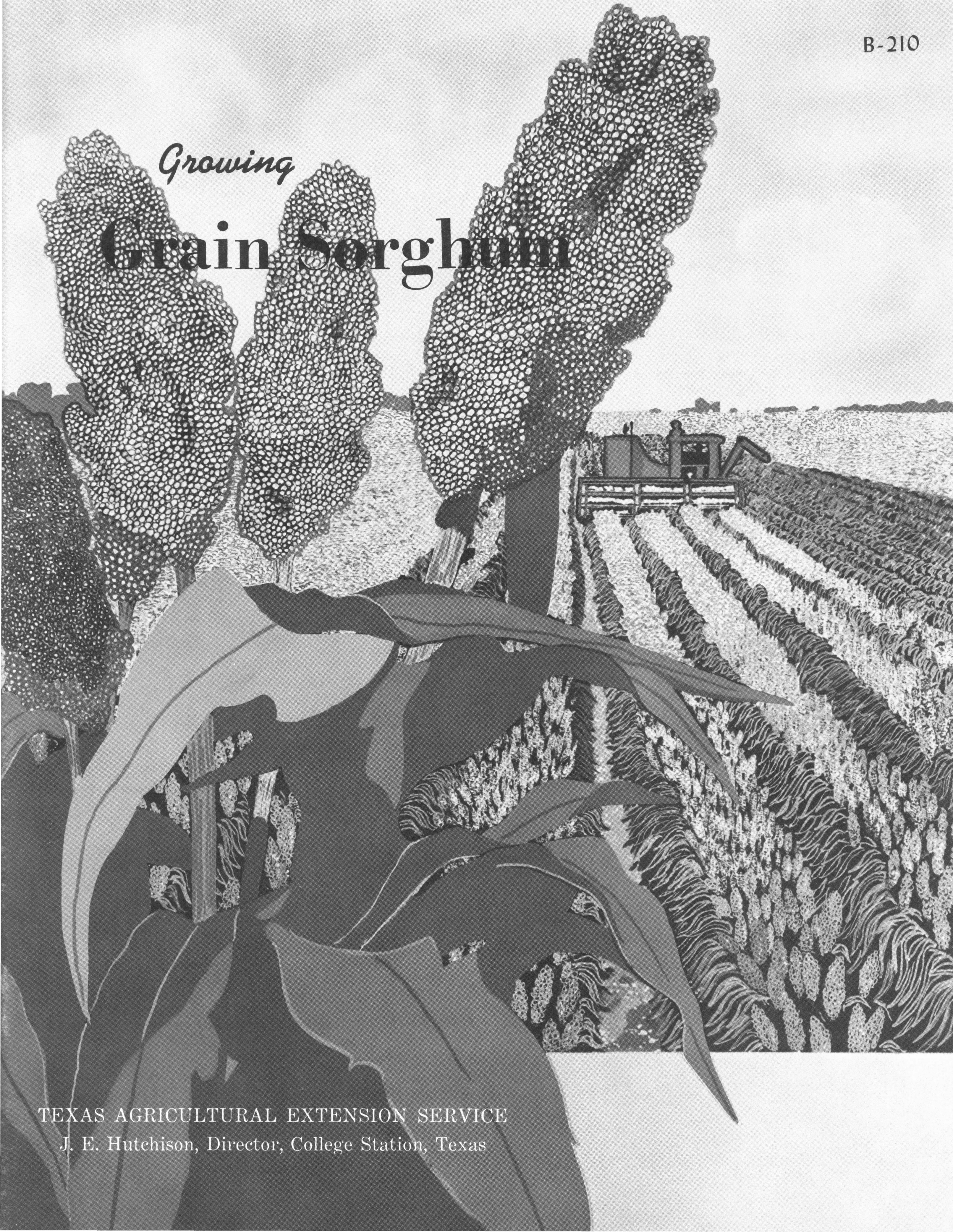
B-210

Growing Grain Sorghum



TEXAS AGRICULTURAL EXTENSION SERVICE

J. E. Hutchison, Director, College Station, Texas

CONTENTS

APPRECIATION

The authors are indebted to the following personnel of the Texas Agricultural Experiment Station for their contribution to the manuscrpit for this publication: J. R. Quinby, N. W. Kramer, J. C. Stephens, K. A. Lahr, R. E. Karper, Norris P. Swanson, E. L. Thaxton, Jr., Clarence A. Moore, Howard S. Whitney and R. J. Hildreth.

Helpful suggestions were made by the following: Earl C. Gilmore, Jr., Jessie W. Collier, Jack G. King, Jack J. Bond, Allen F. Wiese, M. E. Jensen, Kenneth B. Porter, Wayne C. Hall, Homer E. Rea, William O. Trogdon.

Growing Grain Sorghum

BEN R. SPEARS LEE C. COFFEY
Extension Agronomists
The Texas A. & M. College System

THERE ARE MANY TYPES of the sorghum species, including those grown for grain, forage, broomcorn and sirup. Prior to 1942, more sorghum acreage was harvested for forage than grain, but in 1941 grain production began to increase rapidly and since then the picture has reversed. The demand for grain during World War II, the development of small combines and the breeding of adapted varieties more ideally suited for combine harvesting were the main factors influencing this acreage expansion. Earlier maturing varieties spread sorghum north and into drier areas. In 1956, seed of grain sorghum hybrids became available and this encouraged further expansion.

In 1958, more acres of grain sorghum were harvested (7,692,000) than any other crop in Texas and it was second only to cotton in cash value. Although the general acreage trend has been up, wide fluctuations have occurred because of acreage controls and unfavorable weather on cotton and wheat. Since sorghum grain compares favorably with corn as a feed grain, its production for this purpose has been encouraged. Nearly three-fifths of the Texas sorghum grain production in 1958 was on the High Plains, of which approximately 70 percent was produced on irrigated land. Other concentrations of acreages are in the Coastal Bend, Rolling Plains, Blackland Prairies and Rio Grande Plain.

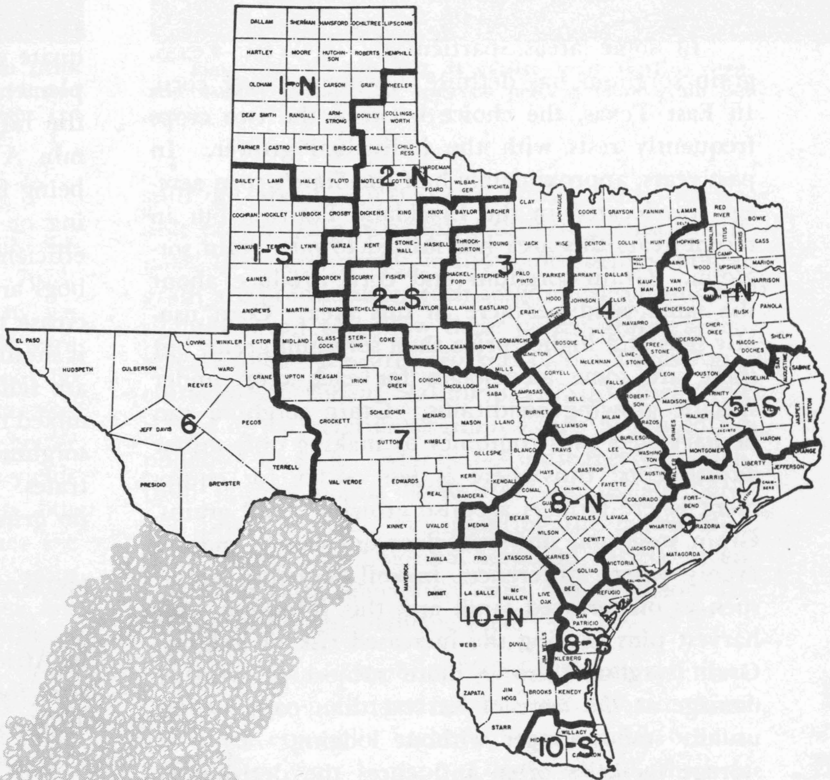


Figure 1. Crop Reporting Districts, Agricultural Marketing Service, United States Department of Agriculture.

