Fertilizer Experiments with Cotton

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By

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SUMMARY

The fertilizer experiments reported in this bulletin may be summarized as follows:

1. Cotton responds to a complete fertilizer on most Tennessee soils.
2. On soils previously fertilized and cropped to cotton, nitrogen is probably the most limiting element in cotton production. In West Tennessee, a nitrogen application of 32 pounds N per acre resulted in an average increase of 323 pounds of seed cotton, or 10 pounds of seed cotton per pound of nitrogen. Phosphate is second in importance followed by potash. Potash is of special importance on the gray soils with poor internal drainage.
3. Phosphate hastens the maturity of cotton and tends to overcome the difficulties caused by excess nitrogen.
4. Cotton is benefited by liming but in rotations where legumes are removed as hay, liming of the land calls for higher applications of potash for the cotton crop.
5. Magnesium had no effect on cotton yields in 3 tests in Tipton County. The minor elements--boron, manganese and zinc—also were ineffective.
6. Concentrated (triple) superphosphate compares favorably with ordinary superphosphate. Yields obtained with fused tricalcium phosphate were somewhat lower, the coarse particle size being definitely inferior on low-phosphate soils.
7. Sulfur does not yet appear to be an important constituent of fertilizers for cotton production in Tennessee.

Fertilizer Recommendations*

(acre basis)

Nitrogen—0 to 40 pounds, preferably one-half at planting, remainder as sidedressing. Amount may be reduced if cotton follows a legume green-manure crop.

Phosphate—0 to 50 pounds P_2O_5

Potash—0 to 60 pounds K_2O

*Specific recommendations for phosphate and potash, based on soil tests, are preferable.

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INTRODUCTION

A number of experiments on the fertilization of cotton has been conducted by the Experiment Station for a period of years. A large portion of this work has been conducted at the West Tennessee Station located at Jackson. In addition, numerous experiments have been conducted on private farms in the cotton-growing areas of the State. From one to five years of work was conducted in Bedford, Carroll, Tipton, and Lawrence Counties. The outlying work with farmers permitted studies of cotton production on many more soil types and conditions than are available on University lands.

Many people had a part in conducting these experiments reported in this publication. C. A. Mooers, presently Director Emeritus, initiated the experiments at the West Tennessee Experiment Station; Sam Odle and later R. H. Ferguson had immediate supervision over the experiments at this Station. R. L. Long conducted the experiments in Bedford and Carroll Counties. L. E. Waldrop conducted the experiments in the Lawrenceburg area. Lester E. Odom, U. S. D. A., BPISAE, personally visited most of the experimental sites and determined the soil type. Lastly, the cooperation of the various farmers, on whose lands the outlying experiments were located, is gratefully acknowledged.

OBJECTIVES OF EXPERIMENTS

The primary objective of these experiments was to study the response of cotton to nitrogen, phosphate, potash, and lime. The importance of magnesium, certain minor elements, and sulfur also was investigated. In fertilizer research the amounts and proportions of each nutrient are varied in order to determine whether more or less of a certain component has any effect on yield and quality. Thus, applications of fertilizers are not necessarily made in amounts that conform exactly with so many bags to the acre of some standard fertilizer mixture. There is little reason why they should be. Different soils and different crops have different plant food requirements.

It should be pointed out that in these experiments, the rate of fertilization was not always that which would be recommended on the basis of a soil test. The results of these experiments do, however, serve as a guide in making fertilizer recommendations. Some correlations of soil tests with crop responses have been published.[1]

[1]Long, O. H. **A comparison of two soil-test methods as correlated with wheat and cotton response to fertilizers.** Soil Sci. Soc. Amer. Proc. 12: 255-261. 1948.

It is appropriate at this point to briefly discuss fertilizer terminology. Fertilizers are sold on the basis of their plant food content. The analysis on the bag shows the percentage of nitrogen, phosphate, and potash in that order. Thus a fertilizer of 6-8-8 analysis contains 6 pounds of nitrogen (N), 8 pounds of phosphate (expressed as P_2O_5), and 8 pounds of potash (K_2O) per hundred pounds of material. If a farmer applied 500 pounds to the acre of this particular analysis, he has applied 30 pounds of nitrogen, 40 pounds of P_2O_5 and 40 pounds of K_2O. In common fertilizer parlance this would be an acre application of 30-40-40 (N-P_2O_5-K_2O).

All too frequently a fertilizer is purchased on the basis of its cost per bag, whereas it should be purchased on the basis of its cost per unit of plant food. The various components in a mixed fertilizer differ in price but two particular fertilizers may be used to illustrate the point. A 6-12-12 fertilizer contains 30 pounds of plant food per hundred pounds of material; a 4-8-8 fertilizer contains 20 pounds of plant food. The components are in the same proportion in both fertilizers (1-2-2 ratio). Thus a 6-12-12 fertilizer at any price less than 1½ times the price of a 4-8-8 fertilizer would be a better buy since the higher analysis fertilizer contains 1½ times the plant food content of the lower analysis. This same argument applies to straight goods (fertilizers containing only one component). Ammonium nitrate, anhydrous ammonia, nitrate of soda, and ammonium sulfate are examples of straight goods and are equally satisfactory as sources of nitrogen. Frequently, however, nitrate of soda will be sold at a price almost equal to that of ammonium nitrate even though ammonium nitrate is twice as high in nitrogen content.

