MP-362 JUNE 1959

A PART OF THE TEXAS A&M COLLEGE SYSTEM

• Fertilizing Grain Sorghum
• in the
• Lower Rio Grande Valley

TEXAS AGRICULTURAL EXPERIMENT STATION

R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

SUMMARY

Data are presented from fertilizer tests conducted by the Lower Rio Grande Valley Experiment Station under both irrigated and dryland conditions. These data indicate that irrigated grain sorghum responds principally to nitrogen fertilization and under some conditions to applications of phosphoric acid. Sixty to 120 pounds of nitrogen generally were sufficient for maximum production. When 180 pounds of nitrogen were applied, significant response also was obtained from 60 pounds per acre of phosphoric acid.

Grain yields were significantly increased by changing row widths from 40 inches to 20 inches. Higher fertility was required for maximum production when the 20-inch row widths were used.

Applications of 60 and 120 pounds per acre of nitrogen resulted in significant increases in protein content of both grain and forage and upon total acre yield of protein. Nitrogen recovery based on the percentage of nitrogen added as fertilizer that was recovered in protein form was 83.2 and 89.6 percent, respectively, when 60 and 120 pounds of nitrogen per acre were applied.

One year's data from a dryland fertilizer test indicate no response from fertilization.

Recommended application practices for the most efficient use of fertilizers are presented.

CONTENTS

Fertilizing Grain Sorghum in the Lower Rio Grande Valley

C. A. Burleson, W. R. Cowley and A. D. Dacus*

GRAIN SORGHUM has been grown in the Lower Rio Grande Valley for many years. At one time its production was primarily a dryland enterprise. In recent years, however, because of cotton acreage allotments and reduced citrus acreage, many farmers in irrigated areas, in need of additional cash crops for surplus acres, have turned to the production of grain sorghum. The development of better varieties, improvement in harvesting and storage facilities and new uses for the grain also have contributed to the expanded grain sorghum production.

Grain sorghum was grown on about 150,000 acres in the Valley in 1954. This acreage produced around 100,000 tons of grain which was less than a ton of grain per acre (13). Such low yields, about average for the Valley, are unprofitable on expensive irrigated land where production costs are inherently high.

In 1955, the Lower Rio Grande Valley Experiment Station initiated research directed toward the development of improved production practices that could be used to increase the per-acre yield of grain sorghum to profitable levels, particularly on irrigated land.

This publication summarizes research on fertilizers and row-spacing conducted during 1955-58 (1,2,3). Also included are some principles and practices of fertilizer usage applicable to grain sorghum production in the Lower Rio Grande Valley.

VALLEY SOILS

The area of Texas designated as the Lower Rio Grande Valley lies in the extreme southern part of Texas and is composed largely of Cameron, Hidalgo, Willacy and Starr counties. The area consists of approximately 1,700,000 acres of alluvial deltaic and marine terraces deposited by the Rio Grande and by local stream action. Some 700,000 acres are irrigated (5).

Soils of the area on which grain sorghum is produced vary considerably as to texture, structure and other morphological characteristics. Sandier soils of the Brennan and Willacy series are located in the northern part of the Valley. These soils respond to management, usually are well to excessively drained internally, and are farmed under both dryland and irrigated conditions.

Medium and fine-textured soils of the Willacy, Raymondville and Hidalgo series are found farther south toward the Rio Grande. These soils are mostly irrigated, and management problems range from few to many as far as drainage conditions are concerned.

Alluvial deposits of the Rio Grande comprise most of the remaining major soil resources. Next to the river on the slightly elevated natural levee are soils such as the Rio Grande, Laredo and Cameron series. Soils on areas lower than the natural levee are finer textured and less well drained. In the first bottom land, the most typical soil is the poorly drained Harlingen clay along with fine-textured soils of the Laredo and Rio Grande series.

The soils have developed under a sub-humid, semi-tropical climate and have retained a high base status, being neutral to calcareous on the surface and calcareous in the subsoil. Such conditions of soil formation in the Valley have produced soils of sandy loam to clay texture; moderately low in organic matter, low in nitrogen, low to high in phosphorus, but high in potassium and calcium.

