TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR,
College Station, Texas

BULLETIN NO. 602 JUNE 1941

FERTILIZER FOR RICE IN TEXAS

R. H. WYCHE

Division of Agronomy

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
T. O. WALTON, President

[Blank Page in Original Bulletin]

Fertilizer experiments with rice conducted on Lake Charles and Crowley clay soils at the Rice Experiment Station, Beaumont, Texas, from 1930 to 1940 show definitely that these soils respond more readily to applications of nitrogen than to phosphate fertilizers. Moderate applications of sulfate of ammonia, 100 to 150 pounds per acre, have given more profitable results than lighter or heavier applications. Superphosphate alone did not produce any appreciable increases in yield, although a combination of superphosphate and sulfate of ammonia produced larger yields than the latter alone during the last few years of the test.

In the cooperative experiments in the rice-growing area, however, different soils responded differently to fertilizers applied to rice. In the experiments on Lake Charles clay soil near Devers, in Liberty County, and on the light-colored soils in Orange County, applications of superphosphate produced larger yields of rice than applications of nitrogen. These soils have not been planted regularly to rice and may be considered comparatively new land. On the other hand, in the tests near Nome in Jefferson County, which were conducted on Lake Charles and Crowley clay soils that have been grown to rice every second or third year for a long time, nitrogen (in sulfate of ammonia) gave better results than superphosphate. In all of these cooperative experiments a combination of sulfate of ammonia and superphosphate produced larger yields of rice than either material alone. These results indicate that new lands are first in need of phosphate for rice. Under long cultivation, however, the nitrogen becomes depleted and the soil responds to both nitrogen and superphosphate.

Nitrate of soda, uramon, and sulfate of ammonia produced practically the same yields of rice. The various phosphates, bone meal, superphosphate, and granular superphosphate, also gave essentially the same results.

Although applications of potash have produced small increases in yield of rice, the increases were not large enough to justify the general use of potash for rice. Applications of manganese, iron, copper, zinc, and boron did not increase the yield of rice.

Applications of fertilizers in the drill with the seed at planting time produced approximately 12.5 per cent larger yields than applications broadcast on top of the soil.

Considering the results of all phases of this fertilizer work, the application of a mixture of 100 pounds of sulfate of ammonia and 100 pounds of superphosphate per acre (which supplies 20 pounds of nitrogen and 20 pounds of phosphoric acid) in the drill with the seed at planting time has been the most satisfactory fertilizer practice for rice.

CONTENTS

FERTILIZERS FOR RICE IN TEXAS

R. H. Wyche, Superintendent

Substation No. 4, Beaumont

Rice has been grown in America for about 255 years, since its introduction into the Colony of South Carolina in 1685 (4). The industry later spread to adjacent states. A limited amount was probably grown in Texas about 1863. However, the crop did not become of any great importance until about 1900. At present the most important rice-producing area of the United States is located in southwestern Louisiana and southeastern Texas. The average annual acreage in Texas from 1915 to 1935, inclusive, was 188,905 acres, which produced 7,742,952 bushels of rice with an annual value of $8,349,333 (1). This is about 20 per cent of the total production in the United States.

The topography of the Gulf Coast Prairie of Texas is very flat with a fall of approximately one foot per mile towards the Gulf of Mexico. This fall is very favorable to the irrigation of rice with a small number of levees, and yet is sufficient for fairly good drainage. The larger part of the soil is a heavy clay with a very impervious subsoil. This type of soil requires a minimum amount of irrigation water, and will support heavy machinery at the time of harvest during a rainy season. In addition, a long growing season with fairly high seasonal temperatures and a heavy annual rainfall are climatic conditions that are very favorable to the growing of rice. A fairly plentiful supply of irrigation water is available from the Neches, Trinity, Brazos, and Colorado rivers. Also water is obtained from wells in a few localities and from bayous in certain sections.

Object and Method of Conducting the Work

The earlier work with fertilizers on rice at the Beaumont Station was published in Texas Agricultural Experiment Station Bulletin 398 (2). The application of sulfate of ammonia alone or in combination with superphosphate had given consistently good results under the particular conditions. The soils in the rice-growing area of the state, however, vary a great deal with respect to type, fertility, and length of time in cultivation. Consequently it would be expected that they would differ in their needs for fertilizers. These differences are recognized by rice growers who use fertilizers, and among whom there are differences of opinion as to the correct fertilizer practice.