EXPERIMENTS AT WEST TENNESSEE EXPERIMENT STATION, JACKSON

Several cotton fertilizer experiments have been under way at Jackson for a number of years. On some areas cotton has been grown continuously for as long as 38 years; on other areas the production of cotton has been studied in rotations with other crops. In these experiments the response of cotton to nitrogen, phosphate, potash and lime has been determined. In addition the effect of winter cover crops on cotton production has been studied and reported in Extension Leaflet 109.

CONTINUOUS COTTON

The results from two long-time fertilizer experiments with cotton are shown in figures 1 and 2. In these experiments cotton was grown under limed and unlimed conditions, with and without fertilizers. Figure 1 shows the acre yields of seed cotton on Lintonia silt loam; figure 2, the yields on Calhoun silt loam. These two soils will be described briefly later in this publication. The annual acre-rate of fertilization was the same on both areas, namely, nitrogen,

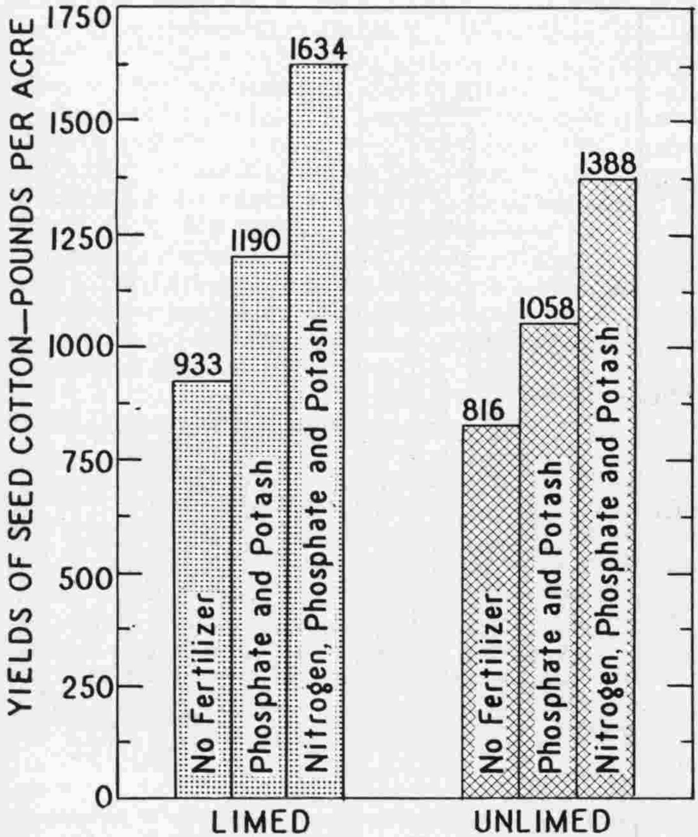

Figure 1—Influence of lime and fertilizer on yields of cotton grown continuously on Lintonia silt loam, West Tennessee Experiment Station, Jackson—32-year average, 1919-1950 (Range 4, plots 25-27).

16 pounds (100 pounds nitrate of soda); phosphate, 32 pounds P_2O_5 (160 pounds 20 percent superphosphate); potash, 25 pounds K_2O (approximately 42 pounds 60% muriate of potash). This rate of fertilization approximates that which would be applied in 400 pounds per acre of a 4-8-6 fertilizer. Lime was applied every fifth year at the rate of 2 tons per acre.

On the Lintonia soil under limed conditions an average of 933 pounds of seed cotton per acre was produced on the unfertilized plot; on the unlimed area the yield without fertilizer was 816 pounds. Phosphate and potash were effective in increasing the yields under both limed and unlimed conditions. The highest yields were made when a complete fertilizer of nitrogen, phosphate and potash was used. Here the yields were 1634 pounds of seed cotton per acre on the limed area and 1388 pounds on the unlimed area.

