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Cotton Fertilizer Tests

in the El Paso Area, 1943-51

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CONTENTS

Cotton Fertilizer Tests in the El Paso Area, 1943-51

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COTTON IS THE PRINCIPAL CROP grown in El Paso Valley. It was planted on 60 to 85 percent of the cultivated land from 1943 through 1951. The maintenance of high yields includes a consideration of the fertilizer requirements of the crop on the soils where it is grown.

Work before 1943 on Mesilla Valley soils in New Mexico (7, 11)[1], which are similar in nature and productivity to those in El Paso Valley, showed that yield increases in cotton resulting from commercial fertilizer applications were generally limited to certain types of soils. In many cases, the yield increases would not pay the cost of the fertilizer and its application. The advent of higher cotton prices and the likelihood of soil depletion as a result of continuous cropping made advisable an examination of the fertilizer needs of the soils in the El Paso area.

The soils in El Paso Valley are composed of stratified river sediments varying in texture from medium sands to heavy clays. They have been classified by the Soil Conservation Service in the Gila and closely related soil series. The soils are variable in physical properties and salt content.

MANY TREATMENTS ON FIELD PLOTS INCLUDED

Early fertilizer tests (1943-45) at the El Paso Valley Experiment Station were aimed at determining the fertilizer nutrients required to produce the highest yields of cotton (8). Later experiments (1, 3, 4) were directed toward determining the types of soils which require fertilizer, the amounts of fertilizer required and the influence of alfalfa in rotation on the need of cotton for fertilizer. Until 1950, all fertilizer experiments were conducted on the station at Ysleta. Tests were established in 1950 and 1951 on private farms in the El Paso Valley. In all the fertilizer experiments reported in this

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[1]Numbers in parentheses refer to the literature cited.

bulletin, Acala cotton was used as the test crop. The experiments included approximately 75 different fertilizer treatments in which nitrogen, phosphorus, potassium and the trace elements were applied to more than 2,000 field plots.

The fertilizers were applied to the soil as a side-dressing after the cotton was up, usually between May 10 and June 10. Applications were made 4 to 10 inches on each side of the row and 4 to 6 inches deep. Each fertilizer treatment in each test was replicated several times in randomized blocks. The fertilizer plots were either two or four rows wide and usually 50 feet long.

Prior to 1950, fertilizers were applied with a tractor-mounted field fertilizer distributor. In 1950 and 1951, applications were made with a tractor-mounted experimental plot fertilizer distributor shown in Figure 1.

For purposes of discussion, the results of the nitrogen and phosphorus fertilizer experiments are divided into two parts: *first*, tests on soils which had been planted to cotton

Figure 1. Experimental plot fertilizer distributor mounted on tractor.

Table 1. Yield of seed cotton as influenced by application of nitrogen fertilizer, 1947-51

Year	Soils in continuous cotton						Soil planted to cotton following alfalfa	
	Light		Medium		Heavy			
	Check	Nitro.	Check	Nitro.	Check	Nitro.	Check	Nitro.
	Pounds of seed cotton per acre							
1947	2269	2139	1735	2134[1]	2181	2427[1]	3891	3845
1948	2696	3068[1]	3388	3318	2215	2380	3618	3556
1949	1630	2288[1]	2055	2562[1]	2753	3041[1]	3178	2986
1950	2833	2876	2243	1998	2802	3015	5381	5541
1951	1261	1139	3655	4300[1]	774	1031[1]	3683	3895
Av.	2138	2302	2615	2862	2145	2379	3950	3965

[1]The odds are 19 to 1 that the difference in yield between the check and the nitrogen-treated plots is real and not the possible result of plant and soil variations in the field.

for 3 to more than 10 years, and *second*, tests on soils where cotton followed immediately after alfalfa.

YIELD INCREASES FROM NITROGEN

Preliminary tests before 1947 indicated yield increases from nitrogen and combinations of nitrogen and phosphorus on the lighter soils. Table 1 shows the yield resulting from nitrogen applications in the tests conducted from 1947 through 1951. Where nitrogen was applied alone on land in continuous cotton, average yields were above the check in 11 out of 15 tests. In 8 of these tests, the odds were 19 to 1 that the yield increases were real and not the possible result of plant and soil variations in the field.

Considering all treatments in the 9-year period, 1943-51, the average yield increase from nitrogen fertilizer applied alone was 2.3 pounds of seed cotton per pound of available nitrogen (N) applied (Table 2).) This was equivalent to approximately 190 pounds of seed cotton per acre (Table 2 and Figure 2) for each treatment. The treatments varied from 50 to 130 pounds of nitrogen (N) per acre.

