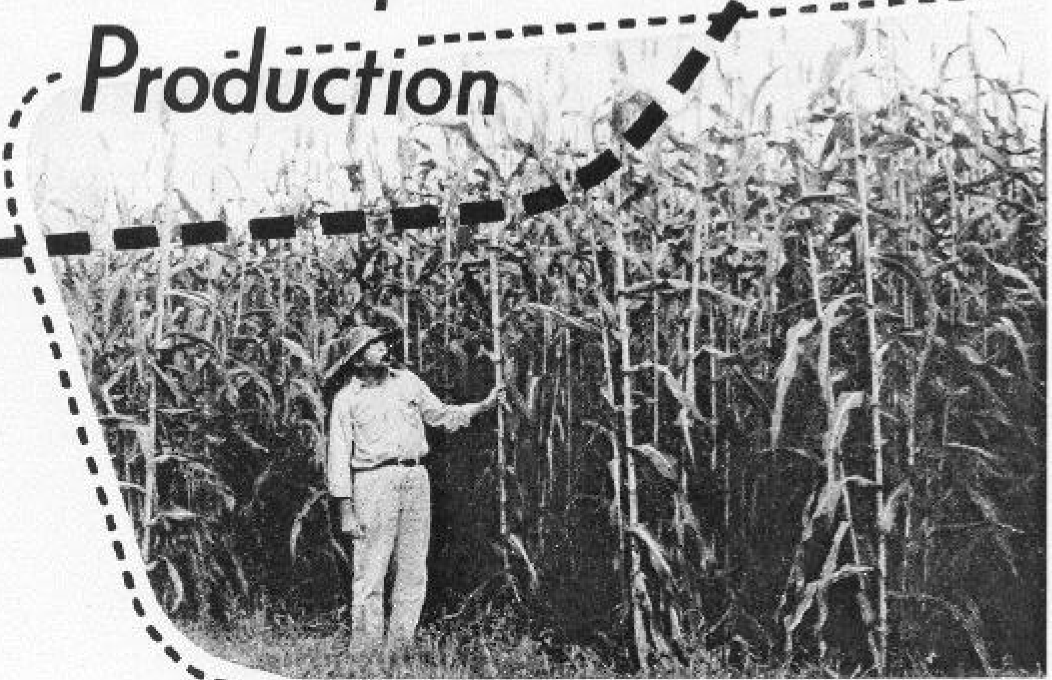
# CULTURE OF SORGO

## for Sirup Production



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The production of sorgo sirup varied considerably from year to year during the 20-year period 1932 to 1951. Annual production ranged from 21,326,000 gallons in 1933 to 2,595,000 gallons in 1952. Prices per gallon received by farmers ranged from 48.1 cents in 1933 to $2.22 in 1952. The peak annual income from sorgo sirup was $21,670,000 in 1946; in that year 10,171,000 gallons were produced.

Some sorgo is grown for sirup in 35 States. Sorgo is adapted to soil and climatic conditions as diverse as those found in Minnesota and Alabama.

Sorgo is grown most extensively for sirup in the Southeastern States. Six States, Mississippi, Alabama, Arkansas, Tennessee, North Carolina, and Georgia, sometimes called the "sorgo sirup belt," produce about 50 percent of the total amount of sorgo sirup. Mississippi and Alabama have been the largest producers for many years.

In general, the acreage of sorgo grown for sirup production on individual farms is somewhat less than an acre. The production of sirup is also on a small scale. Sirup is usually made in the neighborhood for home use; a small surplus is sold. In many communities a group of farmers have the sirup manufactured at a plant that is owned privately or cooperatively.

Sorgo sirup is usually a good-quality product; it is light colored and mild, and has a good flavor. It is a wholesome food, and it is favored as a table sirup.

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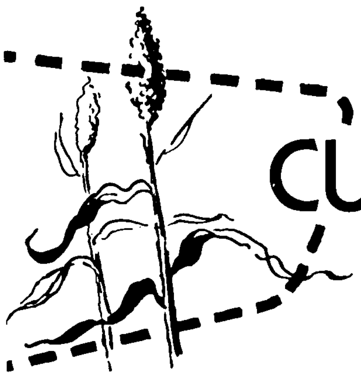

# CULTURE OF SORGO *for Sirup Production*

By I. E. STOKES, *principal agronomist,* O. H. COLEMAN, *agronomist,* and JACK L. DEAN, *assistant pathologist, Field Crops Research Branch, Agricultural Research Service*

The name "sorgo" is commonly used to identify varieties of sorghum that have an abundance of sweet juice. These sweet-stemmed varieties are also called "sweet sorghums" or "sugar sorghums."

Sorgo is grown for sirup or forage, whereas other sorghums, such as kafirs and milos, are grown for grain. Still other types of sorghum include broomcorn, which is used in making brooms and brushes, and Johnsongrass and Sudangrass, which are cultivated for forage.

Cultural methods are similar whether sorgo is used for sirup or forage, but handling methods differ.

The primary objective in growing sorgo for sirup is to obtain the largest possible yield of good-quality sirup. Yield and quality of sirup are influenced by varieties, diseases, insects, cultural practices, harvesting, and manufacturing methods.

## DESCRIPTION OF THE PLANT

Sorgo is a member of the grass family. It is more closely related to kafir, milo, feterita, broomcorn, Johnsongrass, and Sudangrass than to sugarcane. It is perennial in the Tropics but it winterkills in regions where frosts occur.

Young sorgo plants are delicate, and their growth is slow. In germinating, the radicle (first root) bursts through the seed coat. Shortly afterward the plumule appears. It later develops into the shoot that grows upward. The first node or joint is always found just beneath the soil surface, where it puts forth permanent roots. When the seed is planted deeply, the subcrown internode may grow to 2 inches or longer before the first node is apparent. At this point the crown roots develop and the tiller buds are formed. The first main root is sometimes mistakenly called a taproot.

After the seedling stage, the early growth above the surface appears to consist mainly of leaves. However, the stalk is developing during this period—at first mainly by the formation of nodes very close together. A leaf is produced at each node; the bases or sheaths of the leaves closely surround the stalk. The internodes from this time grow more rapidly and become much longer. The number of internodes varies with the variety and the individual stalk. Stalks of most varieties taper from the base toward the top but the last internode, or the peduncle of the head, is uniform in thickness. The exterior of the mature internodes is usually covered with a thin film of waxy bloom. This outer region (or rind) of the internode is hard and contains numerous fibers that strengthen the stalk. The interior of the stalks is composed mainly of soft pith that contains sweet juice.

The feeding roots originate from the lower nodes or joints of the stalks at a point beneath or slightly above the surface of the soil. They radiate in all directions and are always most abundant in the surface soil. The plant obtains its moisture and mineral nutrients largely from the upper foot of soil, although some of the roots extend 3 or 4 feet or more downward. When the soil is moist for long periods of time, tough brace roots may develop from nodes that are considerably above the surface; those from the lower nodes may help to anchor the plant to the soil.

When the plants are 3 to 6 inches tall, some of the buds at nodes below the soil surface develop into shoots that later become secondary stalks, or tillers. In early stages these tillers can be distinguished from initial stalks by the fact that they grow out obliquely. Later they grow upright and develop independent root systems. At this stage they cannot easily be distinguished from the initial stalks. They are as good as the initial stalks for sirup making, but they mature a few days later.

Initial stalks and tillers put out short side branches from their upper nodes when the seedhead (panicle) fails to develop normally or when harvesting is delayed after the seed are ripe. These side branches may grow 12 to 15 inches long and produce small seedheads. Side branches should not be used for sirup production, but their presence on the plants does not decrease the yield or quality of sirup.

## CHARACTERISTICS OF SIRUP SORGO

The desirable characteristics of sorgo varieties for sirup production are: (1) Ability to produce a high yield of medium to large stalks per acre; (2) strong, erect habit of growth, not readily lodging during storms; (3) a high percentage of extractable juice; (4) juice having a high total soluble solids (Brix) content, mostly sugar; (5) resistance to disease; (6) ability to produce a high-quality sirup; and (7) comparatively short growth period. Varieties differ greatly in these qualities, and in their adaptation to soil and climatic conditions. The grower should carefully consider all these qualities in his choice of a variety.

Varieties used for sirup production vary in stalk characteristics and potential ability to produce a high yield of stalks per acre. A good variety should yield stalks that are large in diameter and vigorous enough to reach a good height and develop the maximum number of tillers. Varieties that do not tiller freely usually produce low yields of stalks. Tillering is also influenced by the condition of the soil and by cultural practices, such as row spacing and planting time. It is therefore subject to some control by the grower.

Lodging of stalks increases the cost of harvesting, which is a major expense in producing sorgo sirup. A good variety should resist lodging. Lodging may be due to: (1) Inherited weakness of the stalks that causes them to bend to a horizontal position prior to harvesting, (2) severe disease infection that weakens the stalks by destroying their internal tissue, or (3) caving over of the entire plant, which may be influenced by varietal weakness of the root system, poor cultural practices, insect damage, or high wind during rainstorms.

The percentage of juice extracted depends primarily upon the juiciness of the stalks and the milling equipment. Most of the available commercial varieties have adequate juiciness. In general, the small mills used to crush sorgo stalks consist of three rollers propelled by animal or motor power. Such mills give satisfactory results when properly adjusted. Simple extraction tests to determine the set of the rollers can be made by weighing 100 pounds of stalks, passing the stalks through the mill, and weighing the juice extracted. The weight of the juice is the percent extraction. A good sirup variety will yield at least 55 percent of juice in such a test.

Sirup yield is determined by the total soluble solids (Brix) content of the juice. A good variety should have a high content of total soluble solids in the juice. Varieties differ widely in their potential ability to produce such juice. The total solids content may be influenced adversely by diseases and by cultural practices and climatic conditions that hinder the normal development of the plants.

All commercial varieties are susceptible to one or more of the sorgo diseases. A satisfactory variety should be resistant to diseases. Losses from diseases may range from a slight reduction in yield and quality of sirup to a total loss of the crop. Besides variety, cultural practices and time of harvest may influence the overall effects of a disease epidemic.

A good variety should produce high-quality sirup that has the following characteristics: (1) Light amber color that is almost free of opaqueness; (2) mild, sweet flavor, nearly free of a tang; (3) no colloidal sedimentation, or sediment confined to a trace of small particles near the top of the container; (4) high viscosity—sirup moves slowly when poured from a container, but is free of a jellylike consistency usually associated with a high starch content; and (5) no crystallization, or crystallization limited to a few small crystals. Sound cultural and manufacturing

FIGURE 1.—The sorgo selection at the left is susceptible to red rot. The one at the right is resistant to red rot under normal conditions.

Table 1.—*Relative yields of sorgo at Meridian, Miss.*[1]

| Variety | Tons of stripped stalks per acre | Gallons of sirup per ton of stalks | Gallons of sirup per acre | Days to maturity |
|---|---|---|---|---|
| | *Percent* | *Percent* | *Percent* | |
| Sart | 88 | 129 | 115 | 126 |
| Hodo | 100 | 100 | 100 | 129 |
| Tracy | 75 | 125 | 96 | 106 |
| White African | 71 | 122 | 86 | 106 |
| Honey | 68 | 98 | 67 | 115 |
| Sugar Drip | 56 | 107 | 59 | 100 |
| Iceberg | 58 | 124 | 71 | 106 |
| Atlas | 66 | 100 | 66 | 100 |

[1] All values are expressed in percentage of the yield of Hodo.

practices are also important in producing sirup of good quality.

A good variety should grow rapidly enough to mature before the first killing frost, when planted at the most favorable planting time for a locality. Late-maturing varieties usually produce high yields of sirup; however, these varieties can be grown only in sections where the plants reach maturity by harvesttime.

## VARIETIES

The variety that is grown is one of the most important factors in the production of sorgo sirup.

Explorations have brought to the United States valuable breeding material for use in extensive variety-improvement programs. Typical is the breeding and improvement work conducted at the United States Sugar Crops Field Station near Meridian, Miss. Here the sorghums of the world are being assembled; here they are crossed and studied so that better sirup varieties adapted to the specific requirements of each locality can be developed and made available to farmers.

