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Grain Sorghum Fertilizer Tests on Upland Clay Soils of Central Texas, 1953 - 59

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Summary

The data in this publication summarize the results of fertilizer tests made on grain sorghum at the Texas Agricultural Experiment Station, Substation No. 23, McGregor, during 1953-59. The experiments were conducted without irrigation on upland Grand Prairie or Blackland Prairie soils.

Nitrogen and phosphorus fertilizers consistently gave increased yields of grain sorghum. Responses to phosphorus were greater than responses to nitrogen, but the highest yields were obtained when both nitrogen and phosphoric acid were used. Generally the minimum rate of nitrogen and phosphorus fertilizers gave the highest return on money invested for fertilizer. No yield responses were obtained from the application of potash. Experiments with varying nitrogen rates in the form of anhydrous ammonia gave responses similar to the same nitrogen rates using solid fertilizers.

Applications of 15 to 30 pounds of both nitrogen and phosphoric acid per acre are recommended for grain sorghum on the upland clay soils without irrigation. The recommendations are 100 to 200 pounds per acre of 15-15-0 or 16-20-0 fertilizers in terms of fertilizer grades usually available to farmers. This should be applied at or before planting time but not in direct contact with the seed. Such fertilizer applications have paid 2 out of 3 years; production during the third year was limited by low moisture.

The time of applying nitrogen on continuous grain sorghum, studied during a 1-year period, indicates no differences in yield from the following three times of nitrogen application: (1) in the fall on the stubble of the previous crop; (2) a spring application at planting time; or (3) a split application with half of the nitrogen applied in the fall and the other half at planting time.

Contents

Grain Sorghum Fertilizer Tests on Upland Clay Soils of Central Texas, 1953-59

M. J. NORRIS, H. O. HILL and F. L. FISHER*

THE DATA PRESENTED in this publication result from fertilizer tests on grain sorghum made at the Texas Agricultural Experiment Station, Substation No. 23, McGregor, during 1953-59. The experiments were conducted without irrigation on upland Grand Prairie or Blackland Prairie soils. These soils are located in the 30 to 35-inch rainfall belt in which drouths are common during the sorghum growing period. Most fertilizer experiments have been conducted in areas of greater rainfall. Sometimes efforts are made to extend recommendations based on these data from the more humid areas into the areas of lower rainfall. These fertilizer recommendations generally are excessive for this area because available moisture is the greatest limiting factor in grain sorghum's use of fertilizer. Early information from the studies included in this report indicated that there was not sufficient moisture most years for the plants to use the fertilizer at the high rates being used. As a result lower application rates were substituted in the tests.

Grain sorghum as a cash crop is being planted on much land previously planted to cotton and made availible to other crops because of cotton acreage allotments. This increase in grain sorghum acreage and the increased yield through planting of hybrids increases the economic importance of the crop for the Graind Prairie and Blackland areas. Therefore more research work is being done on grain sorghum to lower its net production cost and increase net returns to the grower.

Experimental Procedures

Fourteen replicated fertilizer tests on grain sorghum were conducted on upland clay soils of the McGregor station during 1953-59. A fertilizer test was not conducted in 1956 because of the extreme drouth. Twelve of the experiments were on San Saba, Denton or Crawford clay soils of the Grand Prairie. Two tests were on Houston clay soils of the Blackland Prairie. The experiment sites were located on soils that had no recent history of fertilizer application or cropping with legumes. Shallow soils purposely were avoided because of their low moisture-storing potential. The Redbine 60 grain sorghum variety was planted through 1955. Grain sorghum hybrid RS 610 was used during 1957-59.

Factorial Fertilizer Trials, 1953-55

A complete factorial design with four replications was used during 1953-55. Nitrogen and phosphoric acid were applied at 0, 30, 60 and 90 pounds per acre. All possible combinations of the four levels of nitrogen and phosphoric acid were used. Sources of nitrogen were ammonium nitrate (33 percent N) and ammonium sulphate (21 percent N). Superphosphate (46 percent P_2O_5) was the source of phosphorus fertilizer. The test location was changed each season in this series of experiments.

Fertilizer Trials of Crops in Rotation, 1957-59

By 1956 it was apparent from past work that 90 pounds per acre of nitrogen or phosphoric acid was higher than needed for maximum grain sorghum yields under dryland conditions of the area. The lowest level, 30 pounds per acre of nitrogen and 30 pounds of phosphoric acid, had produced nearly the maximum yields in the 1953-55 experiments. Information also was needed on the effects of various rates and ratios of fertilizers on crops in cropping systems. For these reasons a new experiment was started in the fall of 1956 with lower rates of nitrogen and phosphoric acid on various crops in cropping systems.