Table 2. Increased yield of seed cotton, pounds per acre, over check as influenced by application of nitrogen (N), available phosphoric acid (P_2O_5), and combinations of both, 1943-51

Fertilizer nutrient	Type of soil			Average all soils	Average all soils
	Light	Medium	Heavy		
	Pounds of cotton per pound of available nutrient				Pounds cotton per treatment[1]
N	2.0	2.6	2.4	2.3	190
P_2O_5	—0.2	0.2	0.2	0.1	10
$N + P_2O_5$	1.6	1.5	0.8	1.3	210

[1]The average increase resulting from the various fertilizer treatments. Nitrogen applied at rates of 50 to 130 pounds per acre. Available phosphoric acid applied at rates of 50 to 320 pounds per acre.

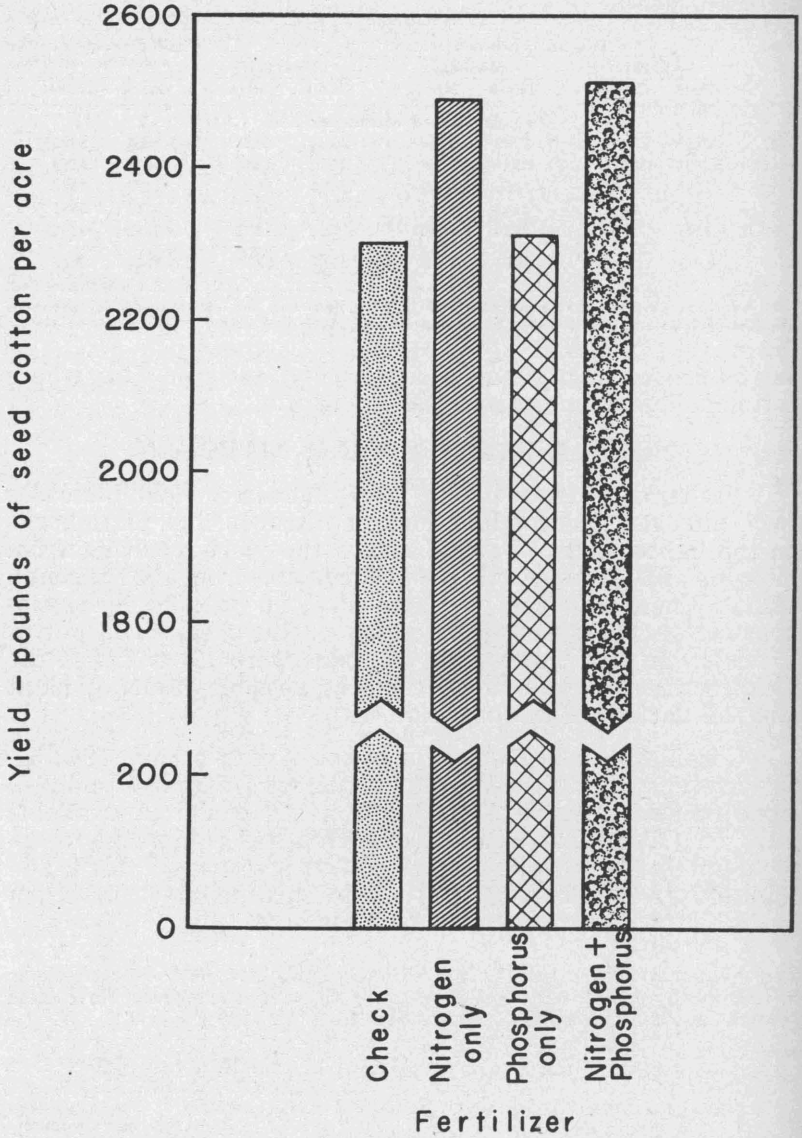

Figure 2. Yield of seed cotton as influenced by applications of nitrogen, phosphorus, and combinations of both. Average of 19 tests in 9 years.

Figure 3, which was adapted from recent fertilizer tests, indicates that the lower rates of nitrogen resulted in more cotton per pound of fertilizer than the higher rates. Sixty pounds of nitrogen increased the yield 200 pounds over the unfertilized plots. An additional 60 pounds of nitrogen (120 pounds N) further increased the yield only 100 lbs. Similar results were obtained where the nitrogen plus phosphorus treatments were applied.