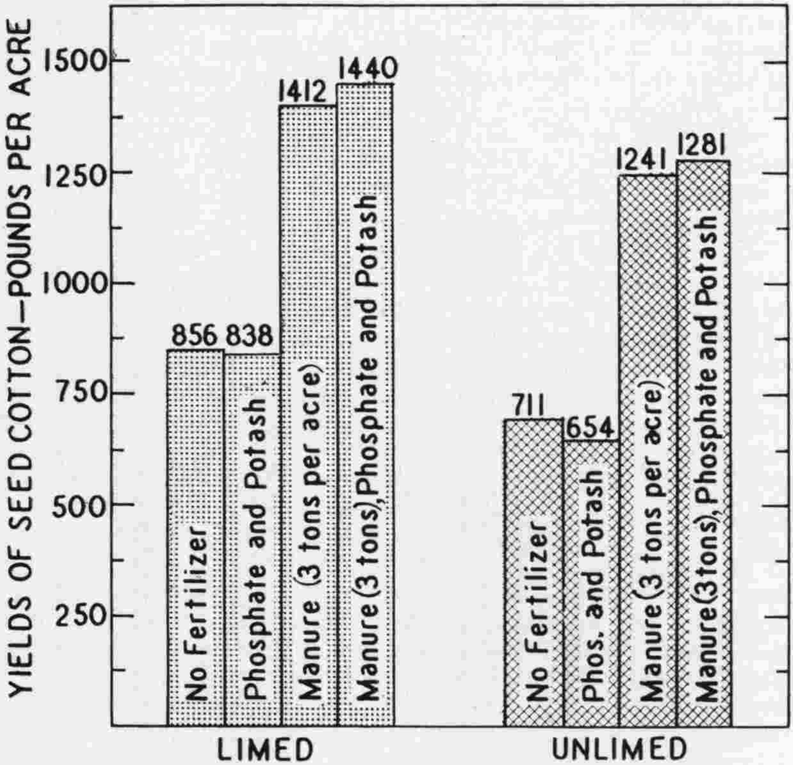

Figure 2—Influence of lime, fertilizer and manure on yields of cotton grown continuously on Calhoun silt loam, West Tennessee Experiment Station, Jackson—38-year average, 1911-1948 (Ranges A and B, plots 12E, 12W).

There has been no tendency for yields to decline during the 32-year period. In fact, average yields were higher in the last 10-year period than in the first. This may be due, in part, to better varieties. Trice and Express were the varieties used in the earlier years; Stoneville and Tennessee 241 were used in the later years. Cotton varieties are discussed in Station Bulletins 211 and 218.

The experiment on the Calhoun soil (figure 2) was similar to that on the Lintonia soil except that farm manure was used as the source of nitrogen. On the limed area yields ranged from a low of 838 pounds of seed cotton per acre where only phosphate and potash were used to a high of 1440 pounds where manure, phosphate and potash were used. On the unlimed area the range in yield was from 654 pounds to 1281 pounds. Yields were increased by liming under all conditions but were not appreciably affected by applications of phosphate and potash.

The Calhoun soils are noted for their low content of available potash, as will be shown later (table 1). Why, then, did cotton fail to respond when both phosphate and potash were applied? A logical explanation is that nitrogen also was a limiting factor and in its absence potash had no effect. A 3-ton application of manure would supply approximately 30 pounds of nitrogen—the equivalent of about 100 pounds of ammonium nitrate—but its nitrogen is slowly available. Manure also contains about the same amount of potash as nitrogen and about one-half as much phosphate as nitrogen. Production gradually declined on the unmanured plots; yields for the last 10-year period averaged about one-fourth less than those during a like period at the beginning of the experiment. On the other hand, the yields increased on the manured plots, averaging about one-fourth greater in the last period.

COTTON GROWN IN A ROTATION WITH OTHER CROPS

The response of cotton to fertilization when grown in a rotation with other crops is of particular interest. The same rotation was followed on two different soils. The acre yields of seed cotton only are shown in table 1. The two soils were Lintonia silt loam, a well-

Table 1.—The influence of lime, phosphate and various rates of potash on acre yields of seed cotton in a 5-year rotation on two soil types, West Tennessee Experiment Station, Jackson, 1929-1947 (Range 2, plots 1-12; Ranges A and B, plots 0-6). [1]

(Average yields of 4 crops) [2]

Lime treatment	Annual acre fertilizer treatment [3]					
	No fertilizer	32 lbs. P_2O_5	25 lbs. K_2O	32 lbs. P_2O_5 12½ lbs. K_2O	32 lbs. P_2O_5 25 lbs. K_2O	32 lbs. P_2O_5 37½ lbs. K_2O
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
			LINTONIA SILT LOAM			
Limed 2 tons per acre [4]	1390	1555	2050	1817	2230	2400
Unlimed	1670	1867	2271	1948	2255	2300
			CALHOUN SILT LOAM			
Limed 2 tons per acre [4]	....	605	1438	954	1396	1578
Unlimed	....	825	1498	1148	1430	1544

[1] Rotation was:

1st year—Cotton
2nd " —Corn
3rd " —Cowpeas or soybeans
4th " —Wheat
5th " —Clover and grass

[2] Cotton was grown in years 1932, 1937, 1942 and 1947.

[3] All treatments (including unfertilized check) received a 5-ton per acre application of farm manure once in 5 years. Manure applied as topdressing on wheat.

[4] Lime was applied every fifth year prior to seeding cowpeas.

drained light- or grayish-brown terrace soil and Calhoun silt loam, a poorly-drained, gray (almost white) terrace soil that possesses a distinct claypan. These rotations were started in 1929; four crops of cotton were grown before the experiment was discontinued in 1947.

The greater yields of cotton on the Lintonia soil are immediately apparent, exceeding the yields on the Calhoun soil by about 67 percent. Yields of the other crops also were considerably greater. This demonstrates the influence of the soil in crop production. Because of its claypan and restricted drainage, the Calhoun soil tends to be wet and cold in the spring and drouthy in summer.