Figure 1 shows the results of selecting for red rot resistance in an established sorgo variety.

Below are brief descriptions of some commercial varieties known to give a good quality of sirup and to be suited to a wide range of soil and climatic conditions in the principal sorgo sirup-producing States. Comparative yield data for these varieties are included in tables 1 to 3. The approximate number of days for sorgo to mature at Meridian, Miss., is shown in table 1.

The grower should ask the nearest agricultural experiment station agronomist or county extension agent about the suitability of these varieties in his locality before procuring seed. He should choose the variety carefully and should buy the best pure seed available.

### SART

Sart is the most promising late-maturing variety of sorgo available for

Table 2.—*Relative yields of sorgo at Holly Springs, Miss.*[1]

| Variety | Tons of stripped stalks per acre | Gallons of sirup per ton of stalks | Gallons of sirup per acre |
|---|---|---|---|
| | *Percent* | *Percent* | *Percent* |
| Sart | 90 | 116 | 107 |
| Hodo | 100 | 100 | 100 |
| Tracy | 81 | 108 | 88 |
| White African | 76 | 102 | 78 |
| Honey | 83 | 107 | 85 |
| Sugar Drip | 69 | 115 | 76 |
| Iceberg | 55 | 114 | 63 |
| Atlas | 71 | 95 | 62 |
| Williams | 71 | 121 | 86 |

[1] All values are expressed in percentage of the yield of Hodo.

TABLE 3.—*Relative yields of sorgo at Crossville, Ala.*[1]

| Variety | Tons of stripped stalks per acre | Gallons of sirup per ton of stalks | Gallons of sirup per acre |
|---|---|---|---|
| | *Percent* | *Percent* | *Percent* |
| Sart | 87 | 123 | 107 |
| Hodo | 100 | 100 | 100 |
| Tracy | 78 | 119 | 94 |
| White African | 72 | 112 | 82 |
| Williams | 70 | 110 | 75 |

[1] All values are expressed in percentage of the yield of Hodo.

sirup production. It is an original variety introduced by the United States Department of Agriculture into the United States in 1945 from the Kordofan Province of Sudan, Central Africa.[1]

Sart (fig. 2) has relatively large white seed, characterized by irregular purplish spots and a brown subcoat. (A field of Sart sorgo is shown on the cover of this bulletin.) The seed protrude well beyond the blackish glumes. Seedheads are erect, compact, and cylindrical in shape. The plants grow 8 to 14 feet tall, depending on the fertility of the land, the available moisture supply, and the length of the growing season. Sart has large-barreled stalks that tiller well when the plants are properly spaced in the field. The hard rind of the stalk enables Sart to resist lodging under ordinary field conditions. It may develop characteristic multiple buds at the nodes late in the season. It is very resistant to leaf anthracnose and stalk red rot, but susceptible to zonate leaf spot and leaf rust and should not be grown where these diseases are prevalent.

When free of disease, Sart has juice of high sugar content and makes an excellent, mild sirup. It produces a high tonnage and has fairly juicy stalks. Total yields of sirup in experimental plots have ranged from 200 to 700 gallons per acre; the average is about 110 percent of Hodo. It usually yields

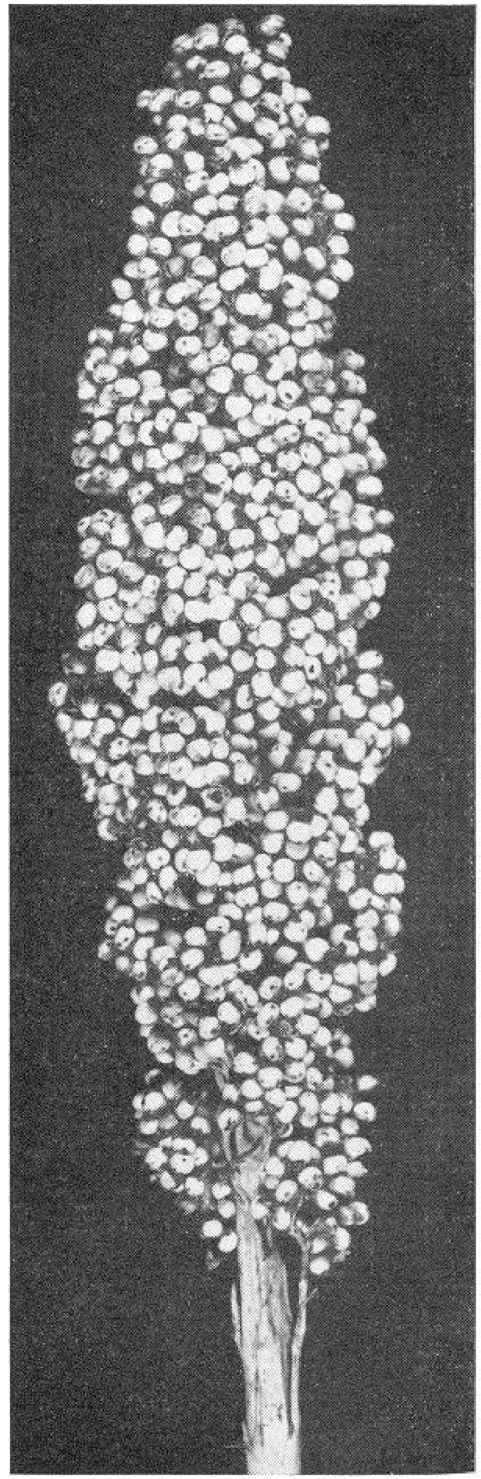

FIGURE 2.—A typical head of Sart sorgo.

[1] Additional information may be obtained from Mississippi State Experiment Station Information Sheet 458, Sart, a New Variety of Sorgo for Sirup Production in Mississippi.

about 20 gallons of sirup per ton of stalks. This variety requires about 126 days to mature. It is recommended for use in Mississippi, Alabama, and southern Georgia. Its growth period may be shortened somewhat by planting early in April, if the spring is warm, because Sart is sensitive to the short days of that time of the year.

### HODO

The origin of Hodo is obscure, although it is known that a variety called Hodo was grown in northern Mississippi for many years before it was described in 1939.[2]

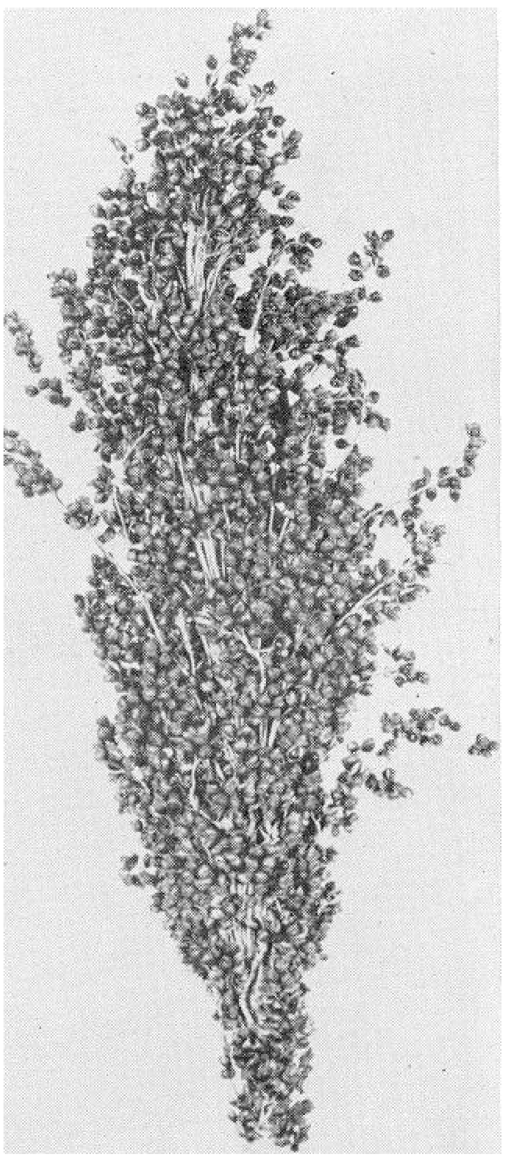

FIGURE 3.—A typical head of Hodo sorgo.

Hodo (fig. 3) has brown, medium-sized seed.

The seed have a brown subcoat and protrude only slightly beyond the dark, reddish-brown glumes. Seedheads are midcompact and somewhat ellipsoid in shape. Hodo is as tall as Sart, but has a slightly smaller-barreled stalk. It tillers well under optimum growing conditions. The stalks are comparatively weak because of their extreme height, and lodge badly when luxuriant in growth or infected with red rot. Hodo is susceptible to leaf anthracnose. It is extremely susceptible to red rot. In some instances red rot has caused it to lodge and deteriorate so badly that it was unsatisfactory for sirup production. Hodo is susceptible to all the important diseases in the major sirup-producing areas of the United States. It should not be grown where leaf anthracnose, stalk red rot, zonate leaf spot, and rust are prevalent.

This variety produces a heavy tonnage of very juicy stalks. The juice contains somewhat less sugar than that of Sart, but the quality of the sirup is excellent. Hodo requires about the same number of days to mature as Sart and is adapted to the same areas.

### TRACY

This midseason variety originated from a cross between White African and Sumac made in 1923 by USDA. The final selection was released in 1953 under the name of Tracy.[3]

Tracy (fig. 4) has small, brown seed. The subcoat is absent. The seed protrude well beyond the small, dark reddish-brown glumes. Seedheads of this

[2] Additional information may be obtained from Mississippi State Experiment Station Information Sheet 310, Hodo, a New Sirup Sorghum, Described.

[3] Additional information may be obtained from Mississippi State Experiment Station Information Sheet 483, Tracy, a New Midseason Variety of Sorgo for Sirup Production in Mississippi.

variety are small, erect, compact, and almost cylindroid. Under optimum growing conditions the stalks grow 9 to 12 feet tall. Tillering is intermediate and somewhat less than that of Sart. The stalks tend to be erect, are quite juicy, and are easily crushed in a small mill. Tracy is not highly resistant to leaf anthracnose, red rot, zonate leaf spot, or rust; but it has not been severely damaged by these diseases during the 10 years that it has been tested in Mississippi.

The quality of the sirup is good but not comparable with that of Hodo. Tracy usually yields about 19 gallons of sirup per ton of stalks. It is an exceptionally heavy-tonnage variety for the midseason group. On an average, the per-acre yield of sirup is about 90 percent of that produced by Hodo. Tracy matures in about 106 days. It is well adapted to the area from Tennessee southward where rainfall is adequate.

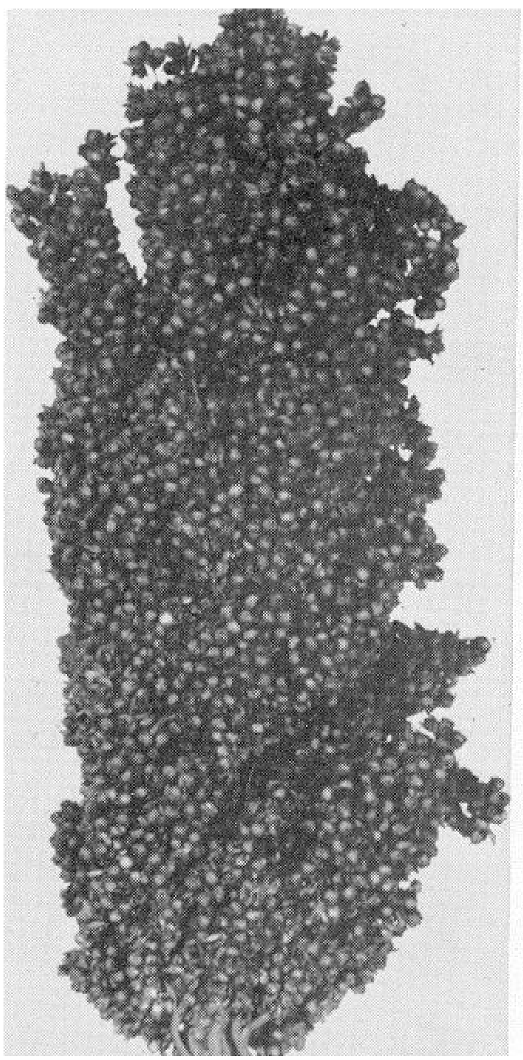

FIGURE 4.—A typical head of Tracy sorgo.