District	Grain sorghum acreage harvested in 1958
1-N	1,949,000
1-S	2,055,000
2-N	395,000
2-S	485,000
3	75,000
4	700,000
5-N	30,000
5-S	42,000
6	10,000
7	180,000
8-N	570,000
8-S	460,000
9	270,000
10-N	236,000
10-S	235,000
State	7,692,000

Where It Grows

Grain sorghum grows on all types of soil suitable for cultivation. It is most productive on deep, well-drained soils that are well supplied with plant nutrients and moisture. Sorghum usually is damaged less than corn by hot dry weather, which makes it better suited as a summer grain crop for many areas of Texas. Excessive temperatures, however, will reduce the yield especially if they occur during blooming and seed development.

In some areas, particularly in West Texas, grain sorghum has definite advantages over corn. In East Texas, the choice between the two crops frequently rests with the individual grower. In past years, approximately half the State's corn acreage was located in the Blackland Prairies, but in recent years this area has shifted toward grain sorghum. Grain sorghum and corn produce about the same yield per acre in this area. Corn usually sells at a higher price than sorghum grain, but there are some advantages for each crop under specific growing conditions. Grain sorghum can be harvested with combines by making only minor adjustments; thus there is less outlay for equipment where farmers are also growing small grains. Grain sorghum, however, does not always mature evenly where differences in soil moisture occur, such as on terraced land, and this interferes with harvest plus causing the increased risk of lodging. Grain sorghum also is more subject to weather damage at the time of harvest than corn. Corn usually stands longer without lodging. Type of storage facilities often influences the decision as to which crop to plant. Grain sorghum grows well in the extreme eastern part of Texas, but disease, insect and bird damage, plus difficulty in drying the grain usually makes corn a more satisfactory crop for that area.

Use

Sorghum grain is used primarily for feeding livestock. Its potential use as human food and in industry may expand greatly in the future.

FEEDING LIVESTOCK

Sorghum grain is an excellent feed for livestock and poultry. It contains slightly more protein and slightly less fat than corn. Grain of current sorghum varieties and hybrids contains neither vitamin A nor xanthophyll although yellow endosperm varieties eventually may be produced that will approach yellow corn in this respect.

Research studies in Texas and other states on the value of sorghum grain and corn in rations for cattle and hogs show that the two are essentially equal in food value, and sorghum grain usually is cheaper than corn. Rations for hogs not on pasture and poultry should be supplemented with vitamin A. In broiler rations, xanthophyll supplements are necessary. Cattle being fed sorghum grain in their rations and also having access to adequate green grazing will not need vitamin A supplements. Where sorghum grain is included in the ration for drylot cattle, they may need vitamin A supplement, depending upon other feeds being fed and age of the cattle. Grinding, cracking or rolling is necessary for maximum feeding efficiency of sorghum grain in cattle rations. When hogs are self-fed free choice, grinding does not increase the feeding efficiency of sorghum grain but it should be ground when completely mixed rations are self-fed or hand feeding is done. Completely mixed rations usually are fed to poultry and ground sorghum grain should be mixed with other concentrates. Sheep use the whole grain efficiently and no grinding is necessary.

HUMAN FOOD AND INDUSTRIAL USES

Sorghum grain, although a major food source in Africa and Asia, presently is of minor importance for human food in the United States. Many different types of sorghum can be developed that have characteristics especially suited for specific uses. During World War II, a dessert similar to tapioca was manufactured from a waxy type of sorghum starch. During this same period, it was an important source of grain alcohol and limited processing has continued. The starch of sorghum grain is similar to that of corn and can be used for food products, adhesives and sizing for paper and fabrics. A wax contained in the seed coat of sorghum is satisfactory for making furniture and shoe polish, carbon paper, sealing wax, electrical insulation and other products.

Sorghum grain milling is of two types. A sorghum grain wet-milling plant at Corpus Christi manufactures starch, dextrins, dextrose, dextrose sirup, edible oil, several byproducts and livestock feed. Dry milling plants produce livestock feed and low-protein flour which can be substituted for starch in some uses.

Figure 2. Sorghum hybrid seed are produced in fields which usually are planted in a sequence of 8 or 12 seed rows (the white heads) and four pollinator rows (the red heads).

Figure 3. RS 610, left, is earlier than Martin, right, and usually produces at least 30 percent more grain per acre.

Hybrids and Varieties

Sorghum hybrids soon may replace largely the old varieties such as Martin and Combine 7078; therefore no detailed description of the many varieties is given here. Certified seed of hybrids were first available in quantities in 1957, and about 50 percent of the grain sorghum acreage in Texas was planted to hybrids in 1958. Most of the better hybrids will produce 20 to 40 percent greater yields than varieties except at very high yield levels, but in other characteristics the hybrids sometimes are not as desirable as Martin. Most hybrids are more susceptible to lodging than Martin and they are not as easy to combine. In addition, there often are more off-type plants in hybrids which cause farmers problems during harvesting. However, it costs little per acre for a farmer to rogue out these off-type plants. As seed growers gain experience in the production of hybrids, the number of off-type plants in farmers' fields should decrease. Despite the needed improvements, hybrids should replace most varieties because of increases in yield.

Methods for the practical production of grain sorghum hybrids became possible following the discovery of a desirable type of male-sterility in sorghum. Sorghum normally is self-fertilized and has perfect flowers that contain both male and female parts. The female parts of each flower consist of an ovary which later develops into a seed and some feathery projections called stigmas that fluff out when the flower opens during blooming. The male parts called anthers, are small yellow tubes which may be noticed hanging by thread-like structures from the flowers following blooming. The three anthers hanging from each flower split open at the end during blooming and these anthers will spill out about 15,000 pollen grain. Only one viable pollen grain is required to fertilize the female part, therefore, many millions of surplus pollen grain are produced on each sorghum head and the slightest wind will blow these pollen grains acress several rows. Research workers of the Texas Agricultural Experiment Station and USDA discovered a type of male-sterile sorghum which produced no pollen of its own. The plants must receive pollen from normal plants to fertilize the female parts and produce seed. By planting the male-sterile plants along side a normal sorghum variety in an isolated area, a controlled cross can be made, resulting in hybrid planting seed.

Martin and Combine 7078 have been the most popular open-pollinated varieties in the State. Martin is not especially high-yielding, but has been a favorite for years because of its dry head which is easily threshed, its high test weight, fair resistance to lodging and diseases and its consistent performance. Combine 7078 is planted in the more drouthy areas where its yield is outstanding compared with other varieties. However, it does not stand very well, is difficult to combine and is especially susceptible to head smut. Limited acreage is planted to Caprock, Plainsman, Redbine-66 and other late varieties. These late varieties generally are planted under irrigation where exceptional high yields are expected.

RS 610 is the most widely grown hybrid in Texas and other sorghum areas. Considerably more certified seed of this hybrid were produced in Texas in 1958 than all other Texas hybrids combined. RS 610 produces high yields when compared with other hybrids under all growing conditions, especially when temperatures are high. It also blooms earlier than Martin and most farmers prefer an early maturing variety of any crop. On the other hand, RS 610 has a number of undesirable characteristics. It does not stand especially well, is not as easy to combine as Martin and it is very susceptible to head smut. However, its exceptionally high yield and early maturity may continue to make it popular.

Texas 660 does best in comparison with other hybrids where yields above 3,000 pounds per acre are expected. This hybrid is especially high yielding under irrigation on the High Plains when yields of 5,000 pounds or more per acre are expected. It ordinarily matures a few days later than Martin, combines fairly well and has average resistance to lodging and head smut.

RS 608 is a new hybrid which has a fair yield record. It does not yield as much as 610 under most conditions, but its harvesting characteristics appear more satisfactory. It seems to have some of the characteristics of Martin, which is one of the parent hybrids. RS 608 is very susceptible to head smut and it may not yield as well on the High Plains under favorable moisture conditions as other hybrids.

Texas 601 has been planted on a smaller acreage than the other Texas hybrids mentioned previously, but it yields satisfactorily under most conditions and is similar to RS 608 in harvesting characteristics. It apparently is similar to Texas 660 in head smut susceptibility.

Figure 4. Texas 620, left, like most hybrids, is taller than Martin. Hybrids usually have heavier heads and lodging occasionally is a problem.

Texas 620 is a high-yielding hybrid under conditions whereby yields of 5,000 pounds or more per acre are expected. It is taller than most hybrids and it is very susceptible to lodging under drouthy conditions, especially on the Blackland Prairies and the Gulf Coast.