On the Lintonia soil yields were increased by phosphate alone, the gain being 181 pounds of seed cotton as an average of the limed and unlimed areas. There was no unfertilized treatment on the Calhoun soil but yields were low where phosphate alone was applied, producing only 715 pounds of seed cotton as an average of the limed and unlimed areas.

The response to potash on Lintonia was pronounced; an application of potash alone at the rate of 25 pounds K_2O per acre resulted in an average yield of 631 pounds of seed cotton greater than was obtained on the unfertilized plots. On Calhoun soil, a similar application of potash resulted in a yield 753 pounds greater than was obtained with phosphate alone. Potash was applied at three rates: 12½, 25, and 37½ pounds K_2O per acre along with a constant phosphate application of 32 pounds P_2O_5. Yields progressively increased with each increment of potash.

Of particular interest is the failure of cotton to respond to lime with any fertilizer treatment except where potash was applied at the highest rate (37½ pounds K_2O). This was not true with the other crops all of which were benefited greatly by liming. This demonstrates the sensitiveness of cotton to low levels of available soil potash. The response of crops to lime and phosphate is a common experience. What is frequently overlooked is the rapid depletion of potash, particularly by the hay crops, unless adequate applications of potash are made either as a fertilizer or in the form of farm manure. The following experiment illustrates this relationship.

COTTON FOLLOWING CORN AFTER SERICEA FOR HAY

The importance of potash in the production of cotton is shown in table 2. Previously this area had been in sericea for several years and the crops had been removed as hay or seed. Following the turning of the sericea sod, corn was grown for several years. These results are published in Station Bulletin 197.

Table 2.—The influence of potash on the acre yields of seed cotton on Lintonia silt loam, West Tennessee Experiment Station, Jackson.

(Cotton followed corn which followed several years of sericea)

Treatment	YEAR			
	1944	1945	1946	Average
	Lbs.	Lbs.	Lbs.	Lbs.
Potash [1]	1183	1593	1755	1510
No potash	1000	1251	1514	1255
Gain from potash	183	342	241	255

[1] Twenty-five pounds of K_2O annually.

Beginning in 1944 cotton was substituted for corn and potash was applied at the rate of 25 pounds K_2O per acre on alternate plots. These same plots had previously received potash when in corn. The other plots received no potash, either when in corn or in cotton. The results are averages of 12 plots.

Potash was responsible for increases in yield ranging from 183 pounds of seed cotton per acre in 1944 to 342 pounds in 1945; the average gain for the 3-year period was 255 pounds.

Continued heavy crop removals, particularly of hay, rapidly deplete the available potash reserves in the soil. This explains why cotton following such hay crops as alfalfa, lespedeza, and sericea often do poorly unless adequate amounts of potash have been applied.

COOPERATIVE EXPERIMENTS IN BEDFORD COUNTY

Fertilizer experiments with cotton were conducted in Bedford County during the 5-year period 1940-1944. These experiments, in cooperation with the Tennessee Valley Authority, were conducted on private farms on representative soils of the Inner Basin. The objectives in these experiments were: (1) to study the fertility status of various soils with special attention to the separate effects of nitrogen, phosphate and potash in cotton production and (2) to evaluate various phosphates developed by the TVA in their plant at Muscle Shoals, Alabama. The second objective necessitated the location of these experiments on soils low in available phosphate. The Hagerstown and Talbott soils which are low in phosphate are common in this area. The performance of the various phosphates will be discussed later in this publication. Unless otherwise specified, when phosphate is mentioned, reference is to standard superphosphate (20 per cent P_2O_5).

The results of 20 field experiments are given in table 3. The data include the name of the farmer-cooperator on whose farm the experiment was located, the soil series, the acre yields of seed cotton on the unfertilized check and on the plots receiving a complete NPK fertilizer. Other treatments were included but the actual yields are not shown in the table. The yields obtained with these treatments were used, however, in computing the separate responses to nitrogen, phosphate, and potash shown in the last 3 columns. By listing the name of the farmer and the soil series, it is hoped that the information will be of more value to the individual farmer and to the agricultural workers in his area.

The separate responses were obtained by subtracting the yields of the phosphate-potash treatment from the nitrogen-phosphate-potash treatment in arriving at the response to nitrogen; the yields of the nitrogen-potash treatment from the nitrogen-phosphate-potash treatment in arriving at the response to phosphate; and the yields of the nitrogen-phosphate treatment from the nitrogen-

Table 3.—The influence of nitrogen, phosphate and potash on acre yields of seed cotton, Bedford County, 1940-1944.