In order to secure additional information on various phases of fertilizer practice for rice in different parts of the rice-growing area of the state new experiments were begun in 1930. The new work embraced some of the better treatments from the previous work and included tests at Beaumont on different kinds and rates of application of fertilizers, methods

*Numbers in parenthesis refer to List of References at the end of this publication.

of application of fertilizers, tests with nitrogenous and phosphatic materials, and cooperative fertilizer tests with rice growers in different localities.

Soils

All of the fertilizer work on the Experiment Station farm at Beaumont and at Nome in Jefferson County was conducted on Lake Charles and Crowley clay soils, the former being the principal rice soil in the state. The tests near Devers in Liberty County also were conducted on Lake Charles clay or clay loam soil. The cooperative tests in Orange County were located on light-colored soils, probably of the Katy series. The soil type, however, was not identified definitely because the soils of the county have not been mapped in detail.

Cultural Practices

The land on the Station farm was cropped to rice every other year and was summer plowed during the years it was not in rice. The land in the vicinity of Nome had been cropped somewhat similar to that on the Station until some seven or eight years ago and has since been planted to rice once in three or four years, being pastured and then summer plowed during the year preceding the planting of rice.

The land used in the test at Devers in 1935 was planted to rice for the second consecutive year, but had never been in rice prior to 1934. The land used in 1938 and 1940 had been cropped to rice rather regularly a number of years ago, then pastured for several years and then used for rice every second or third year for the past six or seven years.

The land used in the Orange County test in 1939 had been planted to rice in 1938, but had not been in rice for about fourteen years prior to that time. The land used in 1940 had been planted to rice in 1937 and 1938, but had not been used for rice for some fourteen or more years preceding 1937.

All of these tests were planted on land that had been plowed to a depth of three to five inches the preceding summer or fall, and then disced and harrowed. All of the rice was planted with a small eight-hole drill. The remainder of the cultural practices were essentially the same as described in Farmers' Bulletin No. 1808 (4).

Results Secured with Different Kinds and Rates of Fertilizers

This work was conducted at Beaumont on Lake Charles and Crowley clay soils. In the earlier years the plats were 1/10 of an acre in size, and usually the treatments were not replicated. From 1921 to 1929 the plats were from 1/33 to 1/22 of an acre in size, and each fertilizer treatment was repeated two or more times. Plats of 1/33 of an acre in size have been used since 1930, and each treatment was repeated four times. The results of the

experiments from 1915 to 1929, as reported in Bulletin No. 398, are summarized in Table 1, for comparison with the data presented in Table 2, covering the experiments from 1930 to 1940.

In the earlier experiments sulfate of ammonia used at the rate of 100 pounds per acre produced the largest yields of rice during the first six and eight-year periods, and the fourteen-year period. The increases over the unfertilized plats were 739, 682, and 519 pounds per acre, respectively, for these periods. Four additional treatments were included in the last six years of the test, 1924 to 1929. During this period a combination of 200 pounds of sulfate of ammonia, 300 pounds of superphosphate, and 100 pounds of potash per acre produced the largest yield of rice, which was 526 pounds per acre more than the yield of the untreated plats. However, 100 pounds of sulfate of ammonia alone increased the yield 302 pounds for this period.

Table 1. Acre yields of rice secured from different kinds and rates of fertilizers from 1915 to 1929