LITTLE YIELD INCREASE FROM PHOSPHORUS

Yield increases from phosphorus resulted in only 2 out of 19 tests. The average yield increase per pound of available phosphoric acid (P_2O_5) applied alone was 0.03 pound of seed cotton per acre. This was equivalent to only 10 pounds of cotton per fertilizer treatment (Table 2), with treatments varying from 50 to more than 200 pounds of available phosphoric acid per acre. There appears to be little need to apply phosphorus in combination with nitrogen, since the combina-

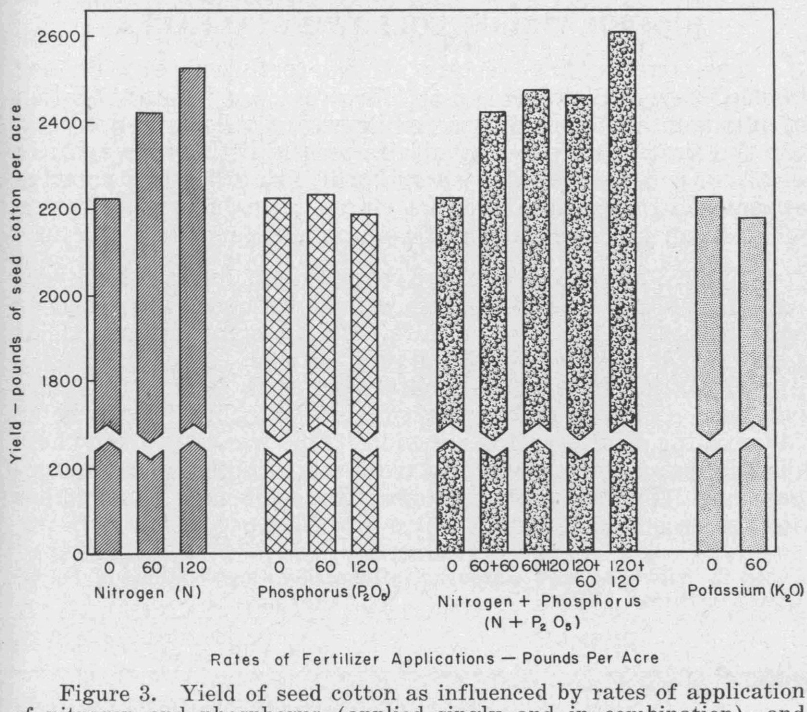

Figure 3. Yield of seed cotton as influenced by rates of application of nitrogen and phosphorus (applied singly and in combination), and potassium. Average of 1949-51 tests.

Table 3. Yields of seed cotton as influenced by rotation with alfalfa, compared with yields from continuous cotton[1]

Year	Fertilized continuous cotton: Average[2]	Fertilized continuous cotton: Highest treatment[3]	Cotton following alfalfa[4]
	Pounds per acre		
1947	2170	2383	3926
1948	2911	3152	3596
1949	2563	2845	3085
1950	2591	2735	5433
1951	2090	2368	3768
Av.	2496	2697	3939

[1]Cotton grown continuously for 3 or more years.
[2]Average yield of all fertilized plots on each soil.
[3]Average yield of highest-yielding treatments on each soil.
[4]Average yield of all plots on each soil.

tion gives little or no more yield than nitrogen alone (Table 2 and Figure 3). Results of the 1945 test, the 1949 test on heavy soil and unpublished data in 1951 indicate, however, that previously unfertilized soils or soils not fertilized for 5 to 10 years may show yield increases from phosphorus applications.

HIGHER YIELDS FOLLOWING ALFALFA

Two outstanding results of the fertilizer tests on soil planted to cotton following alfalfa are: *first,* the application of nitrogen and phosphorus fertilizers to soil planted to cotton the first year following alfalfa was of little or no value in increasing cotton yields; *second,* the alfalfa-cotton rotation appeared to be generally more effective in increasing cotton yields than the application of commercial fertilizer.

Table 3 shows the average cotton yields during the 5-year period, 1947-51, on fertilized soils in continuous cotton and on soils in cotton following alfalfa. In all comparisons, yields were higher where cotton followed alfalfa. The differences in yield varied from approximately one-fifth to over two bales per acre and averaged approximately one bale per acre in favor of the alfalfa-cotton rotation. This was true even where the highest-yielding fertilized plots were singled out for comparison. (See the section, *Discussion of Results,* for further discussion on these data.)

Table 4. Yields of seed cotton as influenced by applications of potash (K_2O) fertilizer, 1951[1]

Treatment Lbs. K_2O per acre	Average yield Lbs. per acre
None	2634
60	2636

[1]Average of three tests.