Table 1 gives an estimate of the fertility status of the principal soils of the grain sorghum-producing areas of the Valley (5). This estimate is based on soil test information of Valley soils from the Soil Testing Laboratory, Texas A. and M. College System, College Station, Texas.

GRAIN SORGHUM FERTILIZER RESEARCH

Methods and Materials

All fertilizer tests reported were conducted in cooperation with farmers or farmer organizations. Research personnel planned the tests, applied the fertilizer materials, took field notes and recorded and evaluated the data. Planting, cultivating, irrigation, insect control and other management practices were carried out by the grower in conjunction with general farming operations of the area.

TABLE 1. FERTILITY STATUS OF SURFACE SOILS OF THE LOWER RIO GRANDE VALLEY

Soil series	Nitrogen	Phosphorus	Potassium	Calcium	Organic matter	Cation exchange capacity, m.e. per 100 gm.
Harlingen Cameron Hidalgo Raymondville	Low to medium	Low medium to high	High	High	Low to low medium	20 to 45
Willacy Brennan	Very low to low	Wide range, very low to high	Medium to high	Low	Very low to low	5 to 25

*Respectively, associate agronomist and superintendent, Lower Rio Grande Valley Experiment Station, Weslaco, Texas; and head, Crops Research Department, Rio Farms, Inc., Monte Alto, Texas.

Fertilizer materials were applied with a tractor-mounted, multiple-cell, belt-type fertilizer distributor similar to the one described by Rea and associates (11).

In trials with conventional row widths (36 to 40 inches), the fertilizer materials were applied in a band 2 to 3 inches below and 3 to 4 inches to the side of the seed zone. In tests where a 20-inch row spacing was used, the fertilizer was banded 2 to 3 inches below the seed zone midway between the rows, or 9 to 10 inches to the side of the seed zone.

In the irrigated tests, all of the phosphoric acid and potash were applied 2 to 3 weeks before planting. Only 60 pounds of nitrogen were applied before planting, with the remaining amount sidedressed at the time the crop was about 18 inches high.

In the dryland test, all of the fertilizer materials were applied in November previous to planting the following March.

The source of nitrogen used in all tests was either ammonium nitrate (33 percent N) or ammonium sulfate (21 percent N). Phosphorus was supplied from superphosphate (45 percent P_2O_5), and potassium was supplied from muriate of potash (60 percent K_2O).

The experimental design in all tests was a complete factorial with four or more replications. Plot size was four to eight rows wide and 50 feet long.

TABLE 2. EFFECTS OF FERTILIZER TREATMENTS ON THE YIELD OF IRRIGATED GRAIN SORGHUM

Fertilizer treatment	Yield in pounds of grain per acre (15% moisture)			
	1955[1]	1956[2]		1958[2]
	20-inch rows	20-inch rows	40-inch rows	20-inch rows
0-0-0	2290	4630	3900	3610
0-0-60	2170	4700	4000	3380
0-60-0	2230	4820	4040	4020
0-60-60	2300	4640	4290	2630
0-120-0	1960	5080	3991	
0-120-60	2230	4920	4440	
60-0-0	4670	5120	4160	3880
60-0-60	4331	5320	4110	4070
60-60-0	4350	5170	4090	4230
60-60-60	4120	5260	4380	4340
60-120-0	4540	5530	4350	
60-120-60	3910	5050	4380	
120-0-0	4960	5400	4270	4100
120-0-60	4870	5780	3990	4240
120-60-0	4830	5320	4160	4280
120-60-60	5041	5510	3940	4240
120-120-0	5350	5560	3840	
120-120-60	4720	5430	4300	
180-0-0				3620
180-60-0				4820
180-0-60				3670
180-60-60				4840
L.S.D.				
0.05	701	489	N.S.[3]	377
0.01	935	652	N.S.	503

[1]Brennan fine sandy loam.
[2]Willacy sandy loam.
[3]Not significant.