RS 630 resembles RS 610 in the fact that it is one of the higher yielding hybrids under a wide range of growing conditions. Its harvesting characteristics generally are satisfactory, but it has a white grain and may have limited use for this reason. It also is rather difficult for seedsmen to produce, but it is immune to head smut.

RS 650 is a high-yielding hybrid under conditions where 5,000 pounds or more per acre may be expected. Under low-yielding conditions, it frequently yields less than Texas 660 and has about the same maturity. It often has poor head exertion under low-yielding conditions and therefore, is more difficult to harvest.

RS 590 and *Texas 611* have not been popular because they do not give as large yield increases over varieties as the other hybrids. Both hybrids usually harvest satisfactorily. Texas 611 possibly is more resistant to lodging than the other hybrids, but the plants frequently are uneven at maturity.

The *DeKalb hybrids,* E 56a, F 62a and C 44a, yield well and harvest satisfactorily. Although these hybrids have loose, spreading heads, this characteristic does not seem to cause the heads to dry more quickly than other hybrids. However, some farmers believe that the heads have less worm damage and mold, but no research information on this is available. At present, E 56a, appears to be the most widely adapted of these hybrids; however, it is almost as susceptible to head smut as RS 610 and RS 608.

The *Amak hybrids,* R-10 and R-12, have produced satisfactory yields in most areas of the State. R-10 has satisfactory harvesting characteristics. R-12 does not have as desirable harvesting characteristics as R-10, but it does have a greater yield potential under irrigation. Both hybrids are very susceptible to head smut.

Other hybrids have been put on the market recently by commercial seed companies, but most of them have not been tested extensively by the Texas Agricultural Experiment Station. Commercial companies are expected to have many other hybrids in the near future.

Figure 5. The seedbed for sorghum in any area is prepared in about the same manner as for other row crops.

Land Preparation and Planting

Methods of land preparation and planting vary widely in the State, depending largely on soil and climate and the equipment available. In general, land preparation is similar to that for cotton and corn in the same area. The grower should prepare the land as early as possible following harvest of the previous crop to allow time for storage of moisture from rainfall or irrigation and for the soil to settle and become firm before planting. Where wind erosion is a problem, seedbed preparation should be delayed to avoid losses in critical periods. Once the seedbed is prepared, the land should be kept free of weeds. Regardless of the weed control method followed, the seedbed should be disturbed as little as possible to conserve moisture and leave it firm.

Sorghum seed should be planted just deep enough to prevent drying out before the plants emerge. The ideal depth is approximately 2 inches. Seed must be in contact with moist soil. Firming the soil often helps to conserve moisture and insure better stands, but the soil should not be compacted since crusting may interfere with emergence. Careful regulation of planters for planting depth and rates is an important step toward successful production.

Fertilization

Grain sorghum uses large amounts of phosphorus, potassium and especially nitrogen where high yields are produced. The amount of these nutrient elements contained in plants yielding 5,600 pounds of grain per acre is shown in Table 1. This table shows that the return of the stubble to land furnishes large amounts of organic matter for soil improvement and conserves nutrient resources.

In some sorghum-growing areas of Texas, soil fertility is high enough to produce maximum yields without adding commercial fertilizers. However, many soils are deficient in one or more of the major elements and fertilizer is required for profitable production. Fertilizer usually is required for maximum returns on irrigated sorghum.

The grade and amount of fertilizer to use should depend on each farm situation, since it will vary with soils and cropping history. A soil test before planting, with expected moisture conditions considered, is the best way to determine fertilizer needs. Leaflets giving general fertilizer recommendations for the various soil areas are available from your county agricultural agent.

Sorghum often is described as "hard on the land," and a reduction in yield of the following crop sometimes is noticed. Some of this reduced yield, especially on dryland, is due to sorghum using more of the soil moisture than other crops, thereby leaving less moisture for carryover to the next crop. Most of the reduced yield on the following crop, however, is due to large amounts of high-carbon stubble residue left on the land. Bacteria, in decomposing this stubble, use large amounts of nitrogen. As a result, large amounts of nitrogen become unavailable to plants until decomposition is completed.

Nitrogen deficiencies can be avoided and the effect of organic matter on soil structure can be improved by adding nitrogen fertilizer to the stubble. On irrigated land, approximately 30 to 60 pounds of actual nitrogen should be added when the stalks are destroyed and plowed under. On dryland where yields of 2,500 pounds of grain or more per acre are produced, approximately 20 to 30 pounds of actual nitrogen are adequate. Under dryland conditions where lack of moisture limits yields and slows decomposition of stubble, the ad-

TABLE 1. Fertilizer Elements in Different Plant Parts of Grain Sorghum at High Yield Levels.

Plant part	Yield	N	P_2O_5	K_2O
			Pounds	
Grain	5,600	100	32	17
Leaves	1,770	15	5	9
Stems	4,980	10	4	14
Roots	2,920	9	10	5
Total above ground	12,350	125	41	40

Figure 6. The difference between the rows fertilized with nitrogen and unfertilized rows is visible in this field. Soil tests are the best basis for determining fertilizer needs.

dition of nitrogen is questionable. Higher rates of nitrogen than those indicated are not recommended because they sometimes cause too rapid decomposition and result in poorer soil structure. The nitrogen deficiency caused by sorghum stubble can be reduced further by plowing the stubble under as soon after harvest as possible, especially if the stalks are green. These practices allow more time to replenish soil moisture and to decompose the stubble.

Severe chlorosis or "yellowing" of sorghum, commonly caused by iron deficiency, occurs on soils on the Rio Grande Plain and to some extent on soils on the High and Rolling Plains. Iron is unavailable to sorghum in these areas apparently because of high calcium content in the soil or calcium layers near the soil surface. In the Rio Grande Plain, scattered chlorotic spots in a field may vary from short strips in a row to an area several rows wide and about 30 feet long. All plants in this area may not be affected. The larger more severely affected areas are often called "hot spots" where in some years the sorghum seedlings turn white and die. In other spots, the sorghum plants turn yellow and produce little or no grain. On the Rio Grande Plain, a spray program with 2.5 percent copperas controlled the sorghum chlorosis and resulted in good grain production. This practice may not be profitable unless soil moisture is abundant. The extent of "hot spots" in previous years also should be considered in determining whether the spraying program will be profitable. The first spray should be applied before the plants are 10 days old and a second spray 14 days later. These sprays should be applied over the entire field since it is impossible to predetermine where chlorotic spots will develop soon enough to avoid stunting of young plants. One or two additional sprayings generally are needed for chlorosis control and good grain production. Later sprays should be applied only where yellow-streaked plants develop. The yellowing usually develops within 14 to 35 days after the second spraying.

The 2.5 percent copperas solution can be made by adding 10 pounds of copperas plus 1 level teaspoon of powdered wetting agent to 50 gallons of water. Stronger solutions burn sorghum plants. Approximately 20 gallons of spray per acre should be applied on each of the first two sprayings.

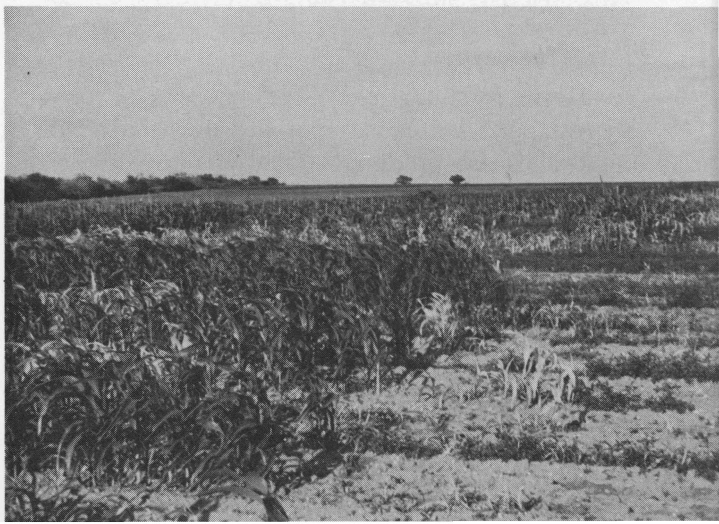
On the clay loam soils of the Rio Grande Plain, soil treatments, with the exception of very high rates of copperas, have been ineffective in preventing iron chlorosis of sorghum. On lighter soils, such treatments may be effective and practical, but these measures should be followed only on a trial basis until procedures can be developed by research.