#### WHITE AFRICAN

This midseason variety was apparently brought from Natal, South Africa, in 1857. It was known for a time as White Mammoth.

White African (fig. 5) has medium-sized, white seed, which have occasional small brown spots at the apex. The subcoat is absent and the seed protrude slightly beyond the blackish glumes. Seedheads are erect, midcompact, and nearly cylindroid. The stalks are medium barreled and grow 6 to 9 feet tall under optimum growing conditions. Tillering is relatively sparse compared with that of Sart. White African is intermediate in lodging but is inferior in this respect to Tracy and Sart. It is similar to Tracy in disease resistance.

White African ranks just below Tracy in yield of stalks, sirup per acre, and sirup per ton of stalks. It is grown to some extent as a commercial variety, matures at about the same time as Tracy, and is adapted to the same localities.

#### HONEY

This variety was grown as early as 1880 by USDA and was formerly known as Honey Cane.

Honey (fig. 6) has medium-sized, brown seed. The seed have a brown subcoat and are usually shorter than the brownish-red glumes. Large, erect seedheads are open, and are variable in shape. Under optimum conditions the large-barreled stalks grow 7 to 10 feet tall. This variety has a very weak stalk in relation to its height, and tends to lodge badly. It is very susceptible to all the major diseases in the sorgo sirup-producing areas.

It produces a good yield of juicy stalks and an excellent quality of sirup.

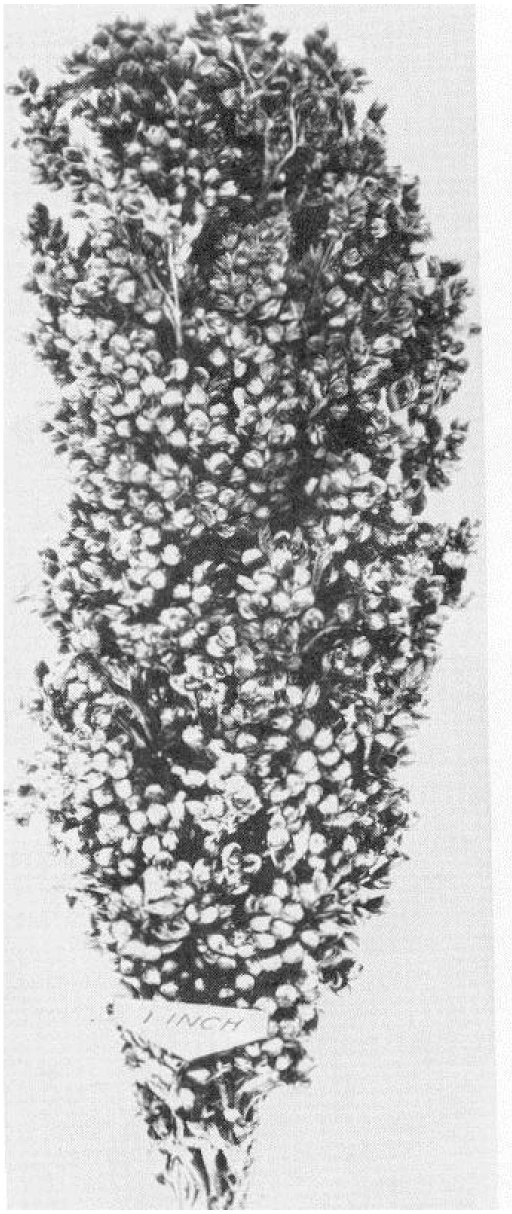


FIGURE 5.—A typical head of White African sorgo.

Honey matures about midway between the maturity dates of Tracy and Sart.

#### SUGAR DRIP

The origin of this midseason variety is not known. Sugar Drip (fig. 7) has medium-sized, brown seed. The seed have a brown subcoat and protrude well beyond the dark reddish-brown glumes. The seedheads are erect, medium sized, relatively compact, and nearly cylindroid. The stalks are somewhat shorter and smaller barreled than those of Tracy. Under good growing conditions Sugar Drip may lodge enough to handicap harvesting operations. Sugar Drip is almost as susceptible to diseases as Honey.

#### ATLAS

Atlas, a midseason variety, originated from a cross between Blackhull kafir and Sourless sorgo.

Seed of this variety (fig. 8) are medium sized, are white, and have brownish spots. The subcoat is absent and the seed extend beyond the blackish glumes. Seedheads are relatively compact and nearly cylindroid. The stalks are somewhat smaller in diameter and shorter than those of Tracy. Atlas does not lodge severely and is somewhat resistant to leaf anthracnose and stalk red rot. It gives considerably lower yields than Tracy but produces a good sirup. Atlas matures at about the same time as Tracy.

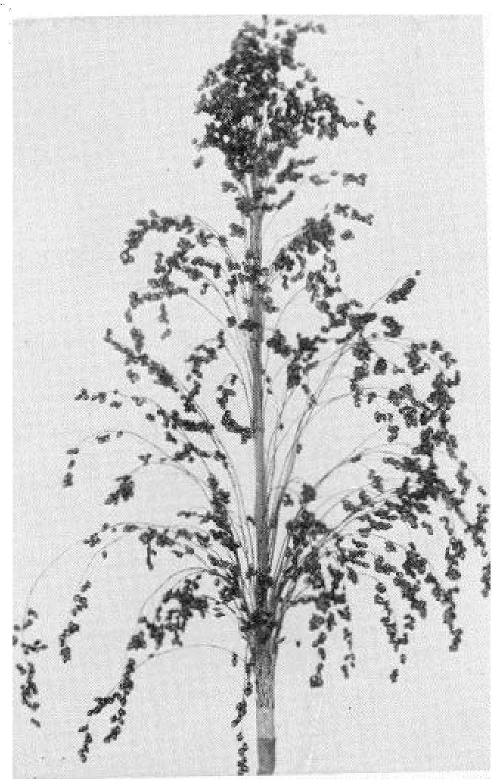

FIGURE 6.—A typical head of Honey sorgo.

#### WILEY

This late-maturing variety originated from two crosses made by USDA. The first cross, made in 1947, involved Collier and MN 822. A second cross was made in 1948 between the first generation from the first cross and MN 2046. A superior selection from the second cross was tested; this was released in 1956 under the name of Wiley.

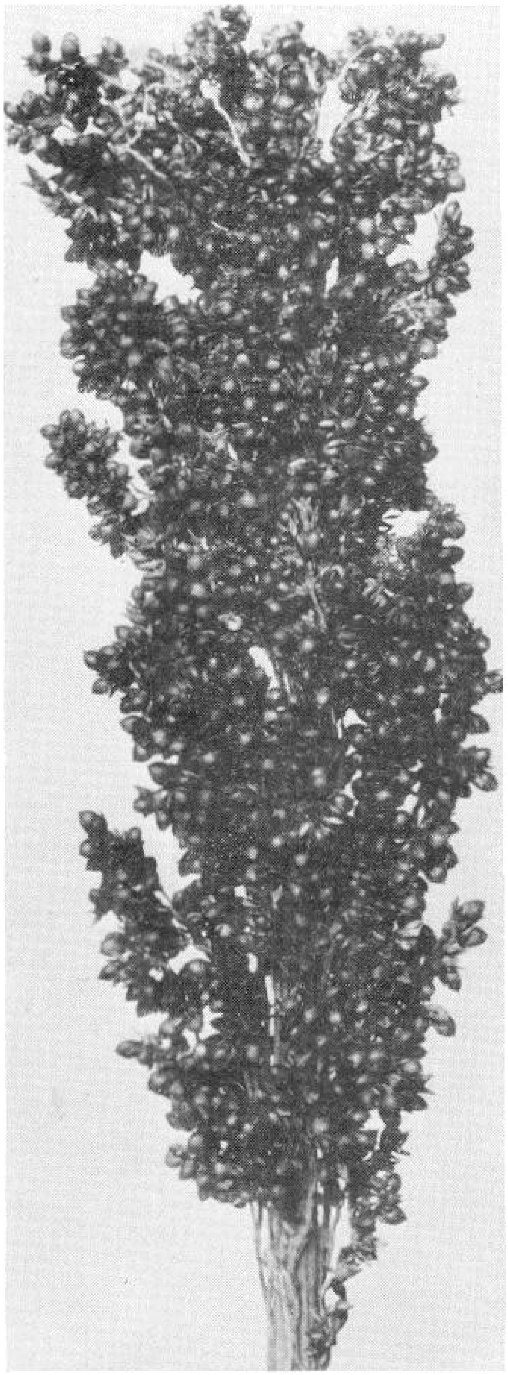

FIGURE 7.—A typical head of Sugar Drip sorgo.

Seed heads of Wiley are of medium length and semicompact to irregularly compact. Small, mostly globose, reddish brown seed extend to about half to three-fourths the length of the straw-colored glumes. The subcoat is absent. Under optimum conditions the stalks grow 12 to 16 feet high. The stalks tend to lodge slightly more than Sart, are quite juicy, and are easily crushed in a small mill. Wiley is immune to red rot and leaf anthracnose, and highly resistant to zonate leaf spot and rust.

The quality of the sirup is good. Wiley usually yields about 19 gallons of sirup per ton of stalks. Acre yields average about 16 percent higher than those of Sart. It is recommended for the area from Tennessee southward.

#### MISCELLANEOUS

Three varieties, Iceberg (fig. 9), Georgia Blue Ribbon, and Williams, have an uncertain ancestry and appear to be closely related. They all have medium-sized, brown seed. The seed have a brown subcoat and are about as long as the dark reddish-brown glumes. Seedheads are semicompact and erect. The juicy stalks are somewhat shorter and smaller barreled than those of Tracy. These three varieties lodge badly and are very susceptible to the major sorgo diseases. They mature at about the same time as Tracy but yield somewhat less tonnage of stalks per acre. They produce an excellent sirup.

## SORGO DISEASES [4]

Only those diseases that are frequently found on sorgo in the sirup area are discussed here.[5]

[4] Information used in this section was furnished by Francis J. LeBeau, formerly Associate Pathologist, USDA.

[5] Detailed information on sorghum diseases is given in Farmers' Bulletin 1959, Sorghum Diseases and Their Control.

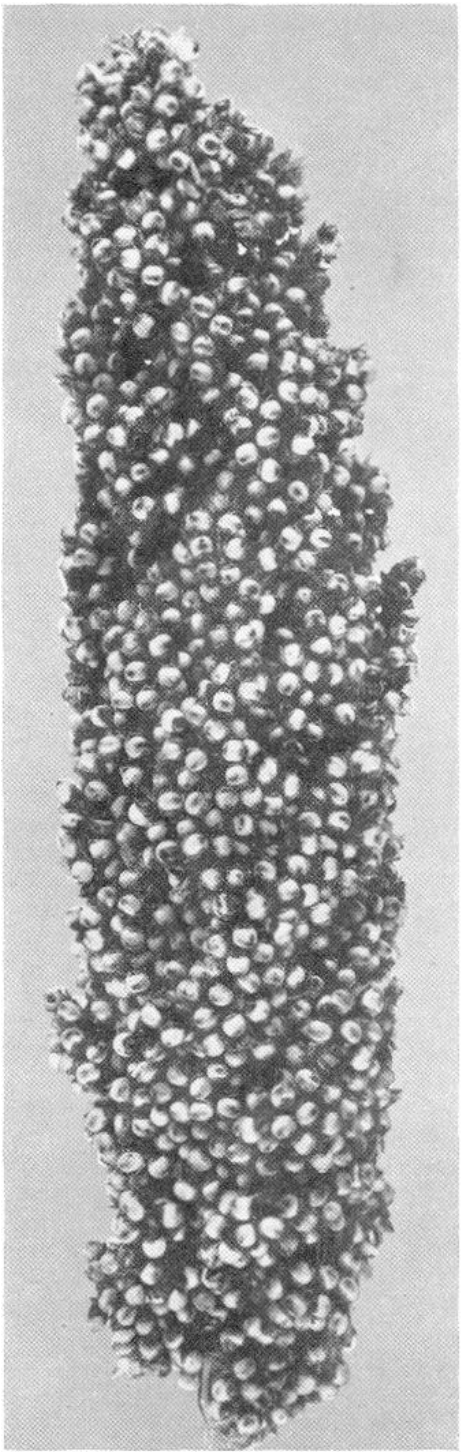

FIGURE 8.—A typical head of Atlas sorgo.