The middle two rows of each plot were harvested by hand and threshed with a combine to obtain yield data.

The 1955 irrigated test was on a Brennan fine sandy loam north of Monte Alto, the 1956 and 1958 irrigated tests were on Willacy sandy loam soils near Monte Alto. The dryland test was on a Raymondville sandy loam near Lyford. Redbine-66 grain sorghum was used in all tests.

Results on Irrigated Land

Effects of Fertilization on Yields

Irrigated grain sorghum fertilizer tests reported here were conducted during 1955-58. All but the 1958 data have been previously reported (1, 2, 3). A summary of the effects of different kinds and amounts of fertilizers on the yield of grain is given in Table 2.

In 1955, the fertilizer response was principally from nitrogen. Sixty pounds of nitrogen doubled the yield, an average increase in grain yield from slightly more than 1 ton per acre to more than 2 tons per acre. An additional 60 pounds of nitrogen, making a total of 120 pounds per acre, increased yields to nearly 2.5 tons per acre.

In 1955, there was no significant response to phosphorus and potash, either alone or in combination with nitrogen.

Fertilizer response was evaluated under both 20 and 40-inch row widths during 1956. A lettuce crop was grown on the land immediately preceding the grain sorghum. The lettuce had been grown with a 100-40-0 fertilizer treatment and the crop was plowed into the soil unharvested because of poor market demand.

The grain sorghum on 40-inch row widths did not respond to fertilization. Apparently the residual fertilizer from the previous lettuce crop was sufficient for maximum production with this row width.

Nitrogen significantly influenced the yield of grain, however, where rows 20 inches apart were used. With the plant population doubled, additional fertilizer was needed for maximum yields. Even though average yields were high without nitrogen, the application of 60 and 120 pounds further increased yields (Table 2). No significant response was obtained from phosphorus and potash during 1956.

The relationship between row spacing and nitrogen fertilization on subsequent grain yields is shown in Table 3. Significant yield increases were obtained from changing the row spacing from 40 inches to 20 inches, with the highest yields occurring under the higher fertility treatments.

A 20-inch row spacing was used in 1958 and fertilizer treatments were modified to include up to 180 pounds per acre of nitrogen. As in previous years, yields were increased significantly by nitrogen fertilization. The first 60 pounds

TABLE 3. EFFECT OF ROW SPACING AND NITROGEN ON THE AVERAGE YIELDS OF GRAIN SORGHUM ON A WILLACY LOAM SOIL, 1956

Pounds of nitrogen per acre		20-inch row spacing	40-inch row spacing	Pounds of extra grain from closer spacing
	0	4800	4110	690
	60	5240	4240	1000
	120	5500	4080	1420
L.S.D. for nitrogen	0.05	199	N.S.	
	0.01	265	N.S.	

gave the highest yield increase, with the 120-pound treatment resulting in only slightly higher yields. Apparently at the 120-pound level of nitrogen, phophoric acid was beginning to be a limiting factor in yield response. This became more apparent when the nitrogen treatment was increased to 180 pounds per acre. At this level of nitrogen, yields were actually depressed when phosphoric acid was not included in the fertilizer treatment. When phosphoric acid was used in conjunction with 180 pounds of nitrogen, further significant increases in grain yields were obtained. This yield response and the nitrogen-phosphoric acid interaction are shown in Figure 1.

Effect of Fertilization on Protein Content

Numerous investigations have been made on the effect of soil fertilization on the protein content of grain and forage (4, 6, 8, 10, 12). Most of these investigations have been concerned with the effect of nitrogen fertilization on the protein content of corn grain. In most cases, grain from corn fertilized with nitrogen had a higher percentage of protein than unfertilized corn. It would be expected that grain sorghum would be affected similarly; however, such reports are not nearly as numerous in the literature. Morrison (9) shows the average protein content of hegari and kafir grain to be 9.6 and 10.9 percent, respectively. Data on the protein content of grain and forage from the 1955 fertilizer tests, Table 4, show that grain from the unfertilized plots was considerably below the protein content given by Morrison.