Date of Planting

A wide range in planting dates is possible since grain sorghum varieties mature in 90 to 130 days from planting. The average frost-free period in extreme northern High Plains is 175 days and may extend to 275 days or more in South Texas. However, parts of the frost-free period are more favorable for growth than others.

The most desirable planting time for grain sorghum in much of Texas is after the last average frost date and when the seedbed is warm and soil moisture is adequate for good germination and fast seedling growth. Although planting may begin by May 15 on the High Plains, plantings made

Figure 7. Iron chlorosis, often called "hot spots," frequently occurs on the Rio Grande Plain and occasionally in other areas. It can be controlled with copperas sprays.



from June 10 to June 25 mature faster, require less water and produce higher yields.

Some factors to be considered in selecting a planting date:

(1) The soil temperature at seed depth should be at least 55 degrees F. Seedlings often turn red or purple, become weak and sometimes die in cool temperatures especially if the soil is too wet or too dry.

(2) The most favorable average daily temperature for sorghum growth is about 80 degrees F. Temperatures above 95 degrees F. reduce yields, but much higher temperatures are tolerated by sorghum if soil moisture is ample. If it is not possible to plant early enough for the sorghum to bloom and set seed before the usual hot, dry period of the summer, it may be advisable to delay planting so that blooming will come after this period. However, late plantings are more likely to be severely damaged by sorghum midge and sorghum webworm insects, especially in the southern half of the State.

(3) The grain drys slowly with high soil moisture, high humidity and cool temperatures. Delayed harvesting increases the risk of loss from lodging and weathered grain. It will be desirable to plant early enough to avoid maturing the crop when these conditions are likely to occur.

(4) A few varieties are sensitive to length of day. Combine Hegari is a late-maturing variety when planted during May and June, but it matures early if planted in March or late summer when the days are shorter. The present hybrids are not influenced materially by day length.

Figure 8. The good stand on the right resulted from use of treated seed. Most seedsmen now treat planting seed with an insecticide as well as a fungicide.

Figure 9. In highly productive irrigated fields, grain sorghum in narrow rows (20 inches or less) frequently produces higher yields than in conventional row widths.

Seed Treatment

Treating sorghum seed with a fungicide and insecticide prior to planting often helps to avoid stand losses resulting from diseases and insects. Covered and loose kernel smut infection also is prevented by the fungicides. Most sorghum seed are now treated with one or both of these materials by the seedsmen or processors before sale to farmers. Tags on the planting seed bags should show what types of material have been used in treating the seed. If the seed have not been treated, the added cost of treating is small. Some effective fungicides are Arasan, Captan, Ceresan and Panogen. Some insecticides are Dieldrin and Heptachlor. Use only the proper amounts of insecticides or fungicides. An overdose may damage germination and seedling growth. Follow the recommendations of the manufacturer in applying the seed treatment. Mercury compounds such as Ceresan and Panogen are effective as fungicides, but an excessive amount of either is especially hazardous.

Row Spacing

The row width used depends on the type of equipment available. Most grain sorghum is planted in 36 to 42-inch rows with cotton and corn equipment. This equipment also can be adapted for narrower rows. Some acreage on the High Plains is planted with grain drills.

Experiment Station tests show that fully irrigated grain sorghum planted in narrow rows of 20 inches or less usually yields more than that planted in 40-inch rows. In dryland and moderately irrigated sorghum, narrow row plantings may not equal yields from conventional row widths.

Aside from yield, other advantages and some disadvantages should be considered in adopting narrow rows. Narrow rows give better distribution of stubble ground cover and control of wind erosion. Narrow rows ordinarily control most annual weeds by shading earlier than wide rows. Control of early and perennial weeds, such as Johnsongrass, may be a greater problem in narrow rows since conventional row cultivation is more difficult. Tillage equipment is available, however, so that the land can be cultivated with one sweep between each narrow row. Lodged sorghum sometimes can be salvaged with pickup attachments on the combine, but available row-type "pick-up" attachments will not handle rows narrower than 26 inches. Distribution of irrigation water may be more difficult in narrow rows. Under some conditions, standard 40-inch row planters can be used to plant narrow rows by making a second trip over the field, planting halfway between the original rows. In using this method, avoid running the tractor wheels on the planted rows or poor stands may result.

If narrow rows are used, avoid as many weeds as possible until the sorghum is well established for effective shading. Seedbed preparation should begin early to kill as many weed crops as possible before planting. Planting should be delayed until the seedbed is thoroughly warm to allow the sorghum to grow off rapidly ahead of weeds. Farmers who use narrow rows should be equipped with rotary hoes for eliminating weeds until the grain sorghum is about 12 inches tall. Herbicides, discussed in another section, also can be used to help control broad-leaved weeds.

Seeding rates in narrow rows should be no higher per acre than recommended for conventional widths. Slightly lower rates probably should be used since more seedlings tend to survive in narrow rows at the same seeding rate. This occurs because the seed are not dropped as thick in the drill row. If the seedbed is such that proper planting cannot be done in narrow rows, more seed must be used to obtain adequate stands.

In some areas, the seed are planted in two rows, regular width, and one or two rows are skipped. The purpose is to distribute the available moisture among fewer plants and amounts to a reduction of planting rate. In dry seasons, this method has some advantages over planting every row since a fair crop may be produced where the thicker planting might fail. On an average of several years, however, yields are somewhat less than if every row is planted.

Planting Rates

The level of soil fertility and expected seasonal soil moisture determines the rate of planting grain sorghum. The more nearly ideal the growing conditions, the thicker the stand should be. The number of pounds of seed per acre required to obtain a desired stand depends on the variety planted because of differences in seed sizes and planting conditions. About 55 to 65 percent of the planted seed will produce seedlings; therefore, seed must be dropped closer than the desired stand.

Two to 8 pounds of seed per acre are required, depending upon growing conditions. A planting rate of 3 pounds or less is sufficient where 2,000 pounds or less of grain are expected per acre, and 8 pounds or slightly more per acre are adequate when exceptionally good soil moisture is assured.

A rule of thumb is to plant 1 pound of seed for each 700 pounds of expected yield. Using this method, 5 pounds of seed per acre would be planted where a yield of about 3,500 pounds generally is produced. This method applies whether 40 or 20-inch widths are used, but slightly lower rates should be used with narrow rows. Seeding rates should be estimated carefully since proper stands of sorghum yield better and lodge less.

Recommended seeding rates are based on average-sized seed. Since seed vary in size, a check on the planters in the turning row is time well spent. More pounds of large seed are required than of small seed to obtain the same stands. Table 2 shows the distance between seed in the drill for different seeding rates of average-size seed. A desired stand can be established regardless of seed size, if the estimated seeding rate fits the expected growing conditions and the seed are dropped at the right intervals.

TABLE 2. The Approximate Spacing Between Average-size Seed in the Drill Rows at Various Planting Rates

Desired seeding rate Lb. per acre	Approximate space between seed in drill row 40-inch rows	20-inch rows
2	4	8
4	2	4
6	1¼	2½
8	1	2
10	¾	1½
12	⅔	1¼

Weed Control

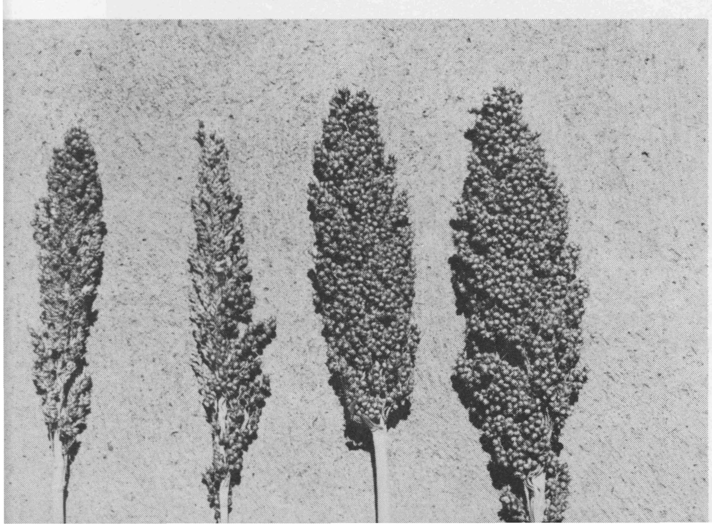
Mechanical methods are preferred for controlling weeds in grain sorghum. Cultivation should be shallow to avoid damaging the roots and only often enough to control weeds. Rotary hoeing shortly after weeds emerge is a cheap and effective method.

