CULTURE OF SUGARCANE FOR SUGAR PRODUCTION IN THE MISSISSIPPI DELTA

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UNITED STATES DEPARTMENT OF AGRICULTURE

CULTURE OF SUGARCANE FOR SUGAR PRODUCTION IN THE MISSISSIPPI DELTA

By

R. J. Matherne, R. D. Breaux and R. W. Millhollon, *research agronomists*
and
R. D. Jackson, *investigation leader*, Agricultural Research Service

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PREFACE

This handbook summarizes information on sugarcane production in the United States based on extensive research findings and grower experience. It is intended to give essential information for growers, producers, processors, extension personnel, and others interested in the production of this crop.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

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CULTURE OF SUGARCANE FOR SUGAR PRODUCTION IN THE MISSISSIPPI DELTA

Sugarcane, introduced to Louisiana in 1751, has been a major crop on farms and plantations since 1820. At present it is the principal means of support of approximately 5,000 growers who employ 16,500 workers in 18 producing parishes. The investment in land, machinery, and other equipment for growing and processing sugarcane is conservatively estimated at $350 million. The last three crops (1967-69) had an average value of $74 million to the sugarcane grower and a retail value of $164 million.

Sugar production in Louisiana fluctuated from a low of 48,000 tons in 1926 to a high of 759,000 tons in 1963 (*3*).[1] Present production is about 25 tons of cane per acre, 180 pounds of sugar per ton of cane, or about 4,500 pounds of sugar per acre (fig. 1) (*1*).

GROWING CONDITIONS

The sugarcane area of Louisiana lies between latitudes 29° N. below Houma and 31° N. above Bunkie (fig. 2). It extends from the Gulf of Mexico in the south to the Red River in the north and from the Mississippi River on the east to the Vermilion River on the west.

The climate is subtropical. Freezes that occur during the winter kill all young growth of summer- and fall-planted cane and damage mill cane standing in the field. Table 1 gives the average temperatures of the sugarcane area at Houma in the extreme south, Lafayette in the west, and Bunkie in the north (*48*).

Rainfall (fig. 3) is generally adequate and reasonably well distributed so that the crop can be cultivated during the late winter and early spring. There is almost no commercial irrigation of cane. There is more rain during the summer when temperatures are high and the cane is growing rapidly and less in the fall when the nights are cool and the cane is increasing in sugar content as it reaches maturity.

Sugarcane grows actively for only about 7 months, from April 1 to October 30. This 7-month growing season is in contrast to the 12- to 24-month seasons of most sugarcane-growing areas of the world. Weekly growth rate averages about 1 to 2 inches during April and May, increases to about 6 inches during June and July, and decreases to

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[1] Italic numbers in parentheses refer to Literature Cited, p. 39.

about 3 inches by the end of September, as shown in figure 4 (*26*). A maximum growth of nearly 13 inches in a week has been recorded. An average crop reaches a height of 9 to 11 feet at harvest.

SOIL TYPES

Sugarcane soils are classified into three general groups—(1) Pleistocene terrace, (2) Recent Alluvial of the lower Mississippi River, and (3) Recent Alluvial of the Red River (*9*).

The Pleistocene terrace soils form