The following cropping systems were included: continuous grain sorghum; continuous cotton; continuous oats; and a 3-year cropping system of grain sorghum, cotton and oats grown in the sequence listed.

Fourteen fertilizer treatments were included on each crop in all cropping systems. The fertilizer treatments were 0-0-0, 0-30-0, 30-0-0, 30-30-0, 0-0-30, 0-30-30, 30-0-30, 30-30-30, 15-30-0, 45-30-0, 60-30-0, 30-15-0, 30-45-0, and 30-60-0. These treatments included a complete 2 x 2 x 2 factorial design so that the main effects and interactions of nitrogen, phosphoric acid and potash on crop yields could be determined. The effects of varying rates of nitrogen and phosphoric acid on crop yields also could be determined at the following rates of nitrogen and phosphoric acid: 0, 15, 30, 45 and 60 pounds per acre.

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TABLE 1. SUMMARY OF GRAIN SORGHUM FERTILIZER TESTS AT McGREGOR, 1957-1959

Fertilizer rate per acre, pounds			Yield grain sorghum, pounds per acre			
N	P_2O_5	K_2O	1957	1958	1959	Average
0	0	0	2960	2640	3180	2930
0	15	0			3780	
0	30	0	3100	2920	3620	3210
15	0	0			3360	
15	15	0			3410	
15	30	0	3500	3130	3660	3430
30	0	0	3340	2990	3210	3180
30	15	0	3830	3240	3570	3550
30	30	0	3480	3150	3720	3450
30	30	30		3130	3760	
30	45	0	3460	3380	4010	3620
30	60	0	3550	3430	4210	3730
45	30	0	3970	3320	3780	3690
60	30	0	3420	3140	3830	3460
0	0	30		2540		
0	30	30		2890		
30	0	30		3100		
L.S.D. at .05 level			315	402	354	

Fertilizer treatments were modified slightly for the 1959 crop year to obtain more information on nitrogen and phosphorus fertilizers by sacrificing some of the information on potash. The following fertilizer treatments were added: 15-0-0, 0-15-0 and 15-15-0. They replaced the following potash treatments: 0-0-30, 30-0-30 and 0-30-30. The only treatment remaining with potash was 30-30-30.

With the above changes the fertilizer variables in the experiment consisted of a 3 x 3 complete factorial with nitrogen and phosphoric acid levels at 0, 15 and 30 pounds per acre; a 30-30-30 treatment as a side comparison to be made with 30-30-0 to determine whether potash was needed; and varying levels of nitrogen and phosphoric acid at 15-pound increments up to 60 pounds per acre. Specific fertilizer treatments are listed in Table 1. Fertilizer treatments used in 1959 will be continued for at least 4 more years.

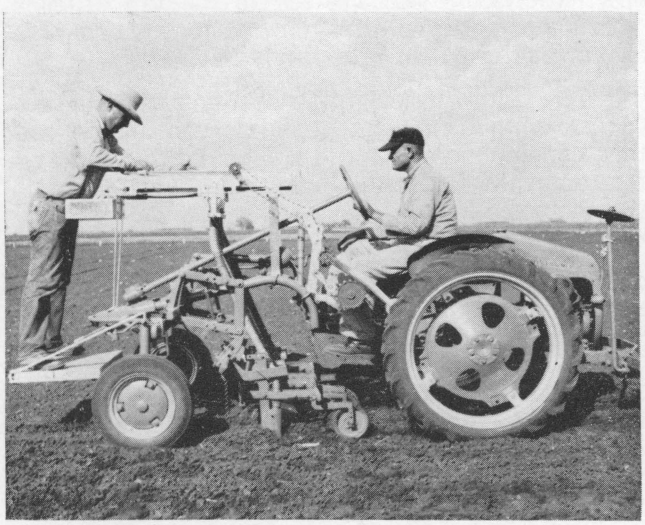

Figure 1. Multiple-cell fertilizer distributor used in applying fertilizer for the experiments summarized in this publication.

The fertilizer was applied at planting time with a specially made multiple-cell, belt-type distributor that applied the chemical and planted the crop at the same time, Figure 1. Fertilizer was placed in a band to the side and slightly deeper than the seed. Each plot consisted of four, 40-inch rows, 66 feet long. Ammonium sulphate (21 percent N) was used as the source of nitrogen, superphosphate (46 percent P_2O_5) was used as the source of phosphorus and muriate of potash (60 percent K_2O) was used as the source of potassium.