Fertilizer treatment		Average yield in pounds for			
Lbs. per acre	Material	Six years 1915-21	Eight years 1915-23	Fourteen years 1915-29	Six years 1924-29
	No treatment	1775	1770	1745	1711
50	Sulfate of ammonia	.....	.....	.....	1890
100	Sulfate of ammonia	2514	2452	2264	2013
200	Sulfate of ammonia	.....	.....	.....	2056
75	Superphosphate	.....	.....	.....	1825
150	Superphosphate	2140	2030	1966	1880
300	Superphosphate	.....	.....	.....	1682
50 75	Sulfate of ammonia Superphosphate	2160	2094	2017	1915
100 150	Sulfate of ammonia Superphosphate	2350	2236	2132	1994
200 300	Sulfate of ammonia Superphosphate	2503	2433	2191	1868
300	Cottonseed meal	2130	2075	.....	.....
300 150	Cottonseed meal Superphosphate	2062	1976	.....	.....
12,000	Manure	1721	.....	.....	.....
12,000 150	Manure Superphosphate	1952	.....	.....	.....
200 300 100	Sulfate of ammonia Superphosphate Sulfate of potash	.....	.....	.....	2237
300 100	Superphosphate Sulfate of potash	.....	.....	.....	2084
200 100	Sulfate of ammonia Sulfate of potash	.....	.....	.....	1858
100	Sulfate of potash	.....	.....	.....	1733

The Experiments from 1930 to 1940

The fertilizer work at Beaumont with different rates and kinds was expanded in 1930 in line with the trend of previous results and included several new treatments. In this work the fertilizers were applied broadcast on top of the soil at planting time during the years of 1930 to 1936. Results obtained from some of the other work with fertilizers on rice have shown that placing the fertilizers in the drill with the seed gave larger yields than similar treatments applied on top of the soil. For this reason, all fertilizers were applied in the drill with the seed during the years 1937 to 1940. Sulfate of ammonia and superphosphate were used alone and in combination at several different rates. Potash, also, was used in combination with sulfate of ammonia and superphosphate. The fertilizer treatments and the average yields of the groups of treatments are given in Table 2.

Sulfate of ammonia was applied alone at the rates of 50, 100, 150, and 200 pounds per acre. As will be observed in Table 2, the yield of rice increased with the rate of application of the sulfate of ammonia. The average yield of the four rates of application was 2,430 pounds of rice per acre, or 15.2 per cent more than the yield obtained from the unfertilized soil. It would seem, however, that 150 pounds per acre is about the most practical rate to use.

The use of superphosphate alone at all rates of application apparently reduced the yield of rice, the reduction increasing roughly with the increase in application, as shown in experiments included in Table 2. When the

Figure 1. Rice Fertilizer test at Substation No. 4. Right, no fertilizer. Left, 200 pounds sulfate of ammonia and 100 pounds superphosphate per acre.

Table 2. Acre yields of rice from different kinds and rates of fertilizers from 1930 to 1940

Fertilizer treatment		Yield in pounds	Increase over unfertilized soil	
Lbs. per acre	Material		Pounds	Per cent
	No fertilizer	2109	.....	.....
50	Sulfate of ammonia	2225	116	5.5
100	Sulfate of ammonia	2328	219	10.4
150	Sulfate of ammonia	2515	406	19.2
200	Sulphate of ammonia	2653	544	25.8
	Average	2430	321	15.2
50	Superphosphate	2034	— 75	— 3.4
100	Superphosphate	2004	—105	— 5.0
150	Superphosphate	1840	—269	—12.8
200	Superphosphate	1872	—237	—11.2
	Average	1938	—171	— 8.1
100 40	Sulfate of ammonia Muriate of potash	2218	109	5.2
100 40	Superphosphate Muriate of potash	1909	—200	— 9.5
100 100	Sulfate of ammonia Superphosphate	2158	49	2.3
100 150	Sulfate of ammonia Superphosphate	2301	192	9.1
100 200	Sulfate of ammonia Superphosphate	2309	200	9.5
	Average	2256	147	7.0
100 100	Sulfate of ammonia Superphosphate	2158	49	2.3
150 100	Sulfate of ammonia Superphosphate	2479	370	17.5
200 100	Sulfate of ammonia Superphosphate	2568	459	21.8
	Average	2402	293	13.9
100 100 40	Sulfate of ammonia Superphosphate Muriate of potash	2266	157	7.4
100 200 40	Sulfate of ammonia Superphosphate Muriate of potash	2153	44	2.1
	Average	2210	101	4.8
100 100 40	Sulfate of ammonia Superphosphate Muriate of potash	2266	157	7.4
200 100 40	Sulfate of ammonia Superphosphate Muriate of potash	2513	404	19.2
	Average	2390	281	13.3