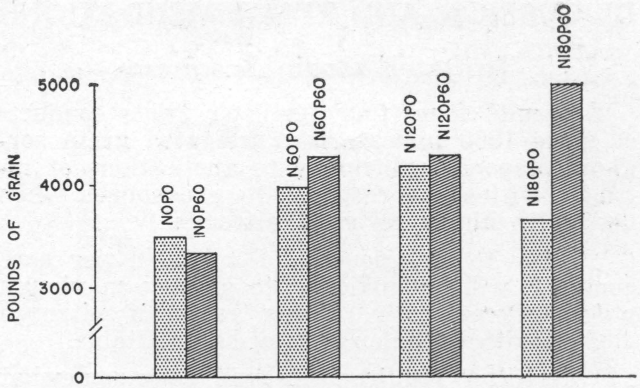

Figure 1. Effect of nitrogen and phosphoric acid on the yield of grain sorghum, 1958.

The average protein content of the grain was increased from 6.58 to 7.92 and 10.30 percent by applications of 60 and 120 pounds of nitrogen, respectively. The protein content of forage also was increased from 2.38 to 3.08 and 4.58 percent, respectively.

Total protein produced per acre in both grain and forage was increased from 236 to 547 and 907 pounds of fertilization with 60 and 120 pounds of nitrogen.

Results on Non-irrigated Land

Results of a dryland fertilizer test conducted in 1956 are shown in Table 5. No yield response from fertilizers was obtained. Apparently the fertility level in the soil was adequate for optimum production under the prevailing moisture conditions. The yields reported are considerably above the average for dryland grain sorghum.

TABLE 4. EFFECT OF NITROGEN FERTILIZATION ON THE CONTENT AND YIELD PER ACRE OF PROTEIN IN FORAGE AND GRAIN OF REDBINE-66, 1955

Nitrogen applied	Grain			Forage				Grain and forage
	Yield, 15% moisture[1]	Protein content		Green weight	Dry	Dry forage protein		Total protein
Pounds per acre	Pounds per acre	Average %	Pounds per acre[2]	Tons per acre	Tons per acre	%	Pounds per acre[2]	Pounds per acre
0	2200	6.58	156	5.62	1.69	2.38	80	236
60	4320	7.92	360	10.04	3.01	3.08	187	547
120	4980	10.30	570	11.68	3.50	4.58	337	907
L.S.D. (0.05)	268		38	0.80	0.24		118	
L.S.D. (0.01)	408		52	1.22	0.36		195	

[1]Grain and forage weights are an average of four replications, as previously reported (1).
[2]Pounds of protein per acre based on the first three replications only.

DISCUSSION AND RECOMMENDATIONS

Irrigated Grain Sorghum

Results from four fertilizer trials conducted since 1955 indicate that irrigated grain sorghum responds principally to applications of nitrogen with some response to phosphorus when used with higher levels of nitrogen.

Sixty to 120 pounds of nitrogen per acre generally will be sufficient to produce maximum yields. Occasionally, higher rates of nitrogen applied with phosphorus may be profitable.

Fertilizer requirements will vary somewhat with previous cropping history and land use practices, and with plant density and row spacing. When 20-inch row widths are used, higher rates of fertilization are essential for maximum production. The reduction of row width alone from 40 to 20 inches resulted in significant yield increases.

In 1955, the application of 60 and 120 pounds of nitrogen per acre increased the protein content of the grain from 6.58 to 7.92 and 10.30 percent, respectively. The protein content of the forage also was increased from 2.38 to 3.08 and 4.58 percent, respectively.

Only 156 pounds of protein per acre were produced without nitrogen; the application of 60 and 120 pounds of nitrogen per acre resulted in yields of 360 and 570 pounds of protein per acre, respectively. Although corn and grain sorghum are sold primarily for their carbohydrate content, farmers and feed processors would need smaller quantities of high-priced protein concentrates if they used grain containing 10 to 11 percent rather than 6 to 7 percent protein.

The yield of protein produced in the forage also was increased from 80 pounds without nitrogen to 187 and 337 pounds per acre from applications of 60 and 120 pounds of nitrogen, respectively.