Each plot received the same fertilizer treatment year after year. By including crop rotations and holding the experiment in the same location from year to year, the conditions of the work more nearly approached the farmer's fertilizer problem than past fertilizer research where the test was moved yearly.

Anhydrous Ammonia Rate Tests

Seven experiments on the effects of various nitrogen rates in the form of anhydrous ammonia were conducted. The nitrogen levels in these experiments were 0, 20, 40 and 60 pounds per acre. No phosphorus fertilizer was used. The nitrogen treatment levels were replicated three or four times. Anhydrous ammonia was applied before planting grain sorghum.

Time of Nitrogen Application on Grain Sorghum

During the 1959 crop year a new experiment was established to determine the effect of the time of applying nitrogen under continuous cropping of grain sorghum with uniform tillage operations for all fertilizer treatments. Nitrogen was applied at the rate of 30 pounds per acre with the following variables in time of application:

1. In the fall, broadcast on the stubble of the previous grain sorghum crop.

2. In the spring, in bands when the grain sorghum crops were planted.

3. A split application with 15 pounds of nitrogen applied broadcast in the fall and 15 pounds applied in bands in the spring.

The following phosphorus variables also were included in this experiment:

1. No phosphorus.

2. 30 pounds of phosphoric acid per acre applied in bands at planting time.

Results of Fertilizer Research

Figure 2 summarizes the four treatments that have been in fertilizer trials every year during 1953-59 except in 1956 when no tests were conducted. No combined analyses of variance of yields were made of the data reported in Figure 2 because of changes in the fertilizer treatments from year to year. Complete analyses were made of the data collected yearly. No significant response due to fertilizers was obtained in 1953 although there were responses. Significant responses were obtained in 1954 and 1957. Highly significant responses were obtained in 1955, 1958 and 1959.

Figure 2 well illustrates the typical response of grain sorghum to fertilizers on upland clay soils of Central Texas. The check plot which received no fertilizer averaged 2,620 pounds per acre. An addition of 30 pounds of nitrogen raised yields to 2,790, an increase of 170 pounds of grain per acre. Thirty pounds of phosphoric acid increased the yield to 2,850 or 230 pounds above the unfertilized treatments. When nitrogen and phosphoric acid were combined in the 30-30-0 treatment, the yield jumped to 2,970, an increase of 350 pounds of grain per acre.

Results from the factorial fertilizer trials conducted during 1953, 1954 and 1955 were similar to those shown in Figure 2. Yield increases were obtained from nitrogen alone. Slightly higher yields were obtained from phosphorus alone. The highest yields were obtained when nitrogen and phosphoric acid both were applied on the same plot. In these experiments the 30 pounds per acre level of nitrogen and phosphoric acid, which was the lowest level, gave as good responses as the 60 or 90-pound level. This indicated that a 30-30-0 treatment should produce near maximum yields for grain sorghum under the soil and climatic conditions of the area. This also indicated the need for additional research with lower levels of fertility than 30 pounds of nitrogen or phosphoric acid.

Results of the Crop Rotation-Fertilizer Tests, 1957-59

The effects of fertilizer treatments on grain sorghum from the crop rotation fertilizer experiment for 1957-59 are shown in Table 1. The fertilizer response on rotated grain sorghum and continuous grain sorghum were similar. For that reason the fertilizer yields shown in Table 1 are an average of the two cropping systems.

Moisture was adequate for good yields each season and nearly optimum in 1959. These were significant responses to nitrogen and phosphorus each year and no response to potash. This table again shows a response in yield to nitrogen alone, a slightly higher response to phosphorus alone and the highest response when the two fertilizer elements were applied together.

Effects of Varying Nitrogen Rates

Figure 3 shows the effects of varying nitrogen rates on grain sorghum yields from experiments conducted during 1957-59. A uniform application of 30 pounds of phosphoric acid per acre was applied to all fertilizer treatments shown in Figure 3, including the 0 nitrogen level.