POTASSIUM FERTILIZER NOT REQUIRED

Several tests were conducted at the El Paso Valley Experiment Station during the 9-year period in which potassium fertilizers were applied to cotton land. In no case was the yield increased by these applications. In 1951, three fertilizer tests were established on privately-owned farms in the El Paso Valley in which potassium was applied singly and in combination with four levels of nitrogen and two levels of phosphorus. Figure 2, showing the effects of potassium applied alone, and Table 4, showing the overall effects of potassium, indicate that applications of potassium had little or no influence on the cotton yield.

NO YIELD INCREASES FROM TRACE ELEMENTS

Preliminary tests using the trace elements, copper, boron, manganese, zinc and iron, applied singly or in various combinations were conducted in 1945, 1947 and 1951. In no instance did the application of any of the trace elements result in higher cotton yields.

DISCUSSION OF RESULTS

The data presented in this bulletin and elsewhere (3, 4, 8) show a wide variation in results obtained each year and from year to year. These variations are due in part at least to the extreme variability in the soils in the El Paso Valley. Variations in the soils result from wide differences in soil texture and salt content, both in the surface and in the underlying layers, and soil structural conditions stemming in part from various cultural practices. Soil variations which occur in short distances in the field are reflected in wide variations in crop growth and often mask yield differences due to fertilizer treatments. For these reasons, conclusions drawn from fertilizer experiments should come from an overall consideration of the results of several years' work.

On most soils which have been in continuous cotton for a number of years, the application of nitrogen usually has resulted in yield increases. Results in 1945, 1949 and unpublished data in 1951 also indicate that, where soils have not been fertilized with phosphorus within the previous 5 to 10 years, cotton yields may be increased by applications of superphosphate.

The lack of response to nitrogen found on some soils may be due to the fact that other factors affecting plant growth are more critical. In many instances, certain physical and chemical conditions of the soil, such as restricted water penetration, inadequate soil aeration, low water holding capacity, hard-pan formation or excessive salt concentration inhibit crop growth even when ample nutrients are present in the soil.

In a similar manner, the lack of yield increases from nitrogen applied on certain soils may be attributed to the generally high native fertility of the soils, which are composed of layers of sediment deposited by the Rio Grande. In other words, assuming that all the cotton stalks and leaves are returned to the soil at the end of each growing season, the fertilizer nutrients removed from the land through cotton farming are practically all contained in the cotton seed. The amounts of the fertilizer nutrients removed from the land in a bale of seed cotton (500 pounds of lint and 870 pounds of seed) are approximately 32 pounds of nitrogen (N), 11 pounds of available phosphoric acid (P_2O_5) and 10 pounds of potash (K_2O). In contrast with one bale of cotton, 4 tons of alfalfa remove approximately 6 times as much nitrogen (presumably partially replaced by root nodule bacteria), 3 times as much phosphoric acid and 20 times as much potash. In similar manner, 10 tons of corn fodder removes 8 times as much nitrogen, 6 times as much phosphoric acid, and 20 times as much potash.

When it is recognized that varying amounts of nitrogen are added to the soil each year through fixation by soil organisms not associated with legumes, it is reasonable to assume that in some soils sufficient nitrogen is present in some seasons to take care of the needs of cotton.

When the fertilizer tests were established for a comparison of fertilizer response on light, medium and heavy soils, and soils the first year following alfalfa, no attempt was made to design the experiments so that specific comparisons between soils could be made. The physical requirements of a field plot test in which specific comparisons between soils could be made were beyond practical limits under conditions prevailing in the area.

The comparisons between the yields on soils in continuous cotton and those in alfalfa-cotton rotation are, therefore, not direct, and conclusions drawn from the data should be interpreted in a general way. It is believed, however, that the soils in the El Paso Valley are sufficiently similar in productivity to justify the general comparison made between cotton yields following cotton with yields following alfalfa.

CONCLUSIONS AND RECOMMENDATIONS

Results of fertilizer experiments at the El Paso Valley Experiment Station (1, 3, 4, 8) and similar findings at other stations (2, 7, 9, 10, 11, 12) in the arid West lead to the following conclusions regarding the fertilization of short staple cotton:

Nitrogen

Nitrogen is the nutrient most lacking in the soils of the El Paso Valley. Applications of nitrogen will result in yield increases on most soils where cotton does not follow alfalfa. The increases occur often enough to warrant the annual application of the fertilizer. There is evidence that yield increases resulting from nitrogen applications are more likely to occur on the lighter soils than on the heavier types, but results at the El Paso Valley Experiment Station indicate that past cropping history is more important than soil texture in determining fertilizer needs.