The use of 2,4-D for weed control is recommended *only* when weeds cannot be controlled through cultivation. Sorghum is most tolerant to 2,4-D when 6 to 12 inches tall. Severe injuries may occur from treatments applied to sorghum when the plants are less than 3 inches high and also during the advanced stages of growth, particularly in the bloom stage. The sorghum root system sometimes does not develop properly when plants are sprayed with 2,4-D and more lodging may occur.

The best control of annual weeds such as goathead, carelessweed or pigweed and Russianthistle in tests at the Southwestern Great Plains Field Station was with ester forms of 2,4-D. The amine form also has given good control and it does not have the vapor hazard of the ester forms. Rates of not more than ½ pound of acid equivalent (1 pint of 4 pounds per gallon of material) per acre should be used. Silvex ester at this rate in 50 gallons of water per acre was effective in controlling carelessweeds as high as 6 to 10 inches in corn at College Station, but in 1954 at Amarillo this material was less effective than 2,4-D ester on grain sorghum.

Use of 2,4-D-type herbicides near susceptible crops such as cotton is hazardous and volatile esters should never be used if cotton is grown in the area. Moderate temperatures ranging from 70 to 85 degrees F. are favorable for spraying with most herbicides. Below 70 degrees F., weed kill is less and above 85 degrees F. there is more possibility of damaging susceptible crops from vapors. Even the low volatile esters release considerable vapors at temperatures above 95 degrees F. All precautions should be taken to avoid damage from spray drift.

Figure 10. Two sorghum heads treated with 1 pound of 2,4-D at the flowering stage, left, compared with two untreated heads, right.



A directed spray can be used for less likelihood of spray drift, and less damage to the sorghum. The spray should be directed below the terminal leaf roll of sorghum but must cover the weed terminals; therefore, the sorghum should be several inches taller than the weeds. Sprayers should be operated at low pressure and equipped with nozzles to deliver a coarse spray. Spraying should be stopped when wind is blowing over 5 miles per hour. Before using herbicides, study a copy of the State herbicide law, available from the Commissioner of Agriculture, Austin, Texas. Regulations are not the same for all sections of Texas. One should be thoroughly familiar with the restrictions in his area and use 2,4-D materials accordingly.

Irrigation

To make the most profit per inch of water applied, the grain sorghum grower should know his soil and the water requirement of the crop. Grain sorghum produces high yields and more grain per acre-inch of water when an adequate supply of soil moisture is maintained throughout the growing season. In most areas, rainfall is not dependable through the entire growing season and irrigation to maintain the proper level of moisture is profitable. A fertile soil also is essential for irrigation to be profitable. The soil should be in good physical condition so as to take up water quickly, have good air circulation, drain properly and have the capacity to absorb and store larger amounts of water. Soil management practices that return as much organic matter to the soil as possible will help maintain and improve soil structure.

PLANT WATER USE

The total water requirement of grain sorghum for maximum yield varies from 16 to 24 inches a year, depending upon the season. The amount of water used by the plant and evaporated from the soil is higher in hot, dry, windy periods than in relatively cool, humid and calm weather. Water conservation is important not only to

Figure 11. Numerous demonstrations are conducted by farmers each year in cooperation with county program building committees and county agricultural agents. Here, the production of several hybrids is being checked.

reduce annual water costs, but also to avoid rapid depletion of the water supply. To prevent runoff and deep percolation of irrigation water, install a properly designed irrigation system and practice careful handling of the water. Some losses of rainfall often are unavoidable, but they can be held to a minimum with a properly designed irrigation system. Sound soil management also helps reduce these losses. Thorough wetting of the root zone permits fewer applications of irrigation water and is desirable over frequent light applications.

The seed begin to use water at germination, but the rate used by the plants is low for the first 2 or 3 weeks. As more leaves are developed, water use rises rapidly and reaches a peak at the boot stage. Water use continues high through the bloom stage to maturity. Sorghum plants continue to use water after maturity until destroyed or killed by frost. Several inches of water may be saved by killing the plants with tillage after harvest and before frost. However, if wind erosion is a hazard it may not be advisable to destroy the stubble. The consumptive use of water by grain sorghum at different growth stages is shown in Figure 13.

Water stress at any time after planting reduces yields. Research shows that water stress at the bloom stage cuts yields as much as 48 percent. Stress at the soft-dough stage reduces yields by approximately 25 percent. Excessive soil moisture after the dough stage sometimes results in tillering or suckering, thus complicating harvest.

DEPTH OF SOIL MOISTURE STORAGE

Grain sorghum gets most of its water from the top 2 or 3 feet of soil, but will use moisture at 5 or 6-foot depths in deep soils. Except on sandy soils, it usually is not practical to wet the soil more than 3 feet during the growing season; therefore, preplanting irrigations should be used to supplement rainfall in providing a reserve of moisture at 5 to 6 feet on deep soils. Preplanting irrigation should supply enough water for the deep moisture demands of sorghum through the entire season without further addition so that all of the available soil root zone can be used. On deep loam and clay soils, fair yields can be made with only a preplanting irrigation if normal season rainfall is well distributed. Since the preplanting irrigation can take place over a long period before the planting date, a considerable acreage can be covered even with a small well supply.

WATER STORAGE CAPACITY OF SOILS

The amount of water that should be applied to a soil depends upon its storage capacity. Water is stored in soils as a film around soil particles and

Figure 12. Adequate soil moisture, especially during and following the boot stage, is essential for the most grain per acre-inch of rainfall and irrigation water.

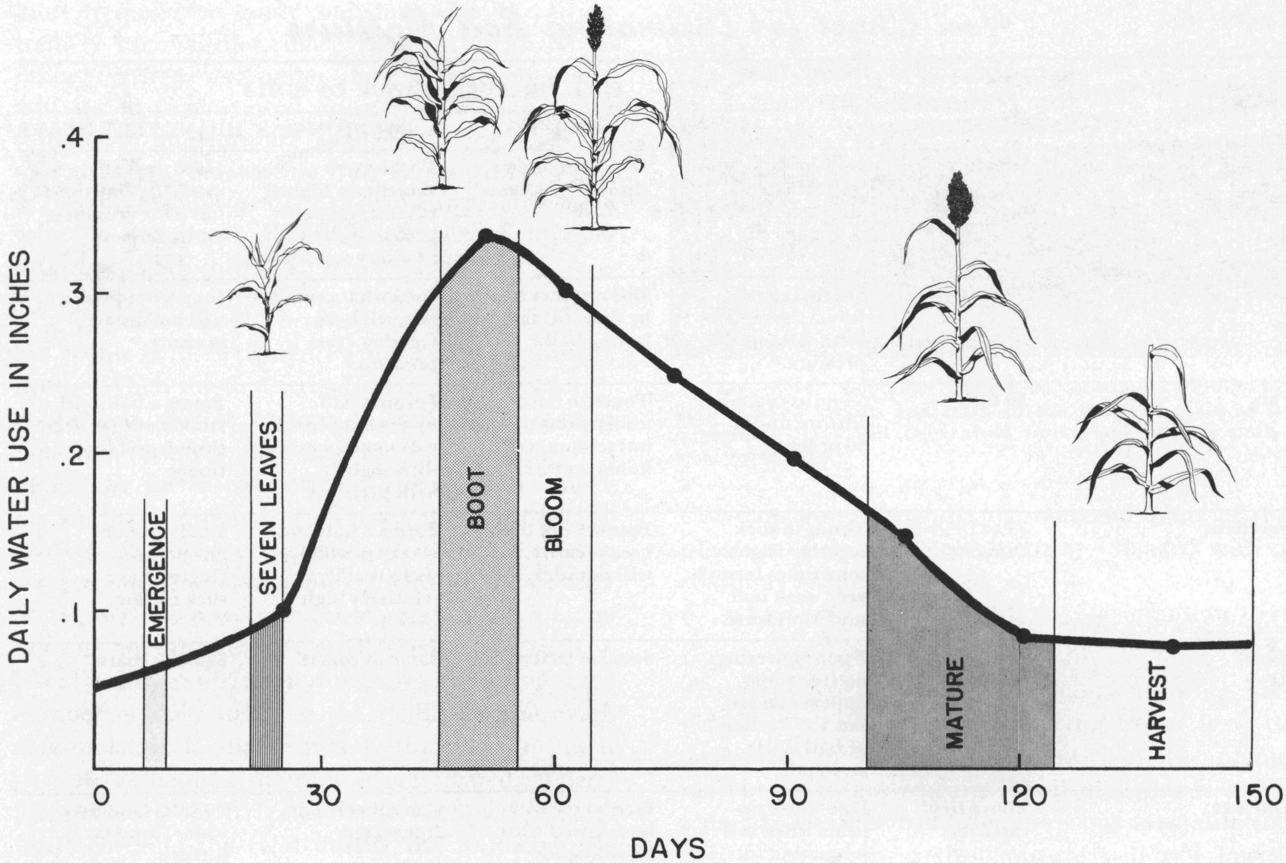


Figure 13. Daily water use from planting to maturity.