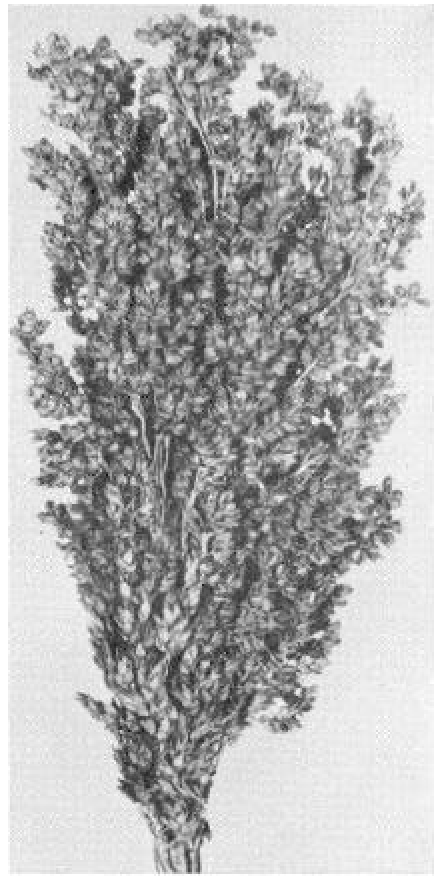

FIGURE 9.—A typical head of Iceberg sorgo.

Damage to a crop of sorgo from any particular disease varies from year to year, depending on locality, weather conditions, and variety. The resistance of different sorgo varieties to diseases should be considered when selecting a variety.

### ANTHRACNOSE AND RED ROT

Anthracnose and red rot [6] [7] are two phases of the most destructive sorgo

[6] Anthracnose is a leaf blight and red rot is a stalk rot; both are caused by the fungus *Colletotrichum graminicolum* (Ces.) G. W. Wils.

[7] More information on anthracnose and red rot is given in Technical Bulletin 1035, Anthracnose and Red Rot of Sorghum.

disease in the major part of the sirup area. Anthracnose may defoliate the plants, markedly reduce the sugar content of the juice, and somewhat reduce the yield of stalks. Red rot, by rotting the interior of the stalks, may cause lodging and subsequent difficulty in harvesting (fig. 10). Badly rotted stalks produce a sirup of inferior quality.

Anthracnose usually appears on the lower leaves in midsummer as small, circular, tan or red to blackish-purple spots. As the spots enlarge, they grow together and destroy large areas of the leaves. When abundant moisture and rainfall prevail, the disease progresses rapidly up the plant and destroys the leaves by harvesttime.

As the plants approach maturity, the fungus develops within the stalk, producing red rot. Infected areas become discolored and in advanced stages the entire stalk, with the exception of the lowermost internodes, becomes rotted. If the diseased stalks are split, red areas, often surrounding white centers, can be seen (fig. 11).

The fungus responsible for anthracnose and red rot overwinters in the crop residues of sorgo, Sudangrass, and Johnsongrass. Rotation and clean cultivation should be practiced to reduce the threat of this disease if a susceptible variety is grown.

The Sart variety is very resistant to anthracnose and red rot. Tracy, though not highly resistant, has never been seriously damaged by either phase of the disease. Atlas is quite resistant to anthracnose and somewhat less resistant to red rot.

#### ZONATE LEAF SPOT

Zonate leaf spot [8] occurs primarily in the more humid sections of the sorgo-growing region. The casual fungus attacks the leaves; eventually it

[8] Caused by the fungus *Gloeocercospora sorghi* Bain and Edgerton.

FIGURE 10.—Lodging in Hodo due to red rot. Resistant varieties in the background are standing.

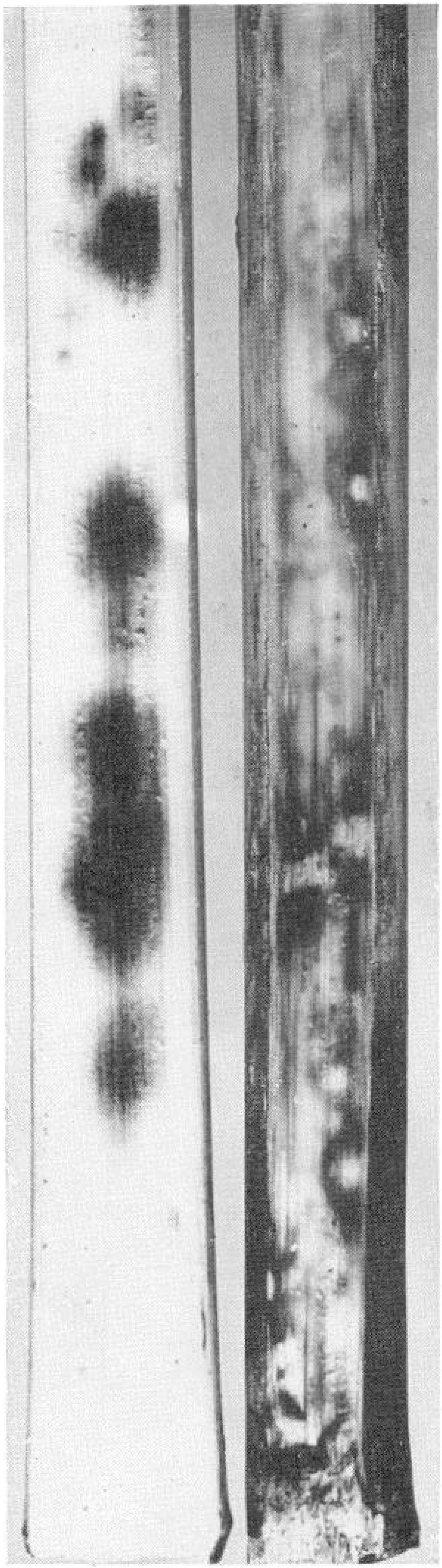

FIGURE 11.—Split sections sorgo stalks showing red rot.

produces large targetlike spots consisting of alternating light and dark circular or semicircular bands. Abundant spotting causes premature destruction of the foliage, reduced sugar content of the juice, and, possibly, reduced yield of stalks. This fungus also attacks Sudangrass, Johnsongrass, other grasses, and sugarcane. Rotation and clean culture to avoid these other hosts of the disease should reduce the likelihood of severe losses in the sorgo crop.

None of the commercial sorgo varieties is known to be resistant to zonate leaf spot.

## RUST

Sorgo rust [9] causes damage in the sirup area in some years; in the more humid sections of the sirup area it causes severe damage almost every year. The presence of the disease on the leaves is indicated by small brownish pustules, filled with powdery brown spore masses. In severe infections these pustules are so numerous that the entire leaf is destroyed. If heavy infection occurs several weeks prior to maturity of the sorgo plant, the sugar content of the juice is seriously lowered. If severe infection occurs when the plants are almost mature, as often happens in some areas, heavy losses may be avoided by harvesting the crop in the late milk or early dough stage.

No commercial sorgo varieties are known to be resistant to rust.

## MINOR LEAF DISEASES

Several minor leaf diseases of sorgo are: Gray leaf spot,[10] rough spot,[11] bacterial stripe,[12] bacterial streak,[13] and bacterial spot.[14]

These diseases vary in prevalence

[9] Caused by *Puccinia purpurea* Cke.

[10] Caused by the fungus *Cercospora sorghi* Ell.

[11] Caused by the fungus *Ascochyta sorghina* Sacc.

[12] Caused by the bacterium *Pseudomonas andropogoni* (E. F. Sm.) Strapp.

[13] Caused by the bacterium *Xanthomonas holcicola* (C. Elliott) Starr & Burk.

[14] Caused by the bacterium *Pseudomonas syringae* Van Hall.

from year to year but rarely cause serious damage.

The chief effect of gray leaf spot and rough spot is a premature destruction of the leaves. Usually, these diseases do not develop early enough to cause serious losses.

The bacterial diseases may appear at any time during the growing season, but do not usually become serious problems. The bacteria can be carried on sorgo seed and in crop debris. Crop rotation and seed treatment usually control these diseases.

#### SMUTS

Three smuts of sorghum occur in the United States: Covered kernel smut,[15] loose kernel smut,[16] and head smut.[17] These diseases are rarely destructive on sorgo in the sirup area. All the sorghum smuts are easily controlled by treating the seed with copper carbonate, basic copper sulfate, New Improved Ceresan, or Arasan. The manufacturers' directions should be followed in applying these treatments.

#### SEED ROT AND SEEDLING BLIGHT

Several soilborne and seedborne fungi reduce stands by rotting the seed after they are planted, or by killing young plants soon after the seed germinate. These fungi may be particularly damaging if a period of cool weather occurs soon after planting. Seed treatment with the same chemicals used to control the smut diseases may help to reduce this type of damage.

#### SUMMARY OF DISEASE-CONTROL MEASURES

Three primary control measures should always be considered in growing sorgo: (1) Planting resistant varieties when they are available, (2) crop rotation and clean cultivation, and (3) chemical seed treatment.

[15] Caused by the fungus, *Sphacelotheca sorghi* (Lk.) Clint.

[16] Caused by the fungus, *Sphacelotheca cruenta* (Kuehn) Potter.

[17] Caused by the fungus, *Sphacelotheca reiliana* (Kuehn) Clint.

## INSECTS INJURIOUS TO SORGO [18]

The sorgos as a rule are not severely damaged by insects. However, they frequently are infested by several species.

#### SORGHUM MIDGE

The sorghum midge [19] occurs over most of the Gulf Coast and South Atlantic States. It is a small orange-colored fly that deposits white eggs in the glumes at blossoming time. The larvae feed on the developing glumes and destroy the sorgo seed. As they grow, the larvae darken from pink to orange. A generation is produced in about 15 days.

The sorghum midge feeds on sorgo, grain sorghum, broomcorn, Johnsongrass, and Sudangrass. It winters as a cocooned larva in the spikelets of the host plant. The flies appear early in the spring at about the time Johnsongrass begins to bloom; they lay their first eggs in the heads of this grass.

It is difficult to control the midge with insecticides. Losses can be reduced, though. Locate sorgo fields where Johnsongrass is not common. Otherwise, cut or destroy any Johnsongrass nearby before it blooms. Plant all the sorgo at the same time and properly space and cultivate to produce uniform heading. Destroy heads that bloom much before the main crop. Plow under or destroy all material in which the midge may hibernate before the flies emerge in the spring.

Satisfactory crops of sorgo for seed can be obtained if paper bags are tied over the heads of selected plants during the blooming season to protect them from midge infestation. Remove the bags shortly after the blooming period because they provide conditions favorable for the corn earworm and corn leaf aphid that attack the seed heads.

[18] From the Entomology Research Branch, Agricultural Research Service. For information on insecticide control of insects attacking sorgo, consult your State agricultural experiment station or the U. S. Department of Agriculture, Beltsville, Md.

[19] *Contarinia sorghicola*

### SUGARCANE BORER

The sugarcane borer[20] occurs in southern parts of Texas, Louisiana, Mississippi, and Florida. It attacks sugarcane, corn, rice, broomcorn, grain sorghum, sorgo, and several wild grasses. The adult is a moth that deposits eggs in clusters on the leaves of the host plant. The eggs hatch into small white larvae that bore into the stalk and make tunnels in it. These tunnels reduce the growth of the injured plants, weaken them so that they break over, and furnish entrance places for various organisms that may lower the sugar content. A generation is produced in about 40 days. The pest overwinters as a larva in the stalks or stubbles left in the field.