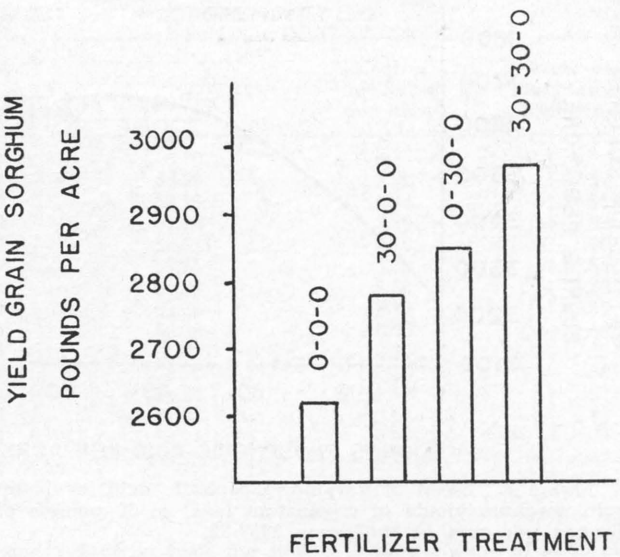

Figure 2. Summary of grain sorghum fertilizer tests at McGregor, 1953-59.

The grain sorghum yield curve, due to the effect of nitrogen shown in Figure 3, was plotted from a polynomial equation that best fitted the data by the "least squares" method. The curve indicates that the greatest yield increase due to nitrogen was obtained with the application of the first 15 pounds increment per acre; a further increase was obtained with the application of 30 pounds of nitrogen. Then the grain sorghum yields leveled off with the 30 and 45-pound applications, and there was a downward trend at 60 pounds per acre. Hence, the optimum nitrogen level for grain sorghum production under the conditions of these experiments with 30 pounds of phosphoric acid was in the range of 15 to 30 pounds of nitrogen per acre.

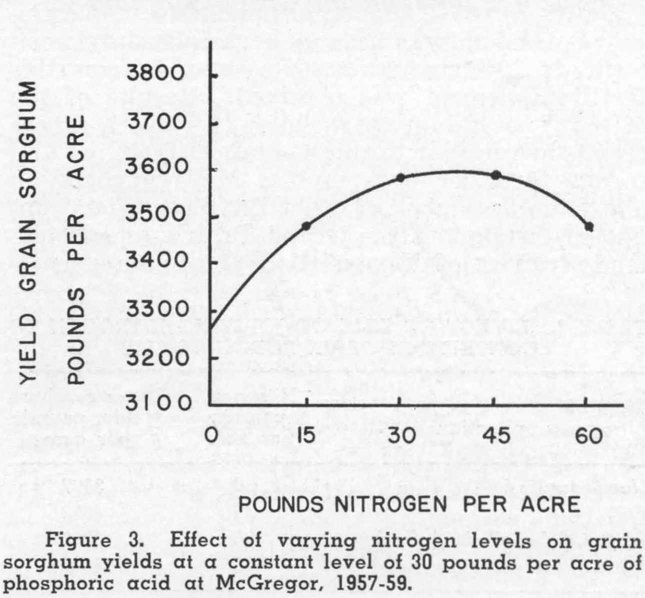

Figure 3. Effect of varying nitrogen levels on grain sorghum yields at a constant level of 30 pounds per acre of phosphoric acid at McGregor, 1957-59.

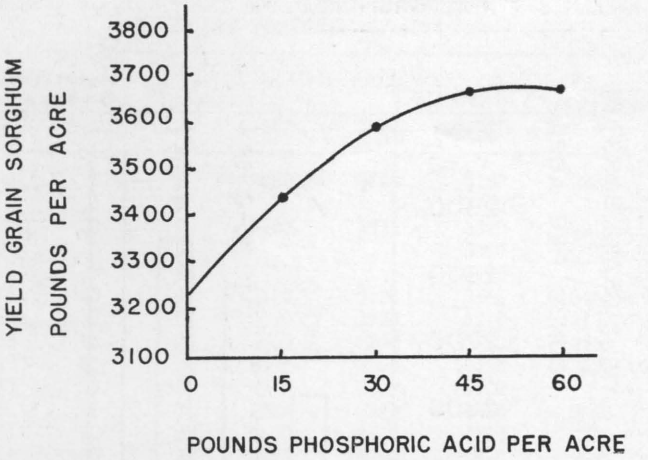

Figure 4. Effect of varying phosphoric acid levels on grain sorghum yields at a constant level of 30 pounds of nitrogen per acre at McGregor, 1957-59.

Effects of Varying Phosphorus Rates

Figure 4 shows the effects of varying phosphorus rates as phosphoric acid on grain sorghum with a uniform application of 30 pounds per acre of nitrogen to all plots including the 0 phosphorus level. The grain sorghum yield curve shown in Figure 4 indicates that the greatest production increase due to phosphorus was obtained from the first 15-pound increment of phosphoric acid per acre. A further high yield increase was obtained with the application of 30 pounds of phosphoric acid. Higher phosphoric acid applications gave small increases, with the grain sorghum yield reaching the highest point and leveling off at 45 pounds of phosphoric acid per acre.