Fertilizer applications equivalent to 60 to 80 pounds of available nitrogen (N) per acre are adequate for high yields of cotton. Higher applications of fertilizer generally do not appreciably further increase the yield.

Where cotton is planted immediately following alfalfa, nitrogen applications are not recommended.

Phosphorus

Increases in yield of cotton resulting from the application of superphosphate are infrequent and are generally confined to soils which have not received any phosphate for 5 to 10 years. The application of superphosphate probably once every 5 years is adequate to meet the need of cotton grown on soils in the El Paso Valley. Before applying the fertilizer, it is recommended that samples of the soil be analyzed chemically to determine whether sufficient phosphorus is available to meet the needs of the crop.

Where alfalfa is grown in rotation with cotton, applications of phosphorus to the alfalfa are probably sufficient to meet the needs of both alfalfa and the cotton which follows.

Potassium

Results of several experiments at the El Paso Valley Experiment Station show that soils in this area contain sufficent potassium. In addition, the irrigation water applied at present rates supplies approximately 75 pounds of potassium per acre annually (5). This amount is far in excess of that removed by cotton.

Trace Elements

Experimental work at this station indicates that applications of trace elements are of little value in increasing the yield of cotton.

GENERAL RECOMMENDATIONS

For highest cotton production, rotate cotton with alfalfa.

Under an alfalfa-cotton rotation, apply phosphorus to alfalfa and eliminate phosphorus applications to cotton. A laboratory test for available soil phosphorus is suggested as an aid in determining whether to apply the fertilizer.

Apply nitrogen fertilizers to cotton annually after the second year following alfalfa. Sixty to 80 pounds of nitrogen per acre are suggested.

Applications of potassium or the trace elements are not recommended.

It is highly recommended that each farmer make a practice of limited fertilizer testing on his farm, as all soils do not respond in the same manner to fertilization. To test a fertilizer, the farmer should apply it to one border and leave the adjacent border unfertilized as a check. By repeating this procedure several times in the field, reliable information can be obtained.

ACKNOWLEDGMENTS

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APPENDIX

Fertilizer Guarantees

Dealers in fertilizer are required by law to state the guaranteed analysis of the fertilizer on the fertilizer bag (6). This guarantee is shown in three numbers, of which the following are examples: 33-0-0, 16-20-0, 0-45-0 and 5-10-5. The three numbers in each guarantee show, in order from left to right, the percent of nitrogen, available phosphoric acid and potash.

Nitrogen is expressed as total nitrogen (N). Terms such as "ammonia" or "equivalent to ammonia" are not allowed.

Phosphorus is expressed as the percent of available phosphoric acid (P_2O_5). The term "available" is defined as the phosphate which will dissolve in a neutral solution of ammonium citrate. In products such as raw rock phosphate, bone meal or tankage, "total" phosphoric acid may be guaranteed; but where this is done, no "available" phosphoric acid can be guaranteed.

Potassium is expressed as the percent of potash (K_2O) which will dissolve in distilled water.

For a detailed discussion on commercial fertilizers, see Texas Agricultural Experiment Station Bulletin 755, "Analysis of Commercial Fertilizers Sold During 1951-52" (6).

Factors Governing Choice of Fertilizers

The choice of fertilizer to apply involves consideration of the fertilizer nutrients lacking in the soil, the method of fertlizer application, the acid or alkaline reaction produced in the soil by the fertilizer and the cost of the fertilizer. The following general rules should be followed in selecting fertilizer:

Apply only the fertilizer nutrients which are in short supply in the soil. Select the fertilizer or fertilizers which will supply only the required nutrients. The application of nitrogen and phosphorus where only nitrogen is required, or the application of nitrogen, phosphorus and potassium where only nitrogen and phosphorus are required, involves both a waste of fertilizer and an unnecessary increase in the cost of fertilization.

On arid soils, apply fertilizers which produce an acid or neutral reaction in the soil. Nitrate of soda, for example, is not recommended because it tends to produce alkali soil conditions.

Purchase fertilizers on the basis of the cost per pound of available plant nutrient, other factors being equal.

Where liquid fertilizers are applied in irrigation water, the irrigation system should be adequate to provde an even dstribution of water over the land.

Where anhydrous ammona is applied directly to the soil, applications should be at least four inches deep; otherwise, appreciable ammonia may be lost to the atmosphere.