(Yields are averages of 2 to 4 plots)

Field No.	Cooperator	Soil Series	Unfertilized check	NPK[1]	Response to: N	Response to: P	Response to: K
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
88	W. H. Robertson	Hagerstown	542	1348	344	596	132
89	W. A. Haskins	Mercer	437	628	32	100	— 18
90-91	Buford Manley	Mimosa	905	1368	—242	362	298
92	C. I. Mullins	Mercer	510	1174	114	496	258
93-94	Tom Fleming	Mimosa	269	677	113	182	400
95	J. N. Dunaway	Hagerstown	268	1024	56	730	182
96	Herbert Farris	Talbott	230	950	108	796	98
97	J. M. Hooker	Talbott	504	1058	434	352	358
122-123	E. L. Jordan	Hagerstown	664	1336	244	478	280
124-125	Travis Brown	Hagerstown	572	942	312	590	— 32
126-127	W. A. J. Poplin	Pickaway	1191	1582	88	116	—104
128-129	J. N. Dunaway	Talbott	529	964	— 42	404	76
159	W. H. Robertson	Hagerstown	614	1284	192	670	364
160	J. M. Hooker	Pickaway	361	1046	— 6	672	144
161	J. N. Dunaway	Hagerstown	512	1240	— 84	756	— 16
183	C. R. Robertson	Hagerstown	....	1420	......	211	......
209	T. H. Crick	Pickaway	364	631	......	118	......
210	Mrs. John Sutton	Mercer	707	1274	......	147	......
211	B. A. Green	Hagerstown	1164	1933	......	349	......
170	C. R. Robertson	Hagerstown	699	1866	58	1145	474
	Average[2]		550	1155	108	528	181

[1] Rate of fertilization:
N = nitrogen, 24 pounds per acre.
P = phosphate, 40 to 60 pounds P_2O_5 per acre.
K = potash, 33 to 41 pounds K_2O per acre.

[2] Fields 183, 209-211 not included in average.

phosphate-potash treatment in arriving at the response to potash. A minus (–) sign indicates that the response was negative. Unless the available soil supply of other plant nutrients is adequate the full effect of the nutrient under study cannot be expressed. For example, an application of nitrogen on a soil critically low in phosphate frequently is of no effect. Once phosphate is removed as a limiting factor, the full effect of nitrogen can be expressed.

The results given in table 3 show that very low yields were obtained when the cotton was not fertilized, the average yield for the 20 experiments being only 550 pounds of seed cotton per acre. Yields were more than doubled when a complete fertilizer was used.

Of more interest are the relative effects of nitrogen, phosphate and potash. A treatment where nitrogen alone was applied (not shown in this table) indicated that in most cases it was of no value. When phosphate was removed as a limiting factor, nitrogen was effective, the average response being 108 pounds of seed cotton from a 24-pound nitrogen application. The response was as high as 434 pounds (field 97).

Phosphate had more effect on yield than either nitrogen or potash. Some response to phosphate was obtained in every experiment, the average being 528 pounds of seed cotton for the 20 trials. On the average, potash was slightly more effective than nitrogen in these experiments, averaging 181 pounds of seed cotton from an application of potash.

COOPERATIVE EXPERIMENTS IN CARROLL COUNTY

Experiments similar to those just described were conducted in Carroll and adjacent counties during the 5-year period 1945-1949. The results from 23 trials are reported in table 4. The general yield level in Carroll County was much higher than in Bedford County. Yields of cotton on the unfertilized checks were almost twice as high as those in Bedford County; the average yield was 1022 pounds of seed cotton per acre. Again appreciable gains in yields were realized from a complete fertilizer application; the average yield being 1459 pounds.

The separate responses to nitrogen, phosphate and potash are presented as for Bedford County (table 3). In these experiments, nitrogen was most effective in increasing yields followed by phosphate and potash in that order. An application of 32 pounds nitrogen per acre (the equivalent of approximately 100 pounds of ammonium nitrate) resulted in an average increase of 323 pounds of seed cotton per acre. This represents about 10 pounds of seed cotton per pound of nitrogen. It will be recalled that phosphate was more effective than nitrogen in Bedford County. This would indicate that the supply of available phosphate in the low-phosphate

Table 4.—The influence of nitrogen, phosphate, and potash on acre yields of seed cotton, Carroll County, 1945-1949.[1]

(Average 4 replications)

Field No.	Cooperator	Soil Series	Unfertilized check	NPK[2]	Response to: N	Response to: P	Response to: K	L.s.d. (5%)[3]
			Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
237	R. L. Long	Inc	1052	1584	448	332	384	404
238	M. O. Kee	Dexter	1272	1708	96	116	416	358
239	J. E. Stephens	Loring	808	1296	708	128	64	203
240	L. D. Hastings	Memphis	444	1060	272	464	152	246
241	C. C. Pinkley	Briensburg-Hatchie complex	944	1352	364	—188	—216	329
242	E. E. Wilson	Faulkner	180	588	238	471	— 80	177
243	A. M. Hays	Loring	516	1124	300	528	20	234
249	B. D. Vick	Memphis	1610	2123	360	23	113	207
250	C. J. Thompson	Dexter	1180	1744	468	428	92	252
251	A. G. Mullins	Grenada	1073	1727	317	524	264	280
252	Perry Reynolds	Loring	963	1496	412	272	120	308
253	J. E. Crutchfield	Grenada	1290	1817	464	57	37	379
322	A. G. Greer	Memphis	1273	1702	491	301	249	318
323	V. E. Barger	Loring	1637	1467	—319	— 66	— 70	406
324	R. C. Churchwell	Eupora	1404	2192	448	444	680	365
325	Tom Lee	Memphis	1040	1020	—140	—100	124	350
360	Luther Pafford	Dulac-Hatchie complex	1356	2227	618	365	73	377
361	A. G. Mullins	Loring	725	1233	50	497	—178	464
362	W. E. Fly	Memphis	637	1424	547	258	—169	324
391	W. E. Fly	Memphis	....	1734	702	399	30	432
392	D. L. Hopper	Calloway	....	920	532	168	156	204
393	Alvin Myracle	Dulac	....	567	279	75	159	117
394	Lawrence Kee	Lexington	....	1446	588	81	39	188
	Average		1022	1459	358	242	107	......