The optimum level of phosphorus for grain sorghum under the conditions of these experiments with 30 pounds of nitrogen was in the range of 15 to 30 pounds of phosphoric acid per acre.

Effects of Potassium on Grain Sorghum

Potassium was used as a variable in experiments in 1958 and 1959. No response from this fertilizer element was obtained. Results of the effect of potassium are included in Table 1. These results are similar to those obtained from oat and forage fertilizer tests on the McGregor station and from a number of other fertilizer trials conducted throughout the Grand Prairie and Blackland Prairies of Texas. Soil potassium usually is adequate for the production of crops in these areas.

TABLE 2. EFFECT OF TIME OF APPLYING NITROGEN TO CONTINUOUS GRAIN SORGHUM, 1959

Time of nitrogen application	Nitrogen, pounds per acre	Grain sorghum yields, pounds per acre
None applied	0	3577
Fall	30	4230
Split (50% Fall, 50% Spring)	30	4238
Spring (at planting time)	30	4422

Effects of Nitrogen in the Form of Anhydrous Ammonia

Grain sorghum responses with anhydrous ammonia as the source of nitrogen fertilizer were similar to responses obtained from solid nitrogenous fertilizers such as ammonium sulphate and ammonium nitrate. Most anhydrous ammonia rate tests were conducted during the dry seasons of 1953 and 1954, which resulted in small yields. The favorable responses indicate that anhydrous ammonia is a satisfactory source of nitrogen fertilizer for Central Texas.

Effects of Time of Nitrogen Application on Continuous Grain Sorghum

The results for one season on the effect of the time of applying nitrogen to continuous grain sorghum are shown in Table 2. The data indicate no important differences between the three following times of application: (1) nitrogen applied in the fall on the stubble of the previous crop; (2) nitrogen applied in the spring at planting time; or (3) a split application with half the nitrogen applied in the fall and the remainder applied at planting time. The highest yields were obtained when nitrogen was applied at planting time. The greatest response was from the comparison of the 0 nitrogen rate with any treatment that included nitrogen regardless of the time it was applied. Thirty pounds of nitrogen gave increases of 650 to 845 pounds of grain per acre over 0 nitrogen plots. These results indicate that fertilizer should be applied at planting time but that it may be applied when land preparation is in progress if it offers any convenience in farming operation.

Profits from Fertilizing

The data in Table 3 show the gain or loss from fertilizing grain sorghum during 1957-59. Actual yields are shown for fertilizer treatments used but calculated yields were made from the yield response curve so that comparisons could be made for fertilizer treatments not actually tested. These data indicate that a fertilizer treatment of 25-36-0 produced the maximum profit, $4.98 per acre more than the unfertilized check plot. This specific fertilizer ratio is not manufactured but 150 pounds of 16-20-0 approaches the treatment and produces an estimated $4.42 net return per acre above the unfertilized grain sorghum. However, 100 pounds of 16-20-0 produces almost as high a net return per acre, $4.32, with considerably less risk because of the lower fertilizer cost.

From the yield response curve the fertilizer treatment that was estimated to produce the maximum yield, 3,720 pounds of grain per acre, was 50-65-0. The net return for this treatment would

TABLE 3. PROFIT OR LOSS FROM FERTILIZING GRAIN SORGHUM, 1957-1959

Fertilizing rate per acre, pounds			Acre yield of grain, pounds		Value of grain per acre[2]	Cost of fertilizing per acre[3]	Profit or loss due to fertilizing
N	P_2O_5	K_2O	Actual	Calculated[1]			
0	0	0	2930		$49.80	0	0
0	30	0	3210	3270	55.59	2.90	+$2.92
15	30	0	3430	3480	59.16	4.70	+ 4.65
15	15	0		3370	57.29	3.50	+ 3.98
30	0	0	3180	3230	54.91	4.10	+ 1.00
30	15	0	3550	3450	58.65	5.30	+ 3.54
30	30	0	3450	3590	61.03	6.50	+ 4.72
30	45	0	3620	3670	62.39	8.90	+ 3.68
30	60	0	3730	3670	62.39	8.90	+ 3.68
45	30	0	3690	3590	61.03	8.30	+ 2.92
60	30	0	3460	3490	59.33	10.10	− .58
50	65	0		3720	63.24	11.70	+ 1.83
25	36	0		3600	61.20	6.38	+ 4.98
16	20	0		3420	58.14	4.02	+ 4.32
24	30	0		3550	60.35	5.78	+ 4.42