Nitrogen recovery, based on the percentage of nitrogen added as fertilizer that was recovered in protein form, was 83.2 and 89.6 percent when 60 and 120 pounds of nitrogen, respectively, were applied.

Valley soils generally test very high in potash, and fertilizer test results show that the yields of irrigated grain sorghum are not increased by potash applications.

Soils vary widely within the Lower Rio Grande Valley. Soil samples should be taken from each field with any major differences in soil type, cropping history and land use. With this information, soil scientists, agronomists and other agricultural specialists can make more specific recommendations as to the best fertilizer program to follow for a specified system of farming.

TABLE 5. EFFECT OF FERTILIZER TREATMENT ON THE YIELD OF GRAIN GROWN UNDER DRYLAND CONDITIONS AT LYFORD, 1956

Fertilizer treatment	Pounds of grain per acre	Fertilizer treatment	Pounds of grain per acre
0-0-0	4120	30-30-60	4160
0-0-60	4110	30-60-0	3910
0-30-0	3930	30-60-60	3940
0-30-60	4110	60-0-0	3850
0-60-0	4330	60-0-60	3860
0-60-60	3970	60-30-0	4000
30-0-0	4140	60-30-60	4040
30-0-60	3900	60-60-0	3870
30-30-0	3930	60-60-60	4160

Non-irrigated Grain Sorghum

Data in Table 5 do not indicate any response from the use of fertilizers on grain sorghum grown under dryland conditions. Data from 1 year's results, perhaps, do not warrant specific conclusions; however, cotton grown at another location in the vicinity likewise did not respond to fertilization.

In non-irrigated agriculture, favorable response of crops to fertilization depends largely on soil moisture conditions. Dryland soils of the Lower Rio Grande Valley are relatively young as far as cropping history is concerned. Limited soil moisture supplies apparently have afforded some protection from exploitation of the inherent fertility in such areas. In many cases, fertility reserves are adequate for maximum production under existing soil moisture conditions. In other instances, where soil moisture is adequate, fertilizer applications may be profitable. Generally, 20 to 30 pounds of nitrogen per acre per application will be sufficient. If moisture conditions continue to be favorable, further light applications may be beneficial. Even with soil test information and crop and land use history, the grower should be guided by soil moisture conditions in determining the amount of fertilizers to apply.

FERTILIZER APPLICATION PRACTICES

Maximum benefit from the application of fertilizers to grain sorghum is possible only when good, sound methods of fertilizer application are practiced. Some of the recommendations of the National Joint Committee on Fertilizer Application (7) concerning methods of applying fertilizer to grain sorghum follow.

Solid and Non-pressure Liquids

Fertilizer usually should be applied in bands to the side and below the seed at planting time. If equipment is not available for simultaneous planting and fertilization, preplant fertilizers may be banded in the bed before planting. Planting should not be done directly over the fertilizer band since such practice may inhibit germination or cause injury to small seedlings. Banding of fertilizer materials approximately 3 inches to the side of the seed and 2 to 3 inches below the seed level is considered good placement.

Broadcast applications of dry fertilizer, or full-coverage injection of solutions or fertilizer applied in irrigation water, usually are less effective than banded or sidedressed fertilizer.

Sidedressed fertilizer should be applied far enough to the side of the row to prevent serious mechanical injury to the roots. The distance away from the plant and the depth in the soil will be governed by the stage of growth.

Split applications of nitrogen often are desirable where leaching may be a problem, with part applied before planting and the remainder applied in one or more sidedressed treatments early in the season.

Soluble fertilizer materials may be applied in irrigation water when it is impractical to apply them by other methods. Fertilizers applied in water usually are only partially as effective to the immediate crop as materials applied by direct soil application. Certain conditions, however, warrant the application of fertilizer materials in irrigation water.