excess amounts percolate downward out of the soil root zone, unless drainage is poor, in which case the soil becomes water logged and plants suffer from lack of air. The approximate available water storage capacity per foot of depth for soils of various texture follows:

Soil Texture	Available Water-inches Per Foot of Depth
Sandy (coarse)	½ to 1
Sandy loam (coarse)	1 to 1½
Silt and clay (medium)	1½ to 2
Clays (fine)	2 to 2½

Sandy soils store less moisture per foot of depth than clay soils; consequently, they require more frequent and lighter applications of water.

ESTIMATING AVAILABLE SOIL MOISTURE

A practical way to estimate the amount of available moisture in the soil is to take soil samples from different depths in the plant root zone, squeeze each sample so as to form a ball and refer to the "feel" chart on page 14 for a description of how soils of various texture feel for the various percentages of available moisture.

PLANNING IRRIGATED ACREAGE

The entire crop production program should be planned before planting to obtain the most profitable irrigated grain sorghum production. The acreage that can be watered adequately throughout the season should be determined and the remaining acreage should receive only a preplanting irrigation as time and water supplies permit. If the water supply is limited, plant an early-maturing hybrid. If large quantities of water are available, consider later-maturing hybrids.

Although peak water use may go as high as .4 inch per day, an irrigation system planned to provide .33 inch during the boot through soft dough stages is adequate. This use includes only

Get one neg. + 6 glossy prints S/S of above line art

. . . . Feel Chart for Estimating Soil Moisture . . . .

DEGREE OF MOISTURE	PERCENT USEFUL SOIL MOISTURE REMAINING	FEEL OR APPEARANCE OF SOILS			
		COARSE	LIGHT	MEDIUM	HEAVY-VERY HEAVY
Dry	0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked; sometimes has loose crumbs on surface.
Low	50 or less	Still appears to be dry; will not form a ball with pressure.*	Still appears to be dry; will not form a ball.*	Somewhat crumbly, but will hold together from pressure.*	Somewhat pliable; will ball under pressure.*
Fair	50 to 75	Same as coarse texture under 50 or less.	Tends to ball under pressure but seldom will hold together.	Forms a ball, somewhat plastic; will sometimes slick slightly with pressure.	Forms a ball; will ribbon out between thumb and fore-finger
Excellent	75 to field capacity	Tends to stick together slightly; sometimes forms a very weak ball under pressure.	Forms weak ball, breaks easily, will not slick.	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers, has a slick feeling.
Ideal	At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as coarse.	Same as coarse.	Same as coarse.
Too wet	Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water forms on surface.

*Ball is formed by squeezing a handful of soil very firmly with fingers.

the water which is transpired by the plant and evaporated from the soil surface. It does not include losses which occur in conveyance from the source of supply to the field or the losses encountered in applying the water to the field. The minimum continuous flow of water necessary to provide for a .33 inch per day consumptive use rate is 6.2 gallons per minute per acre. Losses in conveyance and application should be added to these values to determine the minimum water supply necessary to adequately cover the crop acreage during the period of peak water use.

In the central and eastern portions of Texas, ponds, lakes or storage reservoirs may serve as sources of water. Under such conditions, approximately 1½ to 2-acre feet of water stored for each acre to be irrigated is desirable. The supply of water available is important; however, it is equally important that the water be of suitable quality for irrigation use. Your local county agent can provide information on where water samples may be sent to obtain chemical analysis and recommendations for irrigation use.

APPLYING WATER

Timing of irrigations after planting cannot be predicted because of variation of rainfall and other weather conditions. Plants continue to use available soil moisture in the root zone until the supply is exhausted; then they wilt and cease growing. Highest yields and the greatest returns per acre-inch of water are made by irrigating when approximately half of the total available moisture in the plant root zone of the soil has been used. The best method of knowing when and how much water to apply, is to determine the available soil moisture in the root zone.

Growers should be prepared to irrigate about 3 weeks after planting, if rainfall has not occurred to replace the water used by the crop and lost by evaporation. At this growth stage, adequate available moisture in the surface foot of soil is needed. After this time, on fine-textured soils, irrigation will be required at approximately 10 to 14-day intervals until after blooming whenever rainfall is inadequate to maintain 50 percent available water in the top 2 feet of soil. Irrigation should be more frequent on sandy and shallow soils. In extremely hot weather, more frequent irrigation is necessary; however, under these conditions plants wilt and appear to need water even though ample supplies of moisture are available. Irrigation frequently stops the wilting, but it probably is due to the cooling effect rather than by furnishing more water to the plant. There is no research to indicate that it is profitable.

Irrigation should begin early enough that the last plants to be irrigated do not reach a moisture stress. When the first irrigation is started, a 2-inch application may be enough to refill a soil storage capacity; however, the amount of water applied should be increased each day thereafter to make up for the additional water used during the period. If 10 days are required to irrigate the crop acreage, an application of 4 inches or more may be required to restore the root zone to full storage capacity in the area irrigated near the tenth day. Usually the next irrigation requires about the same number of days to cover the field and the available moisture is approximately the same in each part of the field by the time it is irrigated. Therefore, the rate of irrigation will need less change while covering the field during the following application unless rainfall is received.

Harvesting

Grain sorghum ordinarily is harvested with combines when the grain contains 15 percent moisture or less. When it is necessary to harvest grain at this high moisture content, drying facilities should be available. The combine should be adjusted to do a thorough threshing job, avoid cracking the grain and allow as little trash as possible in the grain. Cracked grain and trash can interfere seriously with safe storage. Grain sorghum hybrids have softer seed than many varieties previously grown; thus cylinder speeds should be slower to avoid cracking.

Grain sorghum may be lodged severely at harvest time and it often is necessary to use pick-up attachments on the combine to salvage the crop. Several companies manufacture attachments for this purpose. In such cases, practically all of the stalks and leaves must go through the machine in the threshing operation and the plants should be thoroughly dry. In some cases, severe lodging results from wind following a quick freeze; however, in other cases the lodging follows insect or disease damage to the stalks or roots and many of the plants may not dry enough to be salvaged with a combine.

Figure 14. Combines should be adjusted carefully to keep cracked kernels and trash in the threshed grain to a minimum. This will help avoid insect and heating problems in storage.

Under certain conditions, desiccant chemicals may be helpful in harvesting grain sorghum. Such materials partially kill the plant, allowing the heads and leaves to dry rapidly for about 9 to 10 days after application. In some cases, the plants may begin to grow again if soil moisture is available. If weather conditions are not favorable for drying the grain, grain moisture will not lower, even if dessicants were applied. Rapid drying will take place only when there is high temperature and low humidity following application. Although high humidity and other weather conditions keep the grain from drying readily, desiccants sometimes permit earlier harvesting because the dead leaves and stems do not have a high moisture content and interfere with storage. The grain can then be dried in a storage structure to a safe moisture level.

Under certain conditions, seed producers use desiccants to permit earlier harvesting of grain sorghum seed in an effort to avoid weather damage. Desiccants also may aid in harvesting grain in humid areas, and in drying weeds and upper sorghum leaves prior to harvest in other areas.

