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

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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 available 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 Grand 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 P₂O₅) 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.

*Respectively, agronomist and superintendent, Substation No. 23, McGregor; and associate professor, Department of Agronomy, College Station, Texas.

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

<table>
<thead>
<tr>
<th>Fertilizer rate per acre, pounds</th>
<th>Yield grain sorghum, pounds per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>N P-O K-O 1957 1958 1959 Average</td>
<td></td>
</tr>
<tr>
<td>0 0 0 2960 2640 3180 2930</td>
<td></td>
</tr>
<tr>
<td>0 15 0 3780 3760 3210 3180</td>
<td></td>
</tr>
<tr>
<td>0 30 0 3210 3210 3210 3210</td>
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<td>0 0 30 2540 2540 2540 2540</td>
<td></td>
</tr>
<tr>
<td>30 0 30 2990 2990 2990 2990</td>
<td></td>
</tr>
<tr>
<td>L.S.D. at .05 level 315 402 354</td>
<td></td>
</tr>
</tbody>
</table>

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.

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, 16-inch rows, 66 feet long. Ammonium sulphate (21 percent N) was used as the source of nitrogen, superphosphate (46 percent P2O5) was used as the source of phosphorus and muriate of potash (60 percent K2O) 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.
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.

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.
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.

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 plot. This specific fertilizer ratio is not manufactured but 150 pounds of 16-20-0 approaches the treatment and produces an estimated 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

<table>
<thead>
<tr>
<th>Fertilizing rate per acre, pounds</th>
<th>Acre yield of grain, pounds</th>
<th>Value of grain per acre</th>
<th>Cost of fertilizing per acre</th>
<th>Profit or loss due to fertilizing</th>
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<tr>
<td>K₁O</td>
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<td>Calculated*</td>
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</table>

Calculated yields were made from a polynomial that best fitted the data.

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).

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**State-wide Research**

The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of the parts of the A&M College of Texas.

**Organization**

Operating in the Main Station, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

**Operation**

The Texas Station is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

- Conservation and improvement of soil
- Conservation and use of water
- Grasses and legumes
- Grain crops
- Cotton and other fiber crops
- Vegetable crops
- Citrus and other subtropical fruits
- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
- Chickens and turkeys
- Animal diseases and parasites
- Fish and game
- Farm and ranch engineering
- Farm and ranch business
- Marketing agricultural products
- Rural home economics
- Rural agricultural economics
- Plant diseases

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Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service.

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AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHEREs and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.