acre of 4–8–8 fertilizer.
[2] Manganese sulphate used at rate of 50 pounds per acre.
[3] Manganese sulphate used at rate to add 50 pounds per acre; zinc sulphate, copper sulphate, zinc sulphate, nickel sulphate, and boron, 3 pounds per acre.
[4] Dolomitic limestone was applied in the fertilizer furrow when fertilizers were applied at rate of 500 pounds per acre.

The dolomitic limestone was applied in the plant furrow two weeks before the plants were set. The soil during the growing season was neutral to slightly alkaline and maintained a pH of 7.0 to 7.4. The addition of limestone to the soil did not make it more productive of sweetpotatoes. There was generally an increase in yield from the manganese and the manganese, zinc, copper, and nickel on the limed soil, but the result is not marked, possibly because of the apparently depressing effect of the limestone.

DISCUSSION

The yields of sweetpotatoes from concentrated fertilizers were not generally so high as from ordinary fertilizers used as a means of comparison in this work. In the experiments reported in this bulletin, 2 concentrated mixtures were used in 1925, 5 in 1926, and 8 in 1927 and 1928. In the first year the 2 concentrated mixtures gave a lower yield than the commercial. In the second year, 2 of the concentrated mixtures gave a higher yield, in the third year 1 concentrated mixture gave a much higher yield, but 7 gave a lower yield than the commercial mixtures. In the fourth year all 8 concentrated mixtures fell behind the commercial.

Concentrated mixture A, consisting of ammonium phosphate, potassium-ammonium phosphate, ammonium nitrate, and potassium nitrate, and concentrated mixture B, consisting of ammonium phosphate, urea, and potassium sulphate, gave the largest yields of the concentrated mixtures in 1926 and in 1928. In 1927 two other mixtures gave larger yields.

Concentrated mixture D, consisting of ammonium phosphate, ammonium chloride, and potassium sulphate, gave the poorest vine growth and the poorest yield of sweetpotatoes in 1926 and 1927. In 1928 the yield with this fertilizer was below that with the commercial fertilizer, but better than with some of the concentrated mixtures. In the 1928 experiments a lower nitrogen mixture was used and 85.5 pounds per acre of ammonium chloride were used as compared to 183 pounds in 1926 and 1927. Ammonium chloride seems to be the disturbing factor in this mixture; the smaller quantities used in 1927 apparently were not sufficient to retard growth.

Although the concentrated mixtures did not give as good yields as ordinary commercial fertilizer, most of the concentrated fertilizers used gave good results. The use of small quantities of mineral nitrogen or of organic nitrogen of vegetable and animal-waste origin, with concentrated mixtures containing principally synthetic nitrogen salts, did not appreciably improve them for the production of sweetpotatoes on Norfolk loamy fine sand, nor did the addition of limestone or of minor essential chemicals, such as manganese, copper, zinc, nickel, and boron, cause the fertilizer to produce appreciably larger yields of sweetpotatoes on this soil.

SUMMARY

The results of fertilizer experiments with sweetpotatoes made in North Carolina on Norfolk sandy loam, Portsmouth fine sandy loam, Cecil sandy loam, and Norfolk loamy fine sand are given. A study was made (1) of fertilizers of different ratios of nitrogen, phosphoric acid, and potash for sweetpotatoes, (2) of various nitrogen sources, (3) of various potash sources, (4) of quantities of fertilizers, (5) of time of application and placement of fertilizers, in relation to the plant, and (6) of concentrated fertilizers.

The fertilizer requirement as to ratio of nitrogen, phosphoric acid, and potash differs slightly with the soil type. For Norfolk sandy loam in the central coastal plain, best results were obtained with fertilizers containing a small percentage of phosphoric acid, 3 to 4 per cent ammonia, and 9 to 10 per cent potash; for Portsmouth fine sandy loam of the central coastal plain, best results were obtained with mixtures containing 3 to 4 per cent ammonia, 3 to 4 per cent phos-