Borer injury to sorgo usually is not heavy until the latter half of August or September. Consequently, early-maturing varieties or early plantings are valuable in decreasing injury. In infested areas, plant sorgo as far as possible from fields of sugarcane, corn, and rice. Before moth emergence in March or April, plow under or destroy stubble and pieces of sorgo in which the larvae hibernate.

### CORN LEAF APHID

This green aphid[21] is sometimes very common on sorgo throughout the sirup-producing area. It is usually found in the central whorl or on the panicle after it has emerged. This aphid has been seen in such heavy numbers that it prevented the formation of grain. It transmits the sugarcane mosaic disease, which attacks sorgo. Planting sorgo at some distance from mosaic-infected sugarcane or wild grasses is desirable.

### FALL ARMYWORM

The fall armyworm[22] is found in the United States wherever sorgo is grown for sirup. The larva is grayish and has three whitish longitudinal bands and a blackish head. It is about 1⅝ inches long when full grown. It eats the leaves of corn, sugarcane, sorgo, and a number of wild grasses, and may strip the plant of leaves.

[20] *Diatraea saccharalis.*
[21] *Rhopalosiphum maidis.*
[22] *Laphygma frugiperda*

### CORN EARWORM

The corn earworm[23] is found throughout the United States. It attacks many food plants. The moth varies from a light olive green to a dark reddish brown. Eggs are laid singly on sorgo leaves and hatch in about 4 days. The caterpillars, feeding mostly in the leaf whorl, become full grown in about 3 weeks and are then about 1½ inches long. They are pink, green, cream, or yellow, and often striped. The pupae pass the winter in the soil. In the Gulf States there are four full broods each year.

### WIREWORMS

Wireworms are the larvae of click beetles. They are yellow or brown and ½ to 1 inch long. They are hard, shiny, and slender.

Wireworms injure sorgo by boring into the plant seed, drilling into the young shoots, and feeding on the roots. Sometimes replanting is necessary.

### OTHER INSECTS

The lesser cornstalk borer[24] has caused serious loss at times by boring into the sorgo plant near the soil surface. This larva is slender, greenish, and has dark-brown, longitudinal bands. It is about 1 inch long when full grown. It makes a rapid jerking motion when disturbed.

The whorls of the sorghum plant often are infested by the sharp-nosed grain leafhopper.[25] Stink bugs[26] have been observed in considerable numbers sucking the glumes. Flea beetles sometimes feed on the under surface of the leaves.

[23] *Heliothis zea*
[24] *Elasmopalpus lignosellus.*
[25] *Draeculace phala portola.*
[26] *Pentatomidae.*

#### INSECTS INJURIOUS TO STORED SEED

Sorgo seed are attacked by many insects that commonly infest stored grain. The more important of these are the Angoumois grain moth [27] and the rice weevil.[28] These insects attack the seed in the field and continue their depredations after the seed are placed in storage. Mixing DDT with sorgo seed at the rate of ½ ounce of 3-percent DDT per bushel of seed controls the insects. This treatment apparently does not decrease germination. Sorgo seed treated with DDT should not be used for livestock feed.

## CULTURAL PRACTICES

Yield and quality of sorgo sirup and the economy of handling the crop are affected chiefly by the soil type, fertilizer practices, growth and diameter of stalks, uniformity in reaching maturity, erectness of the stalks, and ability to withstand deterioration after reaching approximate maturity. The cultural practices that influence these factors are discussed in the following pages.

#### SOIL REQUIREMENTS

Many different types of soil are used for the production of sorgo, but a soil of good physical character and high fertility produces the best yields. It is difficult to get a satisfactory stand on poor soils. Also, growth is slow and the stalks are small. In general, loam and sandy loam soils are best for the growth of sorgo for sirup production.

Soils rich in organic matter are thought to have a detrimental effect on the quality of sirup. However, if other cultural practices are satisfactory, sirup of good quality is frequently made from sorgo grown on soils that are rich in organic matter supplied by green manure crops.

The field should have good natural drainage, especially in localities that may have periods of heavy rainfall. Ample moisture during the growing period is also important for good yields of stalks and sirup. Organic matter improves the waterholding capacity of the soil.

If the planting is to be done early in the season, a soil that becomes warm early should be used.

Heavy clay soils warm slowly in the spring, remain cloddy after the seedbed has been prepared, and have a tendency to form crusts through which the sorgo seedlings cannot push to the surface. Such soils produce poor stands, poor yields, and poor sirup. They should not be selected for sorgo sirup production.

#### CROP ROTATION

Sorgo usually fits into the common cropping system. Cotton and corn are the principal crops in most of the sorgo sirup belt. They can be used with sorgo in a rotation system. Since cotton is a clean-cultivated crop, it usually leaves the land in good condition for sorgo the next year; few weeds will be present in the soil to interfere with the young sorgo plants. The cotton stalks must be thoroughly chopped into the soil several weeks before planting sorgo, so that the deterioration of the stalks will not interfere with the germination of the seed.

A winter cover crop may be grown in the cotton rows. However, during many seasons a cover crop cannot be planted early enough in the fall to produce a satisfactory growth before cold weather. Since the cover crop must be turned under early in the spring to avoid damage to sorgo seed, it usually does not have time to produce a satisfactory yield of green manure.

Sorgo may be grown successfully following a corn crop. The corn stalks must be thoroughly chopped into the soil several weeks before planting time. However, an abundance of weed seed is usually present in the soil following the corn crop; it is therefore better for sorgo to follow some crop other than corn.

[27] *Sitotroga cerealella.*
[28] *Sitophilus oryza.*

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FIGURE 12.—A good growth of soybeans in Mississippi.

Planting soybeans in May or June on land to be used for sorgo the following year is usually a very good practice. The growth is disked down and permitted to remain on top of the soil during the winter months (fig. 12); then it is turned under and allowed to deteriorate in the soil. Or the beans are harvested and the stalk refuse spread on the land. After either treatment, the land usually has enough organic matter to place it in good condition for the sorgo seed the following year.

Other types of leguminous plants, particularly blue lupine (where this crop does well), have been used with equal success.

#### FERTILIZER PRACTICES [29]

Whether the land used for growing sorgo requires fertilizer depends largely on soil texture, rainfall, crop history, and previous additions of manure and fertilizer.

[29] Information for this section was furnished by E. S. Lyons, research agronomist, Field Crops Research Branch, Agricultural Research Service.

The heavy types of soil may produce a good sorgo crop with little or no fertilizer. Sandy soils are less fertile and usually require fertilizer for a good growth of sorgo. Some of the upland soils of intermediate types, such as silt loams, produce low yields without fertilizers.

When legume cover crops are used for green manure, the need for fertilizer, especially nitrogen, is reduced. This is also true for land that has been well manured in the past or for land just plowed out of improved pasture.

Many growers add fertilizer or manure in moderate quantities before planting sorgo on soils of low fertility. This treatment furnishes the young plants with an abundant supply of plant food to give them a quick start. It also helps them to overcome such hazards as weeds, soil crusts, insects, and diseases.

In a fairly fertile soil a small application of fertilizer to help this early growth may be all that is necessary for the entire season. On many soils, however, the quantity of fertilizer applied at planting time should be greater than that needed for a starting effect only. Also, more fertilizer may be added later.

The fertilizer requirements of sorgo are similar to those of corn. If specific information on the fertilizer needs of sorgo is not available, the same practices used for corn should prove satisfactory. However, it may be advisable to omit high-nitrogen applications.

Each grower should study his soils and fertilizer practices and get current fertilizer recommendations from the nearest experiment station or the county extension agent.

Most of the fertilizer used for sorgo is a mixture of nitrogen, phosphorus, and potassium. The ratio varies in different localities, depending on local requirements or customs. Nitrogen is particularly needed in most soils and is usually given first consideration.

It is not possible to recommend a single fertilizer practice to fit all farm conditions. In the absence of specific information about the needs on a particular farm, the grower should use the standard fertilizer formula for his section, such as 4–8–4, 6–8–4, 4–8–6, 5–10–5, or 6–8–8 (N, $P_2O_5$, $K_2O$, respectively) at a rate of 200 to 500 pounds per acre. Where fertility is low, it may be advisable to make a second application (or side dressing) of a mixed fertilizer or nitrogen.

Some growers apply 300 to 500 pounds of a 4–8–4 or 5–10–5 mixed fertilizer per acre before planting and a side dressing of 20 to 30 pounds of nitrogen; the total amount is 30 to 40 pounds each of nitrogen and phosphorus and 20 pounds of potash per year. If more potash is needed a 4–8–8 mixed fertilizer is used at planting time.

It was formerly believed that nitrogen added in an organic fertilizer, such as cottonseed meal or tankage, gave a superior sirup. Present information

FIGURE 13.—Horse-drawn fertilizer distributor.

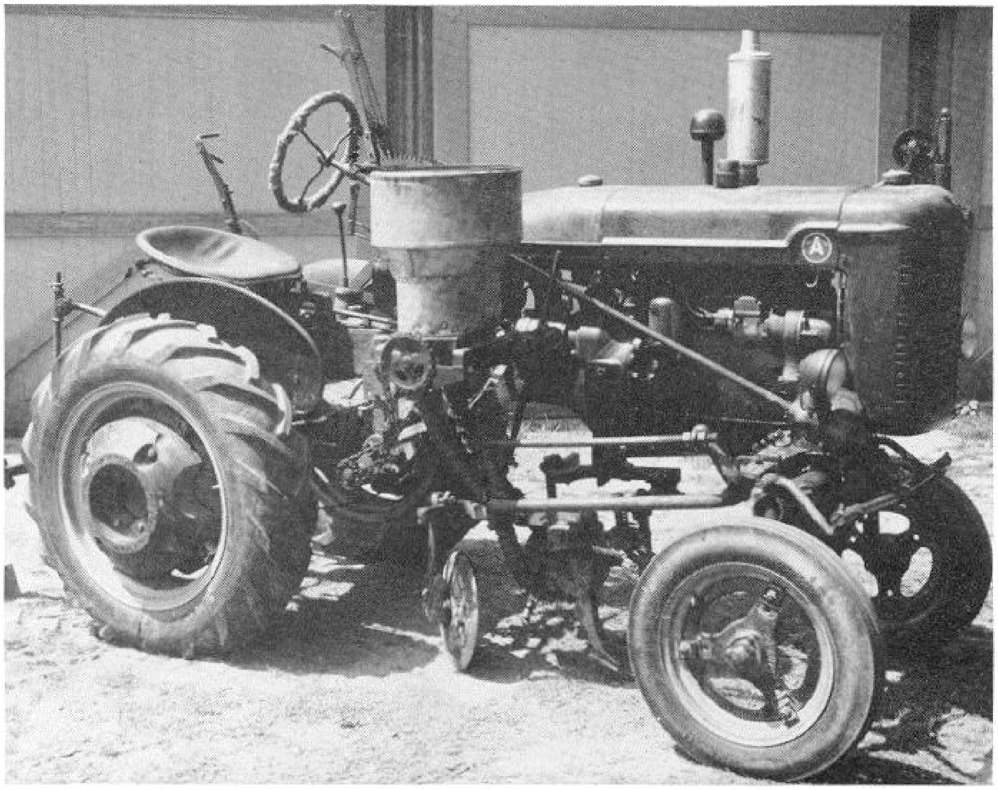

FIGURE 14.—A tractor-propelled fertilizer distributor.

indicates that a sirup of good quality can be produced also by the use of inorganic nitrogen (in ammonium sulfate, sodium nitrate, ammonium nitrate, and anhydrous ammonia). It should be applied during early growth in amounts not exceeding the requirements of the crop.

A late application of manure or high-nitrogen fertilizer ordinarily should be avoided. When a side dressing is used, the fertilizer should be applied before the crop is 30 inches tall. If fresh manure is used, it should be applied to the previous crop instead of directly to the sorgo crop. If heavy additions of manure are made directly preceding the sorgo, a sirup of poor quality may be produced.