yields of rice obtained from the four rates of application of superphosphate are averaged, a yield of 1,938 pounds of rice per acre is obtained. This is 171 pounds, or 8.1 per cent, less than the average yield of the unfertilized soil for the 11 years 1930-40. The reduction in yield caused by superphosphate has been attributed to an increase in growth of grasses which compete with the rice for plant food, especially nitrogen. Similar observations have been noted in the rice areas of Arkansas and Louisiana. This reduction in yield may be avoided by the application of superphosphate, on soils needing phosphoric acid, a month or six weeks after the rice is planted. The injury also may be reduced or avoided by drilling the superphosphate in with the seed as the young rice plants will have a better chance of utilizing the plant food before any great amount is taken up by the grasses. This subject is discussed more fully in Bulletin 398.

Potash was used in combination with sulfate of ammonia, with superphosphate, and in a complete fertilizer. In general, potash did not produce increases in the yield of rice in any combination used.

Methods of Applying Fertilizers

As stated earlier in the bulletin it had been observed that applying superphosphate at the time the rice was planted reduced the yield as compared with applications made six weeks after planting. The work of other investigators on methods of applying fertilizers to other crops also have shown that methods of application greatly affect yields. From all of these studies it has been concluded that the largest yields of crops in general would be obtained if the fertilizer, especially superphosphate, were placed close to the seed. (Other work at this Station has shown that the fertilizers and rates used in this test will not injure rice seed.) In view of these facts, work was started at the Beaumont Station in 1935 to compare the effect of broadcasting fertilizers on top of the soil and applying them in the drill with the seed. The treatments used and yields obtained are shown in Table 3.

A combination of 150 pounds of sulfate of ammonia and 150 pounds of superphosphate per acre was the only fertilizer treatment used during the first two years as a preliminary trial. During this period the application of the fertilizer in the drill with the seed produced an average yield of 2,532 pounds of rice per acre, or about 11 per cent more than the application made on top of the soil. In view of these facts, with the fact that applications of superphosphate on top of the soil generally decreased the yield, two additional treatments, 150 pounds of sulfate of ammonia and 150 pounds of superphosphate, were included in the test in later years.

Superphosphate alone failed to materially increase the yield, as will be noticed in Table 3, when placed on top of the soil, or when placed in the drill with the seed. Sulfate of ammonia alone produced an increase of 346 pounds per acre when applied on top of the soil, but an additional 4 per cent increase was obtained by placing the fertilizer in the drill with the seed. A combination of 150 pounds each of sulfate of ammonia and super-

phosphate drilled in with the seed made the highest average yield, 2,841 pounds of rice per acre, which was 12.6 per cent more than the yield from the same fertilizers applied on top of the soil.

Although the increases in yield produced by putting the fertilizers in the drill with the seed are not very much larger than when they are broadcast on top of the soil, they represent additional profit. This method is no more expensive than broadcast applications.

These results indicate that drilling these fertilizers in with the seed is a better practice than broadcasting on top of the soil.

Table 3. Acre yields of rice from broadcasting and drilling the fertilizer in with the seed

Fertilizer treatment		Method of application		Increase by drilling in with seed	
Lbs. per acre	Material	Broadcast on top of the soil	Drilled in with the seed	Pounds	Per cent
	No treatment	2176	2176	.....	.....
150	Superphosphate	2181	2209	28	1.3
150	Sulfate of ammonia	2522	2623	101	4.0
150 150	Superphosphate Sulfate of ammonia	2522	2841	319	12.6

Figure 2. Methods of applying fertilizers to rice. Left, sulfate of ammonia applied in the drill with seed. Right, sulfate of ammonia and superphosphate applied in drill with seed. Addition of superphosphate to sulfate of ammonia makes practically no difference in growth when broadcast on top of soil.