Pressure Liquids

Experience has shown that it may be hazardous to plant seed directly over recent applications of anhydrous ammonia injected 6 to 8 inches deep. The opening made by the injector blade should be covered properly and sealed to prevent upward movement of free ammonia. Applications which allow diffusion of ammonia into the seed row or root zone of seedling plants may be injurious. Danger of injury may increase in dry soils where high rates of ammonia are used. Damage of this nature can be avoided best by applying the ammonia 6 to 8 inches to the side and below the level of the seed.

Aqua and anhydrous ammonia behave similarly when applied to the soil; therefore, similar equipment and methods may be used in their application.

Sidedressed applications of ammonia materials should be applied 6 to 8 inches deep and 6 to 10 inches to the side of the plants, depending on the extent of the root system. When crops are sidedressed, escaping ammonia may burn the leaves of plants. This damage usually is outgrown in a short time, but the escaped ammonia is lost.

As with other fertilizer materials, anhydrous and aqua ammonia applied in irrigation water generally are only partially as effective as when applied directly into the soil.

ACKNOWLEDGMENTS

The authors acknowledge the cooperation of the following persons in furnishing land, labor and other production facilities: Sam Tayloe, general manager; Rio Farms, Inc., Monte Alto, Texas; and Bruce Gilbert, farmer, Lyford, Texas.

Nitrogen determinations from which protein percentages were calculated were made by the State Chemist, College Station, Texas.

Acknowledgment also is given the county agricultural agents of Hidalgo and Willacy counties for their help in locating cooperators.

LITERATURE CITED

(1) Burleson, C. A., Cowley, W. R., Hubbard, J. L. and Otey, G. Grain sorghum fertilizer trial, Lower Rio Grande Valley, 1955. Tex. Agr. Exp. Sta. P. R. 1823, 1955.

(2) Burleson, C. A., Cowley, W. R. and Otey, G. Grain sorghum fertilizer trials, Lower Rio Grande Valley, 1956. Tex. Agr. Exp. Sta. P. R. 1915, 1956.

(3) Burleson, C. A., Cowley, W. R. and Otey, G. Effect of nitrogen fertilization on yield and protein content of grain sorghum in the Lower Rio Grande Valley of Texas. Agron. Jour. Vol. 48:1956.

(4) Genter, C. F., Eheart, J. F., Linkous, W. N. Effects of location, hybrid, fertilizer and rate of planting on the oil and protein contents of corn grain. Agron. Jour. 48: 63-67. 1956.

(5) Godfrey, C. L. et al. Irrigation potential of selected areas in Texas. Prepared for U. S. Department of Interior, Bureau of Reclamation by personnel of Project 138 of the Texas A & M Research Foundation, 1957.

(6) Harshbarger, K. E., Nevens, W. B., Lounchberry, R. W., Lang, A. L., and Dugan, G. H. Yield and composition of corn forage as influenced by soil fertilization. Illinois Agr. Exp. Sta. Bul. 577, 1954.

(7) Hulburt, W. C. *et. al.* Methods of applying fertilizer. Recommendations of the National Joint Committee on Fertilizer Application. Copyright 1958, National Plant Food Institute.

(8) Krantz, B. A. Fertilize corn for higher yields. North Carolina Agr. Exp. Sta. Bul. 366, 1949.

(9) Morrison, F. B. Feeds and Feeding. The Morrison Publishing Co., Ithaca, N. Y., P. 1120, 1948.

(10) Peterson, H. B. Effect of nitrogen fertilizer on yield and protein content of winter wheat in Utah. Utah Agr. Exp. Sta. 1952.

(11) Rea, H. E., Hulburt, W. C. and Adams, J. E. A multiple-cell, belt type distributor for use with tractor implements in fertilizer tests with field crops. Proc. Soil Science of Amer. Vol. 14, 1949.

(12) Snider, H. J., Chemical composition of hay and forage crops as affected by various soil treatments. Illinois Agr. Exp. Sta. Bul. 518, 1946.

(13) Texas Almanac, 1956-57, Published by *The Dallas Morning News,* Dallas, Texas.

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

State-wide Research

★

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

ORGANIZATION

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

Plant diseases

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

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

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.

Today's Research Is Tomorrow's Progress