The Pure Food and Drug Administration has not set residue tolerances for desiccants nor ruled whether these materials affect the movement of grain into the trade. Therefore, they should be considered only in an emergency where the grain is to be used on the farm and will not go into commercial trade channels. Trials conducted at Substation No. 1, Beeville, indicate that magnesium chlorate is safe when 1.5 to 2 gallons with 10 gallons of water are applied per acre. In 10 days, the moisture content of grain was 10 to 15 percent less than untreated grain sorghum. Steers were fed some of the grain without harm. They gained normally and seemed to prefer the treated grain because of the salty taste. Other desiccant materials such as endothal and sodium chlorate-borates have been used successfully, but the effect on grain-feeding quality is not known.

Grazing Stubble

Pasturing grain sorghum stubble after harvest is a common practice in some areas. Severely drouth-stricken sorghum sometimes is grazed as a salvage measure. Generally there is concern over the possible effect of prussic or hydrocyanic acid on the livestock. There is no positive way to know in all cases whether such sorghum is dangerous, but the following information may be heelpful:

1. Prussic acid content decreases as the plants mature.

2. New growth following harvest, drouth or light frost is often dangerous.

3. Irrigated grain sorghum making normal growth usually contains less prussic acid than sorghum grown under less favorable soil moisture conditions.

4. Frosted or frozen sorghum should not be grazed until the plants have thawed and the killed leaves have dried. Freezing causes rapid release of prussic acid gas that makes the forage toxic during the time it is frozen and while thawing.

5. Sorghum silage probably is safe for feeding. In the ensiling process, a portion of prussic acid is lost. Sorghum silage usually is cut when it is approaching maturity and contains less prussic-acid-forming material than in younger stages.

6. Field drying and curing reduces the prussic acid content of sorghum and it should be safe for feeding. If cut in an immature stage, there is a possibility of danger until fully cured.

7. Prussic acid content increases with nitrogen fertilization.

Storage

Dry grain is the key to safe storage. Sorghum grain can be stored safely for 6 months without turning or aeration if the grain or trash in the bin contains no more than 12 percent moisture. Grain of this moisture content can be stored longer than a year with proper aeration. For storing longer than a year without turning or aeration, the moisture content should be no higher than 11 percent. If sorghum grain is aerated or turned during storage, it can be stored safely for several months at 12 to 14 percent moisture, but storage should not be attempted if the moisture is above 14 percent. High moisture conditions can result from leakage through bin walls or roof; therefore, a tight structure is necessary for protecting the grain from the weather, controlling insects and preventing entry by rodents or birds.

Excessive trash and cracked grain favor stored grain insects. Large numbers of insects may cause heating and molding and increase the moisture content of the grain even though it was below 12 percent moisture when stored. It is extremely difficult to fumigate grain that has a high percentage of trash and cracked grain.

Since it is normal to harvest grain sorghum at moisture contents around 15 percent, drying often is needed for storage. If grain is put under Commodity Credit Corporation loan, safe moisture levels will have to be met by drying at an elevator or by installing farm drying facilities. Drying with unheated air is usually the most practical method for farm storage. After the grain has been dried to a safe moisture level, areation is a practical and economical way to cool grain during storage.

For additional information on drying and storage of grain sorghum and on the control of stored insects, ask your county agricultural agent for B-888, Drying and Storing Sorghum Grain, and L-217, Stored Grain Insects.

Marketing

The grower must decide how to market his grain sorghum for the most profit. He has a choice of either (1) selling the grain at harvest, (2) storing the grain (not under CCC loan) for later sale, (3) storing the grain under CCC loan, and forfeiting the grain to the government or redeeming it before the date of forfeit and selling it on the market or (4) storing the grain and feeding it to livestock or poultry. Number one should be considered only when the net CCC loan price (basic support price less handling and storing deductions) is below the market price at harvest. If the decision is to store the grain, choice number three would be preferred over number two. The grower would have less loss from storage by forfeiting to the CCC should there be a price drop below the loan level after harvest. If the loan price is above the harvest price, the grower cannot lose and may possibly gain by putting his grain sorghum under CCC loan. He can redeem the grain before the forfeit date if the market price goes above the loan price enough to more than pay the costs of redeeming it.

The choice of whether to feed the grain depends on the farmer's need for ready cash at harvest. The market outlook on livestock and poultry prices along with feeding facilities and feeding know-how also should be considered in deciding whether this may offer the most profitable way to use the grain.

The difference in price at harvest and later in the year will vary for different sections of the State. Grain sorghum prices at harvest usually are higher in South Texas than on the High Plains. The High Plains crop is harvested several months later and the grain is then in greater supply. As shown in Figure 15 the average price of Texas grain sorghum begins to fall in June when the South Texas harvest starts and begins to rise after the High Plains harvest. Although this figure shows the general trend and extent to which prices go up after harvest, it cannot be predicted exactly in which month peak prices will occur. The peak may occur in January one year and the next year it may be in April.

The seasonal price spread cannot be compared directly since grain is sold on a 15 percent moisture content basis at harvest and stored grain should be dried to 12 percent for farm storage. The value of the loss in weight as well as other incidental costs and benefits, such as interest charges, discounts for high-moisture grain, taxes and labor, should be considered in storing grain.

Diseases

SEED ROT AND SEEDLING DISEASES

Soil temperatures below 55 degrees F. cause slow seed germination and seedling growth. Seed rot and seedling diseases may be severe. Symptoms of these diseases are rottong seed and dead or weak seedlings. Planting seed should be examined before purchase. Sound seed, undamaged in the

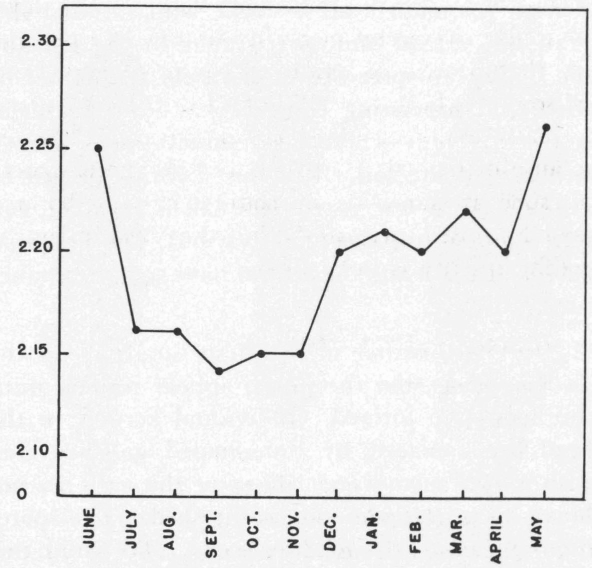


Figure 15. Seasonal price changes of sorghum grain over a 10-year period.

threshing process, should be used. Seed treatment with a fungicide helps reduce damage.

SORGHUM LEAF DISEASES

Several leaf diseases caused by bacteria and fungi attack grain sorghum. High temperatures and humidity favor these diseases and although the damage usually is minor, serious losses sometimes occur in the Gulf Coast area. The general symptoms are spotting and streaking of the leaves with red, brownish-purple and black discoloration. The color varies with the type of leaf disease and with the variety. This leaf streaking sometimes is mistaken for symptoms of nutritional deficiencies. No practical control measures are known, although seed treatment gives some protection. Resistant hybrids may be developed eventually.

SMUT DISEASES

Three smut diseases, head smut, covered kernel smut and loose kernel smut, are caused by fungi.

Head smut caused considerable damage on the High Plains nearly 40 years ago, but it was not a serious problem again until recent years. It now causes extensive damage in South and Central Texas and is a major threat in other areas. It is easily distinguished from kernel smut in that it destroys the entire head and changes it into a large mass of dark-brown, powdery spores. In some instances, the main head is sterile with smutted side branches. Head smut overwinters in the soil and the spores can spread from one field to another by wind and harvesting equipment. Seed treatment is effective only where head smut has not gained entrance in the soil. Resistant hybrids should be available in a few years. RS 630 is resistant, but seed supplies are short. Texas 601, C 44a, Texas 620, Texas 650 and Texas 660 have some resistance to the disease.

Covered kernel smut infests sorghum in the seedling stage, but the plants appear normal until the heads are formed. Individual kernels in the head are replaced by cone-shaped galls covered with a gray membrane. Most of the galls do not break open until the crop is threshed. The spores then spread to the healthy seeds. To avoid this trouble, treat the seed with a fungicide.

Loose kernel smut damage is similar to covered kernel smut except most of the smut galls break open before harvest and the heads appear black and dusty. Plants from smutty seed are stunted and often have many side branches. Spores from smutted heads also can infest late sorghum and cause smutty heads of healthy plants. This disease is less common than the covered kernel smut. It also can be controlled with seed treatment.