[1] Fields 237, 362, 391 and 392 were located in Madison County, field 393 in Decatur County, field 394 in Henderson County.

[2] Rate of fertilization:
N = nitrogen, 32 pounds per acre (40 pounds on fields 391-394).
P = phosphate, 40 pounds of P_2O_5 per acre.
K = potash, 50 pounds K_2O per acre (40 pounds on fields 391-394).

[3] L.s.d. (5%) = Least significant difference at odds 19 to 1. These values represent the amount one treatment should differ from another before that difference can be considered statistically significant.

soils of the Inner Basin is less adequate than in the soils of West Tennessee. Even when nitrogen was applied alone (not shown in this table), cotton yields were increased materially. Nitrogen was more effective, however, in a complete fertilizer.

This question might well be raised: Would further yield increases have been realized from higher applications of nitrogen? An application of 48 pounds of nitrogen was compared with a 32-pound application in a total of 19 trials. An average of 391 pounds of seed cotton was obtained from the 48-pound nitrogen application as compared to 323 pounds from the 32-pound nitrogen application.

In approximately one-half the experiments, however, there was no advantage in the heavier rate. Apparently 100 to 150 pounds of ammonium nitrate or its equivalent in other forms of available nitrogen is sufficient for near optimum yields under the conditions studied. The nitrogen requirement of the cotton crop is not as high as that of corn. Too much nitrogen will result in a tall, rank, growth and delayed maturity.

How are cotton yields affected by varying the amounts of applied phosphate and potash? This was studied in 1945 on fields 237-243 listed in table 4. The averages for the 7 experiments were as follows:

Rate of fertilization (N-P_2O_5-K_2O)	Yields of seed cotton (pounds per acre)
32-20-50	1137
32-40-50	1245
32-60-50	1322
32-40-25	1170

These results show a small response from each increment of phosphate up to and including 60 pounds of P_2O_5 per acre. Fifty pounds of K_2O resulted in a yield 75 pounds greater than was obtained from a 25-pound K_2O application.

INFLUENCE OF PHOSPHATE ON MATURITY

Phosphate hastens the maturity of cotton. A large percentage of the total crop in the first picking is highly desirable since this cotton is usually of a better grade than that obtained in later pickings. Even in the absence of a significant yield response, the use of phosphate may be justified. It is especially important with late-maturing varieties, or when cotton is planted late, or when the growing season is unfavorable, or in seasons with early frosts. Frequently when nitrogen is applied in large amounts, cotton makes too much vegetative growth which results in delayed opening of bolls. Phosphate tends to correct this condition. This is but one of the many examples illustrating the importance of nutrient balance in fertilization practices.

Two instances can be cited to show the influence of phosphate on maturity. In 1940 in Bedford County, 54 percent of the total crop on the phosphate-treated plots was harvested in the first picking as compared to only 38 percent where phosphate was omitted. This represents an average of 6 trials. Again in 1946 in Carroll County, 23 percent of the total crop on the phosphate-treated plots was harvested in the first picking as compared to 16 percent where phosphate was omitted. This represents an average of 5 fields.

COOPERATIVE EXPERIMENTS IN TIPTON COUNTY

Three cotton fertilizer experiments were conducted in Tipton County in 1949. The main objective in these experiments was to investigate the importance of magnesium in cotton production. A deficiency of this element was suspected because of an abnormal coloration of the foliage and shedding of the top crop the year previously. Potassium magnesium sulfate (Sulpomag) was used to supply magnesium. The minor elements boron, manganese and zinc also were added to one treatment in the form of borax and the sulfates at rates of 10, 25, and 20 pounds per acre, respectively. The yields obtained with the various treatments are shown in table 5.

There was no visible response to magnesium in foliage coloration and no significant yield response in any of the 3 tests. This is in agreement with some long-time work at the West Tennessee Experiment Station, Jackson, where comparisons of dolomitic and calcic limestones have indicated no response to the magnesium which is present in the dolomite. Yields were not appreciably affected by the application of the minor elements in any of the 3 tests. There was a small increase on the Caseyville soil but not sufficient to be considered significant.

There was no significant difference in yield between any of the treatments on the Caseyville soil. This trial was located in the Mississippi Delta area and the soil is naturally high in lime and

Table 5.—The effect of various fertilizer treatments on acre yields of seed cotton, Tipton County, 1949.