When the fertilizer is applied in the row, either beside or below the seed, smaller applications are required than when it is broadcast. Both methods appear to be satisfactory. The seed should never be allowed to come in contact with the fertilizer. This contact may cause death of some of the emerging seedlings and result in a poor stand.

Mechanical distributors are usually used to apply the fertilizer during preparation of the rows or beds, or beside the drill at the time of planting. A horse-drawn distributor of the type commonly used for a small acreage of sorgo is shown in figure 13. Tractor-propelled distributors of the type shown in figure 14 are used by many farmers, especially where large acreages are involved. Later, during the cultivation of the crop, the same equipment can be used to apply a side dressing along the row.

### SEEDBED PREPARATION

Thorough preparation of the seedbed by plowing close (flat breaking) to a depth of 4 to 6 inches is important in the production of sorgo. A small horse-drawn plow can be used for preparing the seedbed for a small acreage. Tractor-operated moldboard and disk plows are now used extensively for that purpose on large fields. The land should be plowed early so that there will be ample time for all plant material to decay before the average planting date for sorgo.

Disking the land thoroughly after plowing destroys clods and facilitates decomposition of the organic matter. Most often the organic matter is left on top of the soil through the winter months, where it protects the soil against erosion and remains in the best form until spring. This material is later disked into the soil during seedbed preparation.

The seedbed should be harrowed immediately before planting. A one-row, spike-tooth harrow known as "Little Joe" is useful for small fields. Large, spike-tooth harrows (fig. 15), capable of harrowing 2 or 3 rows at one time, are used when large areas are to be planted.

Before planting, a cultipacker or other suitable roller should be run over a seedbed even if it is well prepared. Figure 16 shows a 1-row roller constructed in a farm shop; a 30-gallon metal drum filled with concrete and a wooden sled were used. The roller crushes the clods, firms the soil, and leaves the land in ridges about 4 inches high. This operation makes possible a uniform depth of planting.

TABLE 4.—*Yields from three date-of-planting tests of sorgo at Meridian, Miss.*[1]

| Date of planting | Stalks per acre | Sirup | |
|---|---|---|---|
| | | Per ton of stalks | Per acre |
| | *Tons* | *Gallons* | *Gallons* |
| Mar. 24 | 14.3 | 17.8 | 254 |
| 31 | 14.1 | 17.7 | 250 |
| Apr. 7 | 15.5 | 17.0 | 263 |
| 14 | 15.5 | 17.0 | 263 |
| 21 | 15.8 | 17.0 | 269 |
| 28 | 14.2 | 17.0 | 241 |
| May 5 | 14.2 | 17.0 | 241 |
| 12 | 15.2 | 16.1 | 245 |
| 19 | 13.2 | 15.8 | 209 |
| 26 | 12.3 | 15.6 | 192 |

[1] Each figure is the average of 12 observations.
Soil: Susquehanna sand. Variety: Hodo.

TABLE 5.—*The influence of planting date on the number of days required for two varieties of sorgo to reach the dough stage of maturity at Meridian, Miss.*[1]

| Date of planting | Number of days to maturity | |
|---|---|---|
| | Hodo | Iceberg |
| Mar. 24 | 186 | 129 |
| 31 | 179 | 126 |
| Apr. 7 | 172 | 126 |
| 14 | 165 | 124 |
| 21 | 160 | 117 |
| 28 | 157 | 117 |
| May 5 | 150 | 110 |
| 12 | 143 | 113 |
| 19 | 136 | 106 |
| 26 | 129 | 106 |

[1] Based on data from date-of-planting tests.

### PLANTING TIME

The optimum time to plant sorgo can best be determined from actual practices in the community. Planting when the soil is thoroughly warm produces good germination, early growth, and uniform stands. An adequate supply of moisture is also essential for satisfactory germination and early growth. Therefore, delay in planting until rainfall is scant and the warming of the soil has resulted in much loss of moisture, is not advisable.

Typical yield data from date-of-planting tests in Mississippi with the Hodo variety of sorgo (table 4) show that under normal conditions the best planting time may extend over a period of several weeks. In the March plantings the early growth was slow; as a result weed control was difficult. In the late May plantings, total production was low. These data show that the best planting period was from early April to the middle of May.

Late plantings grow more rapidly than early plantings (table 5, col. 2, Hodo). However, sorgo must be

FIGURE 15.—Three-section spike-tooth harrow preparing the seedbed for sorgo.

FIGURE 16.—A 1-row roller constructed in a farm shop.

planted early enough to mature before the first killing frost.

The best time to plant is also influenced by the variety. Some varieties are more sensitive than others to the length of day, as shown by the two varieties in table 5. The number of days from planting to maturity decreased much more in Hodo, which is a late-maturing variety, than in the Iceberg, which is a midseason variety.

The late-maturing varieties usually produce the highest yields of sirup per acre. However, even under the best planting conditions the late-maturing varieties take longer to develop than early varieties. The late-maturing varieties can be grown only in localities where the plants reach maturity by harvesttime.

In the major sirup-producing States the planting period may extend from early April to about the middle of May. The planting period may be limited in the northern part of the sorgo sirup belt to a 10- to 15-day period near the middle of May. Otherwise, the plants may not mature before the first killing frost.

### PLANTING METHOD

Planting is one of the most important cultural operations in sorgo production. A uniform, adequate stand influences the yield obtained and the amount of work required to control weeds. The seed should be covered about 1 inch deep on sandy soils and about ½ inch deep on the heavier soils. The soil should be firmly packed around the seed. Many dependable horse-drawn or tractor planters (figs. 17 and 18) that drop the seed regularly either in hills or drills are equipped with a split, concave wheel for covering and packing the soil around the seed. Hill plantings of 2 stalks every 16 inches, 3 stalks every 24 inches, and 4 stalks every 24 inches have produced yields equal to drill plantings where 1 stalk is left every 8 to 10 inches in the row. Sorgo seed germinate within 3 to 5 days under optimum moisture and temperature conditions.

### ROW SPACING

Most sorgo is planted in drills that are spaced about 3 feet apart on low

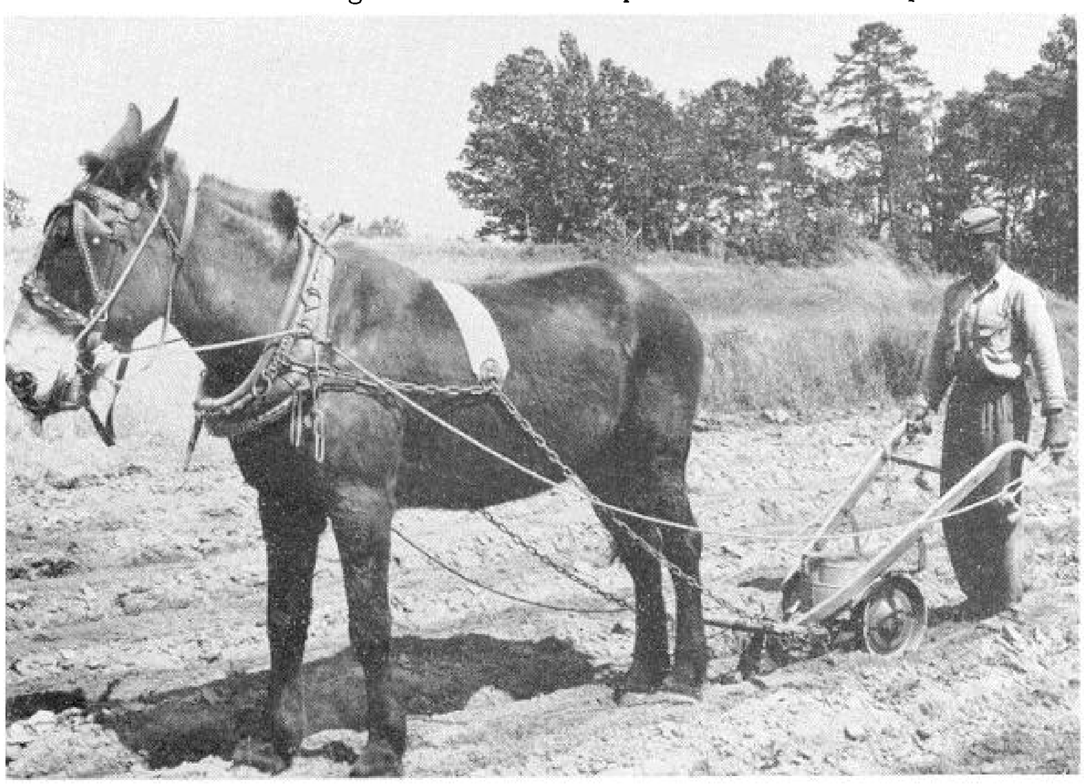

FIGURE 17.—A 1-row planter used for planting sorgo.

ridges or on practically level land. Ridges usually hinder soil erosion on sloping land and facilitate drainage on level land. Planting sorgo in rows 4 to 6 feet apart results in low yields.

The data in table 6 show typical yields from different row spacings. Most of the equipment on farms in the sorgo sirup belt is not designed for cultivating rows spaced 2 feet apart. The relatively small advantage of using such narrow rows usually does not justify the extra total expenditure that is involved. On the other hand the advantages of cultural operations in 5-foot rows are offset by the low yields of stalks and sirup per acre. Rows spaced about 3½ feet apart are generally satisfactory for sorgo production in the sirup belt.

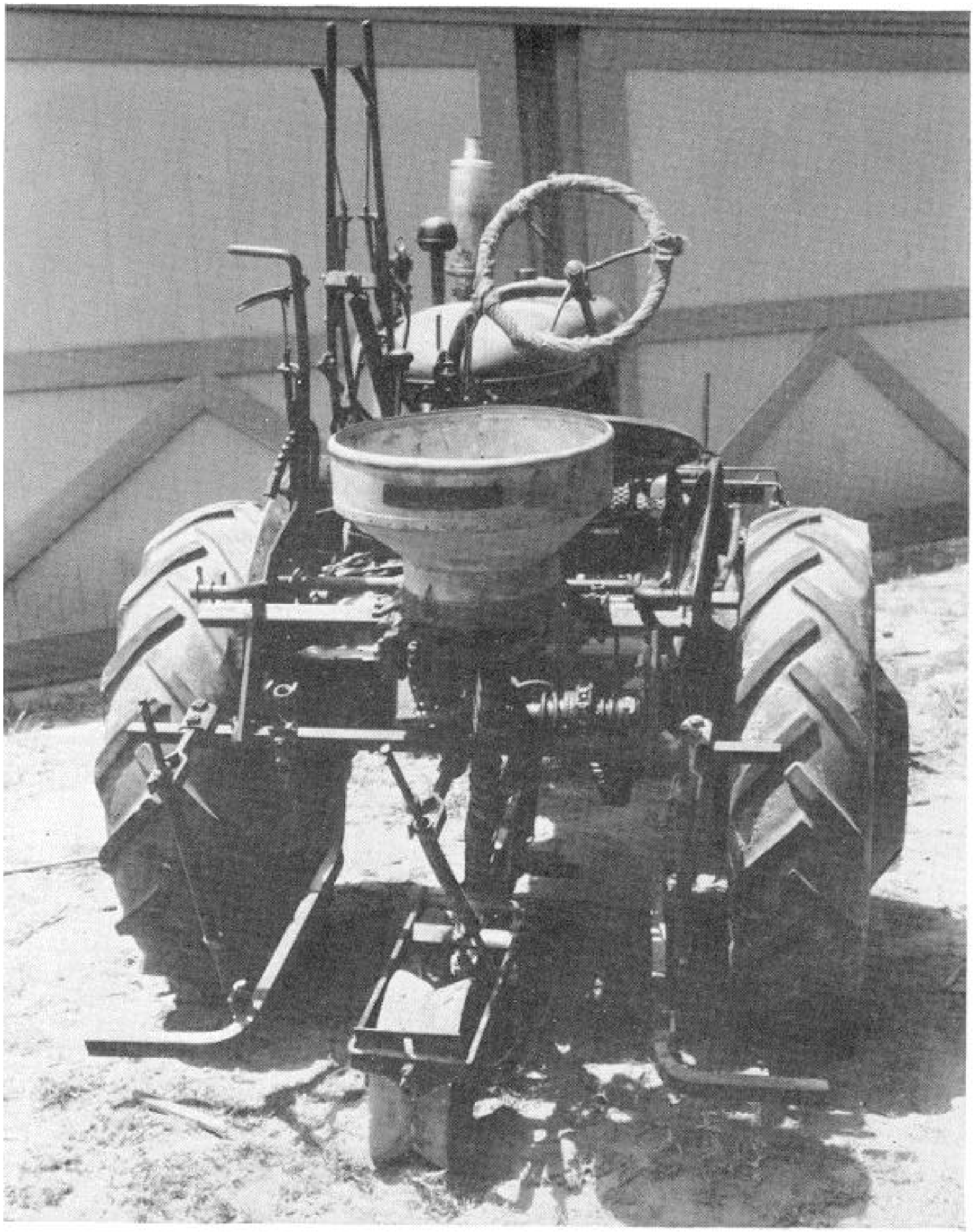

FIGURE 18.—A tractor-operated planter equipped with a knife-type opener.