ROOT AND STALK DISEASES

The most serious root and stalk diseases of sorghum are root rot or milo disease, charcoal rot, fusarium stalk rot, colletotrichum stalk rot and rhizoctonia stalk rot. Although root rot caused severe losses in the 1930's, resistant strains were developed and distributed quickly, the disease is no longer a threat if recommended hybrids and varieties are grown.

Charcoal rot and the other stalk rots occur most often following drouth or extreme heat. They also follow injury to plants by insects and other causes. Charcoal rot damage usually is not noticed before the plants reach maturity and there is a premature ripening and drying, followed by leaning and falling of stalks. Diseased stalks become soft near the ground level and the interior of the lower stalk appears shredded with many small black particles on the fibers.

Fusarium stalk rot damage and symptoms are similar to charcoal rot except that no black particles are produced by the fungus on the plant fibers.

Figure 16. Head smut destroyed these sorghum heads. Most tillers with smut produce no seed. Note sterile head, center. This is typical of head smut damage.

The symptoms of rhizoctonia stalk rot in lodged plants is a reddish pith with the fibers appearing as light streaks. Small brown fruiting bodies of the fungus may be found on the outside of the stalk under the leaf sheaths. Several other crops, including cotton and potatoes, are attacked by the disease.

Colletotrichum stalk rot and one of the leaf diseases is caused by the same fungi. The diseased stalks break over at the base and have reddish or purplish-margined lesions with whitish centers. The pith usually is red or purplish-red.

Definite control measures for the stalk rots are not known. The diseases usually are not serious where there is adequate soil moisture throughout the growing season. Breeding work is directed toward developing resistant hybrids.

Further information on sorghum diseases and their control can be obtained from your county agricultural agent. Ask for Farmers Bulletin 1959, Sorghum Diseases and Their Control, and Miscellaneous Publication 219, Treat Seed Grain.

Insects

Grain sorghum may be attacked by insects from the time of planting to harvest. Heavy infestations require the use of insecticides to prevent destruction or severe damage. The value of a dryland crop of grain sorghum usually is not great enough to justify a large expense for insect control and, fortunately, weather conditions and parasites help keep most of the insects in check.

Several species of wireworms, false wireworms and the southern corn rootworm can destroy stands by feeding on the germinating seed or the seedling plant and roots. Such damage is likely to occur in sorghum that follows a previous small grain or cover crop. Damage is more likely when germination and seedling growth are slow. The application of insecticides as dusts or sprays in the planter furrow gives effective control. Insecticides used as seed treatments will help avoid damage from these insects. Many seed producers now treat seed before sale for this purpose. Damage usually is less if sorghum is planted when soil temperatures and moisture are favorable for fast germination and seedling growth.

Insects that may cause serious losses during the growing season are the sorghum webworm, lesser cornstalk borer, armyworm, cutworm, chinch bug, false chinch bug, stink bug, corn leaf aphid, grasshopper, sorghum midge, sugar cane rootstock weevil and corn earworm. Grain sorghum planted in the eastern half of Texas after May 1 frequently is damaged by sorghum midge and sorghum webworm. These two small insects destroy the grain just as it is developing, thus giving the head a blasted appearance. Sorghum webworms also may attack the grain in more mature stages. Other damaging pests of lesser importance are the flea beetle, sugar cane borer, white grub and red spider.

All insecticides are poisonous and directions on the labels should be followed strictly. Tolerance for residues of insecticides on grain sorghum have been set by the Pure Food and Drug Administration. Regulations specify the type of insecticides that can be used and the number of days that must elapse between the time of application and harvest.

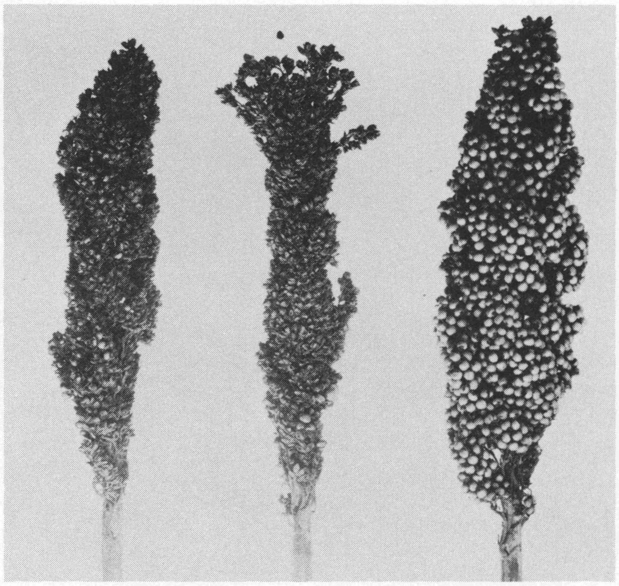


Figure 17. The two heads, left, show that the sorghum webworm occasionally causes severe losses unless controlled with insecticides. In the Southern half of Texas, damage from this insect and the sorghum midge often can be avoided by planting early.

For further information on grain sorghum insects and their control consult your county agricultural agent or an entomologist. See extension Leaflet 218, *Guide for Controlling Insects on Corn, Sorghum, Small Grains and Grasses,* and Farmers Bulletin 1566, *The Sorghum Midge.*

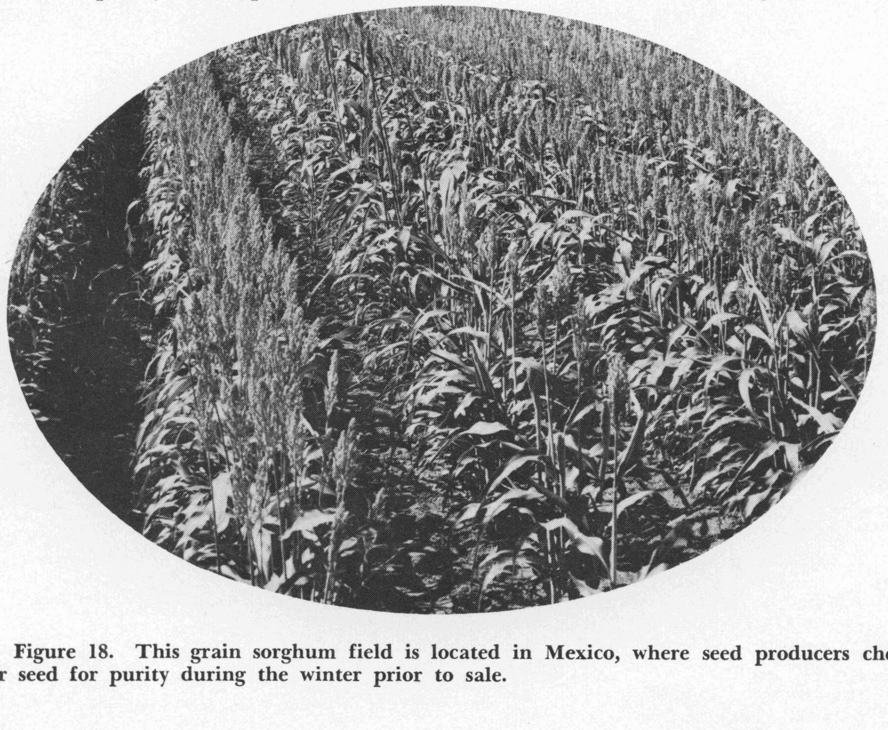


Figure 18. This grain sorghum field is located in Mexico, where seed producers check their seed for purity during the winter prior to sale.

Your County

EXTENSION AGENTS

can furnish you the latest information on farming, ranching and homemaking. They represent both The Texas A. & M. College System and the United States Department of Agriculture in your county.

Most county extension agents have their offices in the county courthouse or agriculture building. They welcome your visits, calls or letters for assistance.

This publication is one of many prepared by the Texas Agricultural Extension Service to present up-to-date, authoritative information, based on results of research. Extension publications are available from your local agents or from the Agricultural Information Office, College Station, Texas.

Cooperative Extension Work in Agriculture and Home Economics, The Texas A. & M. College System and the United States Department of Agriculture cooperating. Distributed in furtherance of the Acts of Congress of May 8, 1914, as amended, and June 30, 1914.
20M—5-59, Reprint