(Average 4 replications)

Fertilizer treatment [1]	Field No., cooperator and soil series		
	395 J. A. Wooten Caseyville	396 Allen Marshall Memphis	397 J. H. Bennett Dyer
	Lbs.	Lbs.	Lbs.
NPK	1292	1584	508
PK	1424	776	492
NK	1404	1524	492
NP	1412	1592	128
NPK plus magnesium [2]	1412	1568	544
NPK plus minor elements [3]	1492	1508	464
L.s.d. (5%) [4]	372	198	217

[1] Fertilization was at rate of 30-40-40 or the equivalent of 500 pounds per acre of 6-8-8, using the sulfate form of potash.

[2] Magnesium applied as potassium magnesium sulfate (Sulpomag).

[3] Includes boron, manganese and zinc at acre rates 10 pounds borax, 25 pounds manganese sulfate, and 20 pounds zinc sulfate.

[4] See explanation at bottom of table 4.

phosphate. On the Memphis soil the only significant response was to nitrogen and this was pronounced, giving an increase of 808 pounds of seed cotton from a 30-pound nitrogen application. A yield response to potash only was obtained on the Dyer soil. An application of 40 pounds K_2O resulted in an increase of 380 pounds of seed cotton. The Dyer soil has very poor internal drainage and is low in available potash. Potash deficiency symptoms were evident even on the potash-treated plots and were so pronounced on the no-potash plots that the plants were almost completely defoliated. Yields were low on this test; cotton was of very poor quality and difficult to pick.

COOPERATIVE EXPERIMENTS IN LAWRENCE AND LEWIS COUNTIES

The outlying cooperative work was moved from the West Tennessee area to Lawrence County in 1950. Data from two of the fertilizer experiments conducted in this new area, both of which were located on Dickson silt loam, are shown in table 6.

Cotton growing conditions were far from ideal in this area in 1950; the weather was cool and rainy and boll-weevil infestation was severe despite frequent dustings for control. The experiments are of interest in that there was a pronounced response to both nitrogen and phosphate. Field 421 showed a significant response to nitrogen, phosphate, and potash. There was an average gain of 390 pounds of seed cotton from an application of nitrogen and a gain of 368 pounds from an application of phosphate.

Table 6.—The effect of various fertilizer treatments on acre yields of seed cotton on Dickson silt loam, Lawrence and Lewis Counties, 1950.

(Average 4 replications)

Fertilizer treatment [1]	Field No., name, address of cooperator	
	421 Warren Fox Leoma, Tenn.	422 D. T. Hardy Hohenwald, Tenn.
	Lbs.	Lbs.
Nitrogen, phosphate, and potash	772	660
Phosphate and potash	256	396
Nitrogen and potash	356	340
Nitrogen and phosphate	560	696
L.s.d. (5%) [2]	136	198

[1] Pounds per acre:

N = 50 (using ammonium nitrate)

P_2O_5 = 40 (using triple superphosphate)

K_2O = 50 (using muriate of potash)

[2] See explanation at bottom of table 4.

COMPARISONS OF DIFFERENT PHOSPHATES

As mentioned earlier, several phosphates produced by the Tennessee Valley Authority have been compared with 20 percent superphosphate in most of the outlying cooperative fertilizer tests mentioned in this publication. Of these phosphates, concentrated (triple) superphosphate, calcium metaphosphate, potassium metaphosphate and fused tricalcium phosphate have been tested in numerous experiments. Up to the present time, fused tricalcium phosphate has not been available commercially but has been used extensively on unit test-demonstration farms. There is some likelihood that it will be available commercially in the near future. The results from 12 trials in Bedford County and 19 trials in West Tennessee are shown in tables 7 and 8.

In these tables cotton yields as obtained with standard 20 percent superphosphate in a complete fertilizer are shown and are assigned a base value of 100. The yields as obtained with no phosphate and the various other phosphates are expressed in percentage of this base yield. In the evaluation of a new phosphate it is highly important that the tests be conducted on soils low in available phosphate and that crop responses to applied phosphate be significant. The lower the value of the no-phosphate treatment, the more responsive that test was to phosphate applications.

The results in table 7 show that calcium metaphosphate and potassium metaphosphate gave a relative yield of approximately 90 as an average of the 12 trials. Fused tricalcium phosphate gave somewhat lower yields particularly when the coarse (–10 mesh) particle size was used.

Results from the tests in West Tennessee are shown in table 8. In these trials, standard superphosphate was compared with triple superphosphate and fused tricalcium phosphate. Triple superphosphate gave a relative yield of 98 and the two fused phosphates gave relative yields of 95 and 96 as an average of 19 tests. If comparisons are restricted to those tests in which crop responses to applied phosphate were relatively large (those marked with an asterisk), triple gave a relative yield of 95; fused –10 mesh, 89; and fused –40 mesh, 90. Other results with these phosphates are reported in the Station Annual Report for 1948. The results to date might be summarized by stating that concentrated superphosphate compares favorably with ordinary superphosphate and that fused gives results somewhat lower than the superphosphates, the coarser particle size being decidedly inferior on soils very low in phosphate. These differences show up at moderate rates of application; indications are that at high rates these differences would largely disappear. Grinding fused tricalcium phosphate to a fineness of 40 mesh appears to be sufficient; its value is not much improved when ground to pass an 80-mesh screen.