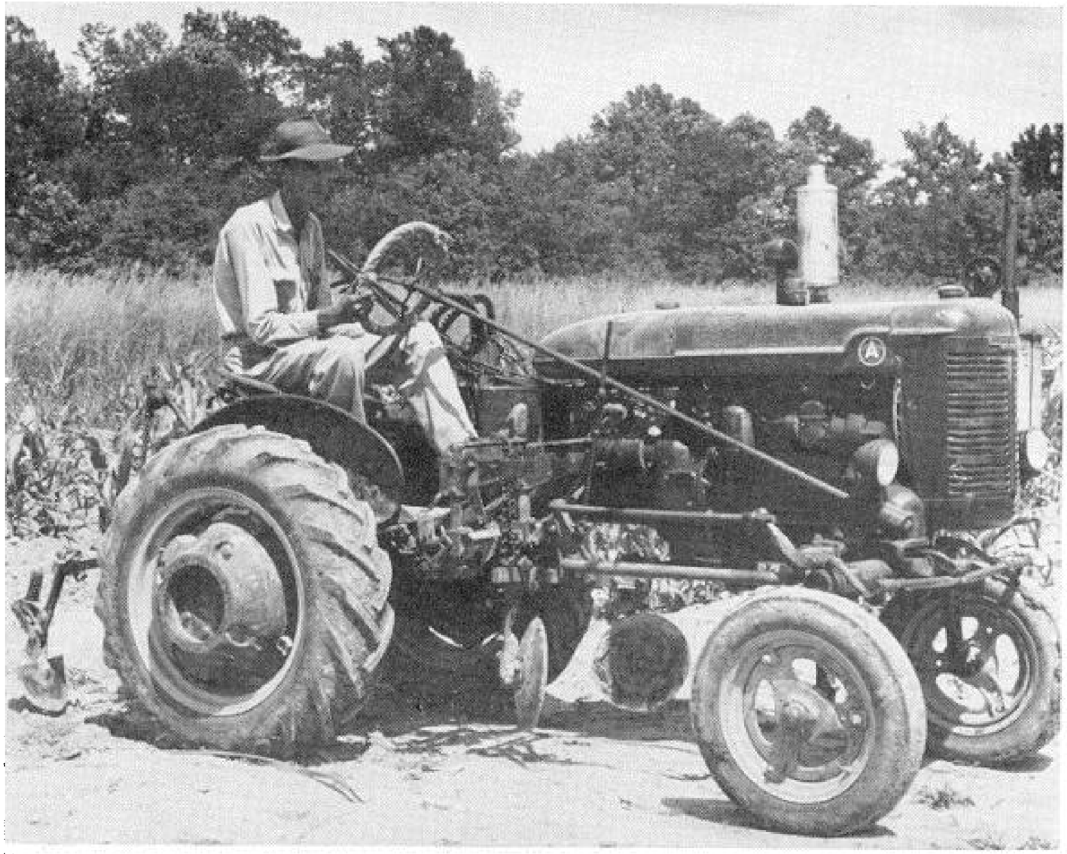

FIGURE 19.—A 1-row tractor cultivator equipped with small disks and sweeps useful for cultivating sorgo throughout the season.

### CULTIVATION

Cultivation should start when the plants are 3 to 4 inches high. Early cultivation can be performed successfully with horse-drawn or tractor cultivators equipped with spring teeth, small plows, or small disks (fig. 19). These critical, early, shallow cultivations control the young weed growth and furnish a mulch around the plants. Depth of cultivation depends largely on the root spread; it should destroy weeds but not prune the root system excessively. Early cultivations may be somewhat deeper than later ones because root development in the early stages is not extensive. In the middles, the early cultivations may be deeper than next to the plants; moderately deep cultivation may often be continued there without causing injury until the crop is ready to lay by.

The cultivation may be level or the rows may be ridged (fig. 20). Ridges reduce soil erosion, facilitate drainage, and anchor the stalks against lodging.

Time of planting, variety of sorgo, type of weed infestation, and climatic conditions influence the number of cultivations. Since late plantings grow

TABLE 6.—*Results of a typical row-spacing test at Meridian, Miss.*[1]

| Row spacing [2] (feet) | Weight of stalks | | Sirup | |
|---|---|---|---|---|
| | Per acre | Per stalk | Per ton of stalks | Per acre |
| | *Tons* | *Pounds* | *Gallons* | *Gallons* |
| 2 | 19.6 | 1.2 | 18.3 | 359 |
| 3 | 18.2 | 1.5 | 19.0 | 346 |
| 4 | 12.2 | 1.4 | 19.5 | 238 |
| 5 | 11.9 | 1.4 | 19.1 | 227 |

[1] Soil type: Susquehanna sand. Variety: Hodo.

[2] The plants were spaced 8 inches apart in the drill. All row spacings were fertilized at a uniform rate per acre.

FIGURE 20.—Cultivating sorgo with a tractor cultivator.

rapidly, fewer cultivations are needed for them than for early plantings. Early-maturing varieties grow faster early in the season than late-maturing ones, shade the soil sooner, and usually require fewer cultivations. Perennial weeds, such as Johnsongrass and Bermudagrass, and fast-growing vigorous annuals may necessitate more cultivations.

#### HOEING AND THINNING

Hoeing to remove weeds and space plants properly in drills may be done when the plants are about 3 inches tall. Whether hoeing is done immediately before or promptly after the first cultivation depends largely on the weed infestation. When the weed infestation is heavy, hoeing is usually easier and cheaper after the first cultivation. Thinning (spacing) should always be done before tillers are put forth; the earlier the thinning is done, the better.

The plants in single drills should be spaced 8 to 12 inches apart at the time of first hoeing. Figure 21 shows a stand of sorgo in which the stalks were spaced 8 to 10 inches apart when they were about 3 inches tall.

Closer spacing of the plants (table 7) results in small, weak stalks and lowered yields of sirup. Similar results are obtained when the stand is not thinned, as indicated in the check. The amount of leafy material on such stalks is much greater than when the plants are spaced 8 inches apart.

Varieties differ in their ability to compensate for wide spacing or gaps in a drill. With most varieties the yield of sirup per acre is decreased when single plants are spaced more than 12 inches apart. This reduction in yield is due to a decrease in the population of stalks per acre. The actual size of the stalks is usually larger.

#### CHEMICAL WEED CONTROL

The use of chemicals for controlling weeds in sorgo shows promise. Investigations are being conducted by the United States Department of Agriculture and the Mississippi State Experiment Station to determine the best

FIGURE 21.—A satisfactory stand of sorgo. Note that the original stalks have produced numerous tillers.

TABLE 7.—*Average results of two spacing tests of sorgo at Meridian, Miss.*[1]

| Spacing of plants[2] | Weight of stalks | | Sirup | |
|---|---|---|---|---|
| | Per acre | Per stalk | Per ton of stalks | Per acre |
| | *Tons* | *Pounds* | *Gallons* | *Gallons* |
| Check[3]... | 21.1 | 1.4 | 17.5 | 369 |
| 4 inches... | 20.4 | 1.6 | 18.6 | 379 |
| 8 inches... | 22.3 | 1.9 | 19.3 | 431 |
| 12 inches.. | 20.9 | 2.1 | 19.4 | 405 |
| 16 inches.. | 18.8 | 2.2 | 19.4 | 365 |
| 20 inches.. | 17.5 | 2.4 | 18.8 | 329 |

[1] Each figure is the average of 12 observations. Soil: Ochlockonee sandy loam. Variety: Hodo.

[2] The seed were planted in a single drill in rows spaced 42 inches apart.

[3] The checks, not thinned, on the average had one plant per inch.

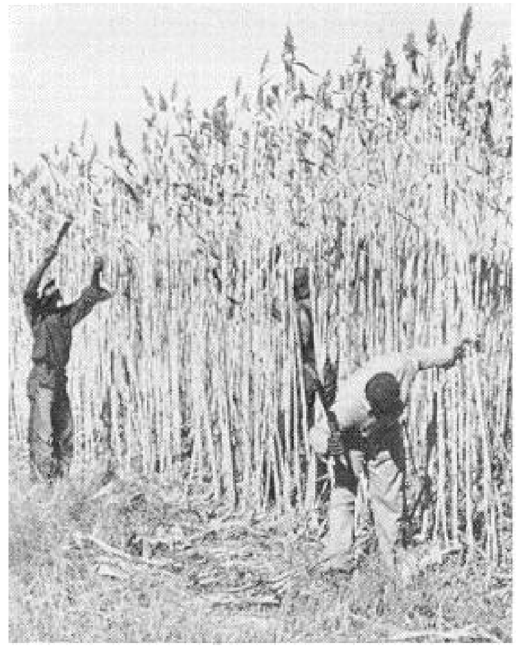

FIGURE 22.—Cutting sorgo with a cane knife at Meridian, Miss.

weed killer to use and the best way to apply it.

## HARVESTING

Changes in the composition of the juice and soundness of the stalks as the crop matures influence the quantity and quality of the sirup. It is essential that the grower be skilled in judging the right time for harvesting.

After the stalks reach their full size, maturity of the entire plant advances at about the same rate as the maturity of the seedhead. The plants are generally considered mature when the seed are hard (ripe). However, this is only an approximate method of determining maturity of the plant. Differences in maturity of the stalks as shown by the seedheads depend on varieties and on climatic conditions from one year to another.

Descriptions of the stages of maturity of the seed are given below:

*Early-flowering.*—Flowers open 2 inches down from the top of the seedhead (panicle).

*Flowering.*—Flowers open ¾ of the distance down from the top of the seedhead.

*Late-flowering.*—All flowers on the seedhead open.

*Early-milk.*—Contents of the seed a thin milky liquid.

*Late-milk.*—Contents of the seed a thick milky semisolid. This stage is often described as late-milk to early-dough.

*Dough.*—Contents of the seed of the consistency of soft dough.

*Hard-dough.*—Contents of the seed firm, pliable, and easily crushed between thumb and index finger.

*Ripe.*—Seed firm, sometimes hard, and not easily crushed with the fingers.

When suitable facilities are available, the most accurate way to determine the time for harvesting is to run adequate mill and laboratory tests to evaluate the yield and quality of sirup. The best product is obtained sometime immediately preceding the ripe stage.