Comparison of Different Nitrogenous and Phosphatic Materials

Cottonseed meal and manure as sources of nitrogen, along with sulfate of ammonia, were used in the fertilizer work during the first years of the fertilizer tests at Beaumont, 1915 to 1923. They were discarded after a few years because they did not give as satisfactory results as sulfate of ammonia, as shown in Bulletin 398. Superphosphate was used as the only source of phosphoric acid in the experiments until 1936. At that time it was decided to compare several forms of both nitrogen and phosphoric acid as fertilizers for rice. Sulfate of ammonia, nitrate of soda, and cyanamid comprised the nitrogenous materials during the first two years, but granular sulfate of ammonia and uramon were included during the latter part of the test. Both the regular and granular forms of superphosphate and raw bone meal were used to supply phosphoric acid in 1936, soft phosphate with colloidal clay being included in the last four years.

All nitrogenous materials were applied in amounts to supply 20 pounds of nitrogen per acre. The various phosphatic materials also supplied 20 pounds of phosphoric acid per acre. All fertilizers were applied in the drill with the seed with the exception of cyanamid which was drilled in just prior to seeding to prevent injury to the seed. The materials used and the yields of rice obtained from 1936 to 1940 are shown in Table 4.

The results show very little, if any, difference in value between the nitrogenous materials. Cyanamid produced a slightly smaller yield of rice, but this was probably caused by this fertilizer having to be placed in the soil in such manner as to prevent its injuring the seed and, naturally, being further from the seed than was the case with the other materials. The comparable yields show a combination of sulfate of ammonia and

Table 4. Acre yields of rice from different nitrogenous and phosphatic materials

Materials	Yield in pounds						Comparable yield
	1936	1937	1938	1939	1940	Average	
No fertilizer	2366	2188	1976	2069	2475	2215	2215
Nitrogenous materials:							
Sulfate ammonia (granular)	.....	.....	3060	2469	3238	2922	2758
Nitrate of soda	2356	.....	3322	2288	3131	2774	2706
Sulfate ammonia (regular)	2331	2419	3214	2275	3296	2707	2707
Uramon	.....	.....	.....	2350	3218	2784	2695
Cyanamid	.....	2388	.....	2288	2632	2436	2466
Sulfate ammonia and nitrate of soda	.....	.....	.....	.....	3432	3432	2906
Phosphatic materials:							
Bone meal	2494	2519	3098	2656	3184	2790	2790
Superphosphate (regular)	2497	2362	3154	2394	3312	2744	2744
Superphosphate (granular)	2522	2344	3214	2275	3296	2730	2730
Soft phosphate with colloidal clay	.....	2319	2535	2431	3015	2575	2529
Superphosphate and bone meal	.....	.....	.....	.....	3246	3246	2750

Figure 3. Sources of nitrogen and phosphoric acid for rice. Right, nitrogen from a combination of sulfate of ammonia and nitrate of soda. Left, received no fertilizer.

nitrate of soda to be slightly superior to any one material alone, but as this treatment appeared in the test but one year it is doubtful if this is a significant difference.

The results indicate that soft phosphate with colloidal clay is less valuable than the other phosphatic materials. The two superphosphates produced yields that were approximately equal, with bone meal producing a slightly larger amount of rice.

Cooperative Tests

The results of the fertilizer work conducted on the Lake Charles and Crowley soils on the Experiment Station farm at Beaumont have shown rather conclusively that the use of 100 to 200 pounds per acre of sulfate of ammonia alone or with superphosphate has given consistently good results under the particular conditions. Because the soils in other parts of the rice area vary considerably with respect to type, fertility, management, and length of time in cultivation, it may be possible that the results obtained at the Beaumont station are not applicable to all of the soils of the area. In order to get specific information on the fertilizer needs of the soils in other localities cooperative tests were conducted with several rice growers located on representative rice soils. These tests have been conducted in Jefferson County near Nome, near Devers in Liberty County, and in Orange County.

Tests Near Nome

Results of the tests near Nome are similar to those obtained in the work on the Experiment Station. Phosphoric acid alone produced only a slight increase in the yield of rice. Nitrogen alone produced an increase in yield of 326 pounds per acre. A combination of nitrogen and phosphoric acid increased the yield 377 pounds per acre above that of the unfertilized soil. The addition of potash to the nitrogen and phosphoric acid produced the heaviest yield, 2,722 pounds of rice per acre, or 421 pounds more than the unfertilized plats.