phoric acid, and 8 to 9 per cent potash; for Cecil sandy loam of the piedmont section, best results were obtained with mixtures containing 2 to 4 per cent ammonia, 4 to 6 per cent phosphoric acid, and 7 to 9 per cent potash; and for Norfolk loamy fine sand of the northern coastal plain, fertilizers giving best results contained about 3 per cent ammonia, 3 to 6 per cent phosphoric acid, and 6 to 9 per cent potash. The fertilizer requirements for sweetpotatoes, as regards ratio of nitrogen, phosphoric acid, and potash, of the soil types worked with, do not differ widely. Commercial fertilizers used for sweetpotatoes differ greatly in composition. In the larger sweetpotato sections, the fertilizers generally used contain from 3 to 4 per cent ammonia, 8 to 10 per cent potash, and about 8 per cent phosphoric acid. The data obtained in the experimental work, on soils which in previous years have received fertilizers containing high percentages of phosphoric acid, show largest yields with fertilizer mixtures containing a lower ratio than 8 per cent phosphoric acid, to 4 per cent ammonia and 8 per cent potash. For virgin soils or soils previously planted to crops without the additions of phosphate fertilizers, an 8 per cent phosphoric acid mixture would probably be required for best results.

For sweetpotatoes grown on Norfolk sandy loam, Portsmouth fine sandy loam, and Cecil sandy loam, fertilizers applied at the rate of 750 and 1,000 pounds an acre gave better yields than smaller or larger quantities. The increased yield from 1,000 pounds an acre over 750 pounds was usually small and of doubtful economic importance. For the Norfolk loamy fine sand larger quantities were profitable, from 1,200 to 1,500 pounds an acre giving best results.

On heavy soil types, synthetic and mineral nitrogen salts gave as large yields as mixtures of these with organic nitrogen materials. On Norfolk loamy fine sand, where fertilizers are used at a rate ranging from 1,000 to 1,500 pounds an acre, a 4 per cent nitrogen mixture, with nitrogen derived entirely from mineral sources, was injurious to newly set sweetpotato plants and resulted in poor stands and reduced yields. It may be concluded that fertilizer for sweetpotatoes on sandy soils should have its nitrogen derived partly from mineral or synthetic nitrogen and partly from organic materials.

Potassium sulphate and potassium chloride proved to be satisfactory sources of potash for sweetpotatoes. The yields produced by both were practically the same. Kainit as the sole source of potash in an 8 per cent potash mixture, when used at the rate of 1,400 pounds an acre, caused injury to newly set plants, resulting in poor stands and reduced yields. On all the soils worked with, kainit gave smaller yields than did potassium sulphate or potassium chloride.

Complete fertilizers containing kainit as the source of potash and fertilizers containing nitrate of soda as the source of nitrogen caused injury to sweetpotato plants when applied before the plants were set in the row and ridged, but no injury was observed when the fertilizers were applied either as a side dressing or broadcast on top of the plant row after the plants were well rooted. When the fertilizer was applied in the plant row before planting, the concentration of soluble salts in the soil within the root zone of the young plants was sufficient to kill the plants. This accumulation of soluble salts in the surface soil was not great where fertilizer containing potassium sulphate

or potassium chloride was used or when fertilizer having its nitrogen derived equally from mineral salts and from organic material was used. The percentage of dead plants was generally correlated with the amount of salts concentrated in the soil within the root zone of the young plants.

Fertilizers applied broadcast on top of the plant row or applied as a side dressing after the plants were well established caused no injury to young plants and produced larger yields than fertilizers applied in the row before the plants were set.

Concentrated fertilizers, made primarily from synthetic chemicals, gave good results with sweetpotatoes on Norfolk loamy fine sand when applied in the furrow before setting the plants, if precautions were taken to apply the fertilizer 10 days before setting the plants and mix it in the soil. The yields from concentrated fertilizers were not so large as from ordinary fertilizer mixtures made from the older materials. The addition of dolomitic limestone or of minor essential elements, such as manganese, zinc, copper, boron, and nickel, to concentrated fertilizers did not markedly improve them for sweetpotato production on Norfolk loamy fine sand.

LITERATURE CITED

(1) BLEDSOE, R. P., and SKINNER, J. J.
1929. FERTILIZER RATIO EXPERIMENTS, CONDUCTED ON CECIL SANDY CLAY LOAM. COTTON, CORN, AND WHEAT GROWN IN ROTATION. Ga. Agr. Expt. Sta. Bul. 151, 31 p., illus.

(2) FERRIS, E. B., and ANDERSON, W. S.
1926. A REPORT OF WORK AT SOUTH MISSISSIPPI BRANCH STATION FOR 1926. Miss. Agr. Expt. Sta. Bul. 238, 18 p.

(3) GEISE, F. W.
1926. THE INFLUENCE OF NITROGEN, PHOSPHORUS, AND POTASH, SEPARATELY AND IN COMBINATION, ON SWEET POTATO PRODUCTION. Amer. Soc. Hort. Sci. Proc. (1925) 22:363–370, illus.