The effect of time of harvesting sorgo at different stages of maturity on yield of sirup is shown in table 8. The data indicate a progressive increase in the sugar content of the juice and in the yield of sirup per ton of stalks from the early-flowering through the ripe stage. Harvesting should therefore be delayed until the seed reach the hard-dough stage, provided other factors permit the making of a good-quality sirup. Delaying the harvesting operations after the seed have reached the

**Table 8.**—*Results of four time-of-harvesting tests of sorgo at Meridian, Miss.*[1]

| Stages of maturity | Weight per stalk | Laboratory mill juice analyses | | | | Sirup per ton of stalks |
|---|---|---|---|---|---|---|
| | | Extraction | Brix | Sucrose | Purity | |
| | *Pounds* | *Percent* | | *Percent* | *Percent* | *Gallons* |
| Early-flowering | 1.45 | 57.3 | 11.23 | 4.70 | 41.9 | 12.7 |
| Flowering | 1.43 | 57.8 | 12.07 | 5.64 | 46.7 | 13.8 |
| Late-flowering | 1.39 | 58.0 | 13.14 | 6.92 | 52.7 | 15.0 |
| Early-milk | 1.45 | 58.5 | 14.73 | 8.86 | 60.1 | 17.0 |
| Late-milk | 1.40 | 57.5 | 15.20 | 9.57 | 63.0 | 17.3 |
| Dough | 1.39 | 57.9 | 15.76 | 10.28 | 65.2 | 17.8 |
| Hard-dough | 1.30 | 56.8 | 16.34 | 10.94 | 67.0 | 18.3 |
| Ripe | 1.41 | 56.2 | 16.54 | 11.29 | 68.3 | 18.4 |
| Post-ripe 1 week | 1.34 | 55.7 | 15.79 | 10.64 | 67.4 | 17.4 |
| Post-ripe 2 weeks | 1.26 | 56.1 | 15.18 | 10.11 | 66.6 | 16.8 |
| Post-ripe 3 weeks | 1.24 | 54.4 | 14.65 | 9.32 | 63.6 | 15.8 |

[1] Each figure is the average of 100 observations.

hard-dough stage is not usually profitable.

Some varieties that yield a good-quality sirup when harvested in the dough stage produce a poor quality when harvested at a later stage. Varieties that are particularly susceptible to diseases may yield a good quality of sirup, though in a smaller quantity, in the late-milk stage; if harvesting were delayed, the stalks might be almost worthless.

Harvesting practices vary considerably throughout the sorgo sirup belt, depending largely on the acreage involved and on local customs. Stripping the leaves from the stalks by hand is usually done first. If possible the stripping should be done while the stalks are standing. Leaves may be struck off with a paddle, a cane stripper, or the knife used to cut the stalks, or they may be pulled off by hand. Leaf sheaths usually remain on the stalks. All side branches should be removed from the stalks. The top internode, or peduncle, contains less sugar than the remainder of the stalk and should be removed with the seedhead.

Cutting sorgo for sirup production is also commonly done by hand (figs. 22 and 23). A corn knife, cane knife, or hoe may be used for this job. As the stalks are cut they are laid across the rows preparatory to being hauled to the mill. Sometimes the stalks are loaded directly on wagons or trailers as they are cut, thus saving time in handling. Generally, the stalks are cut near the surface of the soil; if cut

Figure 23.—Cutting sorgo with a hoe at Crossville, Ala.

higher there is a loss of tonnage and total production of sirup. Juice from the lower internodes usually contains less sugar than that from internodes in the middle of the stalks.

Since most sorgo sirup is manufactured on small-scale equipment, stripped stalks must sometimes remain in the field or at the mill for several days before they are milled. This practice does not cause a loss of sirup if the stalks are in good condition at the time of harvest, if they are stored not longer than 7 to 10 days, and if they are not subjected to freezing temperatures.

Some farmers shock the sorgo stalks in the field or at the mill during the storage period, either with or without the leaves. If the leaves are not removed before milling, the yield of juice and the yield and quality of sirup may be decreased.

Many farmers save seed for planting the next crop or for sale to other farmers. This is a good practice if the seed have reached the hard-dough stage of maturity at the time of harvest, if the field is sufficiently isolated to prevent mixing with other varieties, if the seed have not been damaged by insects or freezing temperatures, and if suitable facilities are available for drying the seed.

FIGURE 24.—Grinding sorgo at a sirup mill in Coosa County, Ala. Note the juice coming out of trough.

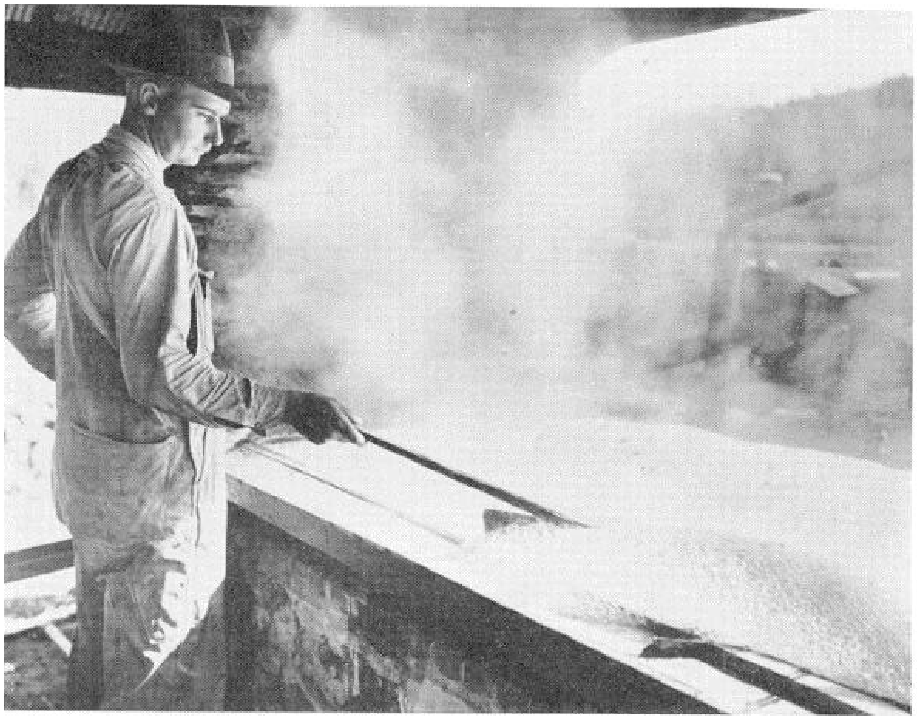

FIGURE 25.—Finishing sorgo sirup in the finishing pan at a sorgo sirup mill in Coosa County, Ala.

The seed may be dried by (1) spreading the seedheads thinly on a floor where there is good aeration, or on an almost flat roof during dry weather; (2) tying the seedheads in bunches or placing them loosely in gunny sacks and hanging them in a sunny or airy place; or (3) subjecting the seedheads to artificial heat in a drier. The last method is usually the surest and quickest way of adequately drying the seed. A good procedure dries not only the seed but also the peduncles and branches of the seedheads in a relatively short time.

When the seedheads are dry, the seed should be threshed immediately either by hand or with a suitable thresher. After threshing the seed should be thoroughly cleaned and cured by proper aeration or in a drier. They should then be placed in tight containers and treated chemically to prevent insect damage during the winter months. (See "Insects Injurious to Stored Seed," p. 17.)

## MANUFACTURE OF SORGO SIRUP

The yield and quality of sorgo sirup are also influenced by the equipment and process used in manufacture and by the skill of the sirup maker. The principal manufacturing methods are presented briefly.

Several types of mills are used. When the total volume of sorgo is small, a small, upright, 3-roller mill propelled by animal power is usually used for crushing the stalks. Larger mills, usually consisting of three horizontal rollers, and propelled by motor power, are used when large quantities of sorgo are involved (fig. 24). The extraction of juice should be between 50 and 60 percent; that is, 100 pounds of stripped and topped stalks should furnish 50 to 60 pounds of juice. Extracting less juice results in less sirup. More juice may be extracted if such a procedure does not lower the quality of the sirup.

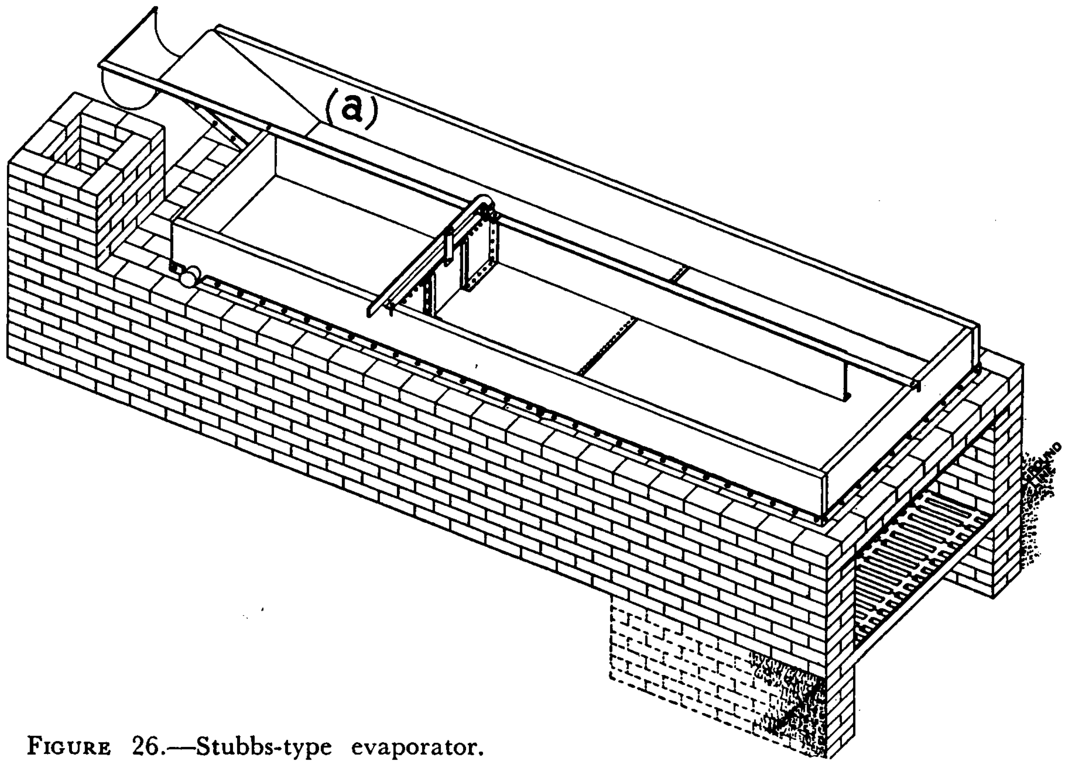


FIGURE 26.—Stubbs-type evaporator.

Most farmers make sorgo sirup on open-type, galvanized-iron or copper evaporators (fig. 25). These evaporators are shallow and have crosswise baffles. One big advantage of the continuous-type evaporators is that a steady stream of cold juice enters the lower end of the pan and then flows slowly to the opposite end, where it is drawn off as finished sirup.

The Stubbs pan is another type of continuous, open evaporator. It is not used so widely but it requires somewhat less skill for efficient operation. The model shown in figure 26 is 12 feet long, 3 feet 6 inches wide, and 10 inches deep. The juice side (a) is 15 inches wide; the other side is 2 feet 3 inches wide. Juice enters the upper end of (a), travels lengthwise along the high, longitudinal partition, around the end of this partition, and back up to the finishing-off compartment.

Fuels used for heating the evaporators include wood, oil (kerosene or fuel oil), liquid petroleum gas, and coal. In small-scale operations the fire heats the bottom of the evaporator. In large-scale operations, steam coils placed in the evaporator heat the juice.

The juice is clarified in the evaporator. When the cold juice is heated, certain proteins and nonsugar substances are coagulated. This coagulated material, called skimmings, rises to the surface and is removed.

After clarification, the juice is evaporated to sirup density as rapidly as possible. The desired sirup density can be determined by a sirup hydrometer or a thermometer. A suitable thermometer is preferred because it provides an accurate and continuous observation of the sirup density. When tested near the boiling temperature, the reading for sirup of good density should be 35° to 36° Baumé with the sirup hydrometer, or 226° F. (108° C.) with a good thermometer.

The finished sirup should be filtered as efficiently as possible, cooled to the proper temperature, and stored in containers. The temperature of the sirup should be 190° F. for filling half-gallon and smaller containers, 180° for gallon containers, and 120° for barrels.



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