Table 7.—The relative effect of different phosphates on yields of seed cotton on various soils in Bedford County, 1940 and 1941.

(Standard superphosphate at rate 54 pounds P_2O_5 per acre = 100)

Field No.	Year	Soil type	Standard superphosphate (acre yields)	No. phosphate [1]	Calcium metaphosphate	Potassium metaphosphate	Fused tricalcium phosphate [2]		
							−10 mesh	−40 mesh	−80 mesh
			Pounds	Percent	Percent	Percent	Percent	Percent	Percent
88	1940	Hagerstown silt loam	1346	56	98	83	....	....	....
89	"	Mercer silt loam	628	84	107	88	....	....	....
90-91	"	Mimosa silt loam	1368	74	85	88	....	....	....
92	"	Mercer silt loam	1174	58	87	84	....	....	....
93-94	"	Mimosa cherty silt loam	677	73	71	78	....	....	....
95	"	Hagerstown silt loam	1024	29	88	78	....	....	....
96	"	Talbott silty clay loam	950	16	96	94	....	....	....
97	"	Talbott silty clay loam	1058	67	94	89	....	....	....
122-123	1941	Hagerstown silt loam	1336	64	88	76	54	58	70
124-125	"	Hagerstown silt loam	942	37	99	148	58	71	98
126-127	"	Pickaway silt loam	1582	93	99	99	97	93	98
128-129	"	Talbott silty clay loam	964	58	90	81	76	84	75
		Average	1088	60	92	90	73	77	86

[1] Nitrogen and potash applied to all treatments at rate 24 pounds N and 33 pounds K_2O per acre.

[2] Contained about 0.15 percent fluorine.

Table 8.—The relative effect of different phosphates in a complete NPK fertilizer on acre yields of seed cotton, West Tennessee, 1945-1948.
(Based on actual yields obtained with standard superphosphate with an assigned value of 100 percent.)

Field No.	Year	Soil series	Std. super.	No phosphate	Triple	Fused, —10 mesh	Fused, —40 mesh	Fused, —80 mesh
			Pounds	Percent	Percent	Percent	Percent	Percent
237*	1945	Ina	1584	79	65	76	92	106
238	1945	Dexter	1708	93	102	95	95	97
239	1945	Loring	1296	90	92	96	101	98
240*	1945	Memphis	1060	56	90	75	86	95
241	1945	Briensburg	1352	114	121	117	115	109
242*	1945	Faulkner	588	20	78	61	84	82
243*	1945	Loring	1124	53	107	110	89	97
249	1946	Memphis	2123	99	95	108	99	......
250*	1946	Dexter	1744	75	104	88	90	......
251*	1946	Grenada	1727	70	85	81	74	......
252*	1946	Loring	1496	82	103	94	95	......
253	1946	Grenada	1817	97	98	110	111	......
322*	1947	Memphis	1702	82	107	95	94	......
323	1947	Loring	1467	104	99	96	105	......
324*	1947	Eupora	2192	80	95	91	79	......
325	1947	Memphis	1020	110	123	113	123	......
360*	1948	Dulac	2227	84	94	89	99	......
361*	1948	Loring	1233	60	97	99	86	......
362*	1948	Memphis	1424	82	109	105	115	......
Average relative yield			100	83	98	95	96	......

* Fields in which responses to phosphate were relatively large.

VALUE OF SULFUR IN FERTILIZERS

Sulfur is an essential plant nutrient; its uptake by plants often exceeds that of phosphorus. Several fertilizer materials contain sulfur. Standard superphosphate (20 percent) contains about 50 percent calcium sulfate or about 11 percent sulfur. The sulfur content of ammonium sulfate, frequently used in mixed fertilizers, is about 24 percent. Concentrated (triple) superphosphate, nitrate of soda, and ammonium nitrate contain no sulfur.

In addition to the sulfur supplied by the various sulfur-bearing fertilizers, an appreciable amount is present in the air and is brought down in the rainfall. The amount present in the air varies with location and season of the year. The burning of coal, wood, etc., releases appreciable amounts of sulfur into the atmosphere; in the areas surrounding large manufacturing plants, the amounts released would be quite large. Among workers in fertilizer research, these questions are frequently raised: If sulfur were not applied in fertilizers, would the amount present in the soil and additions from the rainfall be sufficient to meet the crop requirements for sulfur? Even if the present soil supply were adequate, how long would it remain so if no additions were made in fertilizers?

Comparisons of the performance of concentrated superphosphate with 20 percent superphosphate provide some information on the first question. Since concentrated superphosphate contains no sulfur and since sulfur was not in the nitrogen and potash salts used, the satisfactory performance of concentrated superphosphate (table 8) would indicate that sulfur was not a limiting element in these particular experiments.

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