(4) ———
1929. FERTILIZER STUDIES AND THE PRODUCTION OF SWEET POTATOES. Md. Agr. Expt. Sta. Bul. 311, 38 p., illus.

(5) HOTCHKISS, W. S.
1921. SWEET POTATO FERTILIZER EXPERIMENTS AT SUBSTATION NO. 2. Tex. Agr. Expt. Sta. Bul. 277, 7 p.

(6) HOUGHLAND, G. V. C.
1928. FERTILIZER STUDIES WITH SWEET POTATOES. Soil Sci. 26:291–304.

(7) JOHNSON, T. C., and ZIMMERLEY, H. H.
[1924]. EFFECT OF CERTAIN SODIUM AND POTASSIUM SALTS ON SWEETPOTATO PRODUCTION IN EASTERN VIRGINIA. Amer. Soc. Hort. Sci. Proc. (1923) 20:155–162.

(8) KEITT, T. C.
1912. SWEET POTATO INVESTIGATION. S. C. Agr. Expt. Sta. Bul. 165, 43 p., illus.

(9) KNAPP, B.
1922. FARM HELPS FROM EXPERIMENTS. Ark. Agr. Expt. Sta. Bul. 181, 103 p., illus.

(10) NOLL, C. F., SCHREINER, O., and SKINNER, J. J.
1915. FERTILIZER RATIO EXPERIMENTS WITH GRASS ON HAGERSTOWN LOAM. Penn. Agr. Expt. Sta. Ann. Rpt. 1913/14 (pt. 2):22–36, illus.

(11) PATE, W. F., and SKINNER, J. J.
1924. RESULTS OF FERTILIZER EXPERIMENTS WITH COTTON AND IRISH POTATOES ON SOME OF THE PRINCIPAL SOIL TYPES OF NORTH CAROLINA. N. C. Dept. Agr. Bul. Sept., 1924, 69 p., illus.

(12) QUINN, J. T.
[1926]. SOME EFFECTS OF FERTILIZERS ON SWEET POTATOES. Amer. Soc. Hort. Sci. Proc. (1925) 22: 360–362.

(13) SCHERMERHORN, L. G.
[1924]. INFLUENCE OF FERTILIZERS ON THE YIELD AND FORM OF THE SWEET POTATO. Amer. Soc. Hort. Sci. Proc. (1923) 20 : 162–165.
(14) ———
1924. SWEET POTATO STUDIES IN NEW JERSEY. N. J. Agr. Expt. Sta. Bul. 398, 19 p., illus.
(15) SCHREINER, O., and SKINNER, J. J.
1918. THE TRIANGLE SYSTEM FOR FERTILIZER EXPERIMENTS. Jour. Amer. Soc. Agron. 10 : 225–246, illus.
(16) SCOTT, J. M.
1920. SWEET POTATO FERTILIZER EXPERIMENT. Fla. Agr. Expt. Sta. Bul. 156, p. [59]–63, illus.
(17) STUCKEY, H. P.
1914. SWEET POTATOES, CULTURE, STORING AND STUDIES IN FERTILIZING. Ga. Agr. Expt. Sta. Bul. 107, p. [83]–112, illus.
(18) UNITED STATES DEPARTMENT OF AGRICULTURE.
1931. AGRICULTURAL STATISTICS: FRUITS AND VEGETABLES. U. S. Dept. Agr. Yearbook 1931 : 780–781, illus.
(19) VOORHEES, E. B.
1891. EXPERIMENTS WITH FERTILIZERS UPON WHITE AND SWEET POTATOES. N. J. Agr. Expt. Sta. Spec. Bul. P, 24 p.
(20) ZIMMERLEY, H. H.
1929. SWEET POTATO FERTILIZERS. Va. Truck Expt. Sta. Bul. 66, p. [701]–717, illus.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	E. L. MARSHALL.
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Forest Service	R. Y. STUART, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Bureau of Plant Quarantine	LEE A. STRONG, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Weather Bureau	CHARLES F. MARVIN, *Chief.*

This bulletin is a contribution from

Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Soil Investigations	A. G. MCCALL, *Chief.*
Division of Soil Fertility	OSWALD SCHREINER, *Principal Biochemist, in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1932

For sale by the Superintendent of Documents, Washington, D. C. . . . . Price 5 cents

END