Table 5. Cooperative test at Nome

Treatment	Acre yield of rice, pounds							Per cent increase over unfertilized
	1935	1936	1937	1938	1939	1940	Average	
No fertilizer	1625	1669	2614	1990	3213	2696	2301	.....
Nitrogen alone	2010	1753	2913	2604	3532	2950	2627	14.2
Phosphoric acid alone	1655	1669	2695	2280	3403	2808	2418	5.1
Phosphoric acid and nitrogen	1932	1736	2988	2561	3677	3173	2678	16.4
Phosphoric acid, nitrogen and potash	1986	1896	3165	2508	3587	3193	2722	18.3

Tests in Liberty County

The yields obtained in the tests near Nome are recorded in Table 6 and show that phosphoric acid alone was very beneficial on new land, but of doubtful value on old land. Nitrogen alone was of very little value in either case. A combination of nitrogen and phosphoric acid was superior to either alone during both years. Potash was not very effective on these soils. However, a combination of nitrogen, phosphoric acid, and potash made the largest average yield, 3,561 pounds of rough rice per acre for the three years, or 610 pounds more than the untreated soil.

Table 6. Cooperative tests in Liberty County

Treatment	Acre yield rice, pounds				% increase over unfertilized
	1935	1938	1940	Average	
No fertilizer	2109	3321	3422	2951	.....
Nitrogen alone	2163	3472	3530	3055	3.5
Phosphoric acid alone	3059	3041	3722	3274	10.9
Nitrogen and phosphoric acid	3190	3474	3862	3509	18.9
Nitrogen, phosphoric acid, and potash	3156	3480	4048	3561	20.7

Tests in Orange County

Table No. 7 records the results obtained in Orange County.

Nitrogen alone was of very little value. Phosphoric acid alone increased the yield of rice 1,020 pounds per acre, or 43 per cent. A combination of nitrogen and phosphoric acid increased the yield 1,204 pounds per acre, or 50.7 per cent, over that of the unfertilized soil. The heaviest yield, however, was obtained from the treatment that included nitrogen, phosphoric acid, and potash. This application produced 3,602 pounds of rice per acre, or 1,228 pounds more than was obtained from the plats receiving no fertilizer.

Table 7. Cooperative tests in Orange County

Treatment	Acre yield rice, pounds			% increase over unfertilized
	1939	1940	Average	
No fertilizer	2558	2191	2374	.....
Nitrogen alone	2686	2339	2512	5.8
Phosphoric acid alone	3796	2993	3394	43.0
Nitrogen and phosphoric acid	4143	3013	3578	50.7
Nitrogen, phosphoric acid, and potash	4365	2838	3602	51.7

Figure 4. Cooperative test in Orange County. Left center reecived no fertilizer. Right center received superphosphate. Extreme right shows part of plat receiving sulfate of ammonia.

Work with Manganese, Copper, Zinc, Iron, and Boron

Some of the fertilizer work conducted on other crops in some cases has shown a deficiency of one or more of the so-called minor elements. It was considered doubtful that the yields of rice in Texas were being affected by a lack of any of these elements. However, in order to obtain some preliminary information on the possibility of the need of such investigations on the rice soils of the state, the cooperative tests were enlarged to include one treatment that contained several of the elements thought most likely to be deficient.

In this work 500 pounds per acre of 4-8-4 fertilizer was used with and without manganese, copper, zinc, iron, and boron. The manganese was supplied in 20 pounds of potassium permanganate; copper, in 10 pounds of copper sulfate; zinc, in 20 pounds of zinc oxide; iron, in 50 pounds of ferric sulfate; and boron, in 10 pounds of boric acid. Boric acid was used at the rate of 20 pounds per acre in 1938, but appeared to have resulted in slight injury to the seed. The average yields of rice from the use of the complete fertilizer with and without the other elements are given in Table 8.

The use of these additional elements has resulted in a decrease in yield each year in the tests in Liberty County, but probably did not affect the yields at the other locations.

Table 8. Yields in pounds of rice per acre from the use of minor elements (Iron, Manganese, Copper, Zinc, and Boron)

Location of test	Without minor elements	With minor elements
Liberty County	3764	3337
Nome, Jefferson County	3096	3278
Experiment Station, Beaumont	2208	2148
Orange County	3602	3588
Average	3168	3088

Acknowledgments

The Texas Public Service Company of Beaumont, the Devers Canal Company of Devers, the Croak Brothers of Orange, and Mr. Hugh Long, Jr., of Beaumont furnished the seed, land, and water for the cooperative tests conducted on their farms. In addition, they furnished all labor necessary excepting for planting and harvesting of the tests.

Summary

The rice fertilizer work has shown that the soils on the Rice Station at Beaumont respond to nitrogen and that the yields increase as the amount of fertilizer is increased. The use of 50 pounds of sulfate of ammonia per acre increased the yield of rice 116 pounds, and the heaviest rate of sulfate of ammonia, 200 pounds per acre, produced the largest yield, which was 544 pounds more than was obtained from the unfertilized soil. These soils do not respond to phosphoric acid alone, but a combination of nitrogen and phosphoric acid was superior to nitrogen alone during the latter part of the test.

There was a difference in the response of the soils in the various localities to the application of fertilizers to rice. Nitrogen alone produced practically no increase in yield of rice on the soils tried in Liberty county. Phosphoric acid alone increased the yield only 323 pounds per acre for the three years. However, it did increase the yield 950 pounds per acre in 1935 when used on a soil that was being cropped to rice for only the second time. A combination of nitrogen and phosphoric acid produced an increase in yield of rice of 558 pounds per acre in these tests.

The use of phosphoric acid alone in the Orange county tests increased the yield of rice 1,020 pounds per acre. The soils tested in this county did not respond to nitrogen alone, and only a slight response was obtained by using it in combination with phosphoric acid.

The use of fertilizers on the soils tested near Nome, in Jefferson county, produced results very similar to those obtained on the Station at Beaumont.

The results obtained indicate there is no need of potash being included at this time in the fertilizers for rice on the soils tested.

When the fertilizer was drilled in with the seed it gave a larger yield of rice and resulted in less growth of weeds and grass than when it was broadcast on top of the soil. In comparing the two methods of applying fertilizers to rice on the Station soils, the largest yield, 2,841 pounds of rice per acre, was obtained from a combination of nitrogen and phosphoric acid drilled in with the seed. This was an increase of 319 pounds over the yield obtained by the same fertilizer applied broadcast on top of the soil.

Nitrate of soda, uramon, and regular and granular sulfate of ammonia are of practically the same value as sources of nitrogen for rice on the Station soils. Cyanamid was of less value as it could not be drilled in with the seed on account of injury to the latter. A combination of sulfate of ammonia and nitrate of soda produced the largest yield obtained from any of the nitrogenous materials, but as this treatment was used only one year, this yield was not considered to be significantly larger than the others.

Bone meal and regular and granular superphosphate were of approximately equal value as sources of phosphoric acid. Soft phosphate with colloidal clay was an inferior source of phosphoric acid on the Station soils.

The results obtained from the use of iron, manganese, copper, zinc, and boron as fertilizers for rice will not justify their use for this purpose on the soils tested.

The results as a whole show that a combination carrying 20 pounds of nitrogen and 20 pounds of phosphoric acid as would be supplied in 100 pounds each of sulfate of ammonia and superphosphate, per acre applied in the drill with the seed at planting time is good fertilizer practice on the principal rice soils of the area.

LITERATURE CITED

(1) Statistics of Texas Agriculture, L. P. Gabbard and C. A. Bonnen, Circular No. 80, page 22, Texas Agricultural Experiment Station, October, 1937.

(2) Fertilizers for Rice in Texas, E. B. Reynolds and R. H. Wyche, Texas Agricultural Experiment Station Bulletin 398, June, 1929.

(3) Varieties of Rice for Texas, R. H. Wyche and H. M. Beachell, Texas Agricultural Experiment Station Bulletin 485, November, 1933.

(4) Rice Culture in the Southern States, Farmers' Bulletin 1808, Jenkin W. Jones, J. Mitchell Jenkins, R. H. Wyche, and Martin Nelson, October, 1938.