[1]Calculated yields were made from a polynomial that best fitted the data.
[2]Grain sorghum priced at $1.70 per hundredweight.
[3]Cost of nitrogen valued at $0.12 per pound; cost of phosphoric acid valued at $0.08 per pound (plus a charge of $0.50 per acre for application).

be considerably less than for 16-20-0 because of the extra fertilizer cost. Although nitrogen and phosphorus fertilizers consistently have given increased yields on grain sorghum even in dry years, they do not necessarily give increases great enough to pay fertilizing expenses and produce a profit. For instance, the yield increase from 30-30-0 and 30-0-0 in Figure 1 were not enough to pay for the fertilizers. The 0-30-0 treatment in Figure 1 produced a net gain of $.55 per acre per year above the cost of fertilizing.

Paying responses have been obtained from 15 to 30 pounds of nitrogen and 15 to 30 pounds of phosphoric acid 2 years out of every 3 during 1953-1959. Crop yields were limited by lack of moisture, in seasons when fertilizing was not profitable.

Conclusions and Recommendations

Experiments with grain sorghum during 7 years have shown that nitrogen and phosphorus fertilizers are needed for best production on the upland clay soils of the Blackland and Grand Prairies of Texas. The greatest grain sorghum yield response generally was obtained from 15 pounds of nitrogen and 15 pounds of phosphoric acid per acre. Further increases were obtained up to a fertilizer treatment of 30-30-0 per acre. Maximum yields due to fertilizers were obtained from the 30-30-0 treatment during the 7 years. However, the yield response curve of the data for the more favorable rainfall period, 1957-1959, indicated that the maximum yield from fertilizer would be reached with a 50-65-0 fertilizer treatment.

Fertilizing to produce maximum yields is not recommended because it results in a greater financial risk and a lower net income per acre.

The amount and kind of fertilizer to use depends on the previous fertilizer and cropping history of the field. A field that has been in sweetclover with phosphoric acid applied with the sweetclover probably would not require any fertilizer. But fields that have no history of nitrogen and phosphoric acid applications might give paying responses to fertilizer applications higher than 30-30-0.

Potassium is not recommended as fertilizer in the upland clay soils of the area, because no crop yield responses to potassium were obtained.

Preliminary work on the effect of the time to apply nitrogen on continuous grain sorghum indicates that nitrogen can be applied with satisfactory results any time from harvest of the previous crop to grain sorghum planting time.

The following recommendations are suggested for fertilizing grain sorghum on upland clay soils without irrigation: 100 to 200 pounds per acre of 15-15-0 or 16-20-0 fertilizers applied at the most convenient time at or before planting sorghum. One hundred pounds probably will pay for itself more consistently, but 200 pounds should be adequate for near maximum yields.

If fertilizer is applied at planting time, it should be placed in a band to one side and below the sorghum seed. Fertilizer applied in direct contact with the seed damages seedlings plants.

Acknowledgments

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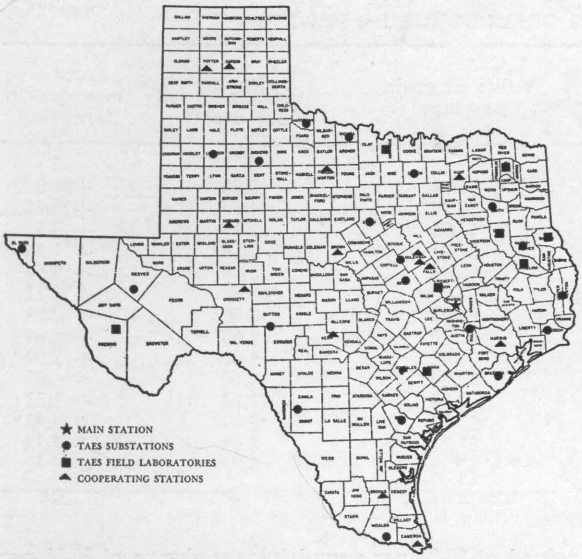
Special acknowledgment also is made to J. P. Ross and W. M. Meador, technical assistants, Texas Agricultural Experiment Station, who assisted in carrying out the field work and recording the data.



Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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Citrus and other subtropical fruits	Fish and game
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Insects	Rural agricultural economics

Plant diseases

Two additional programs are maintenance and upkeep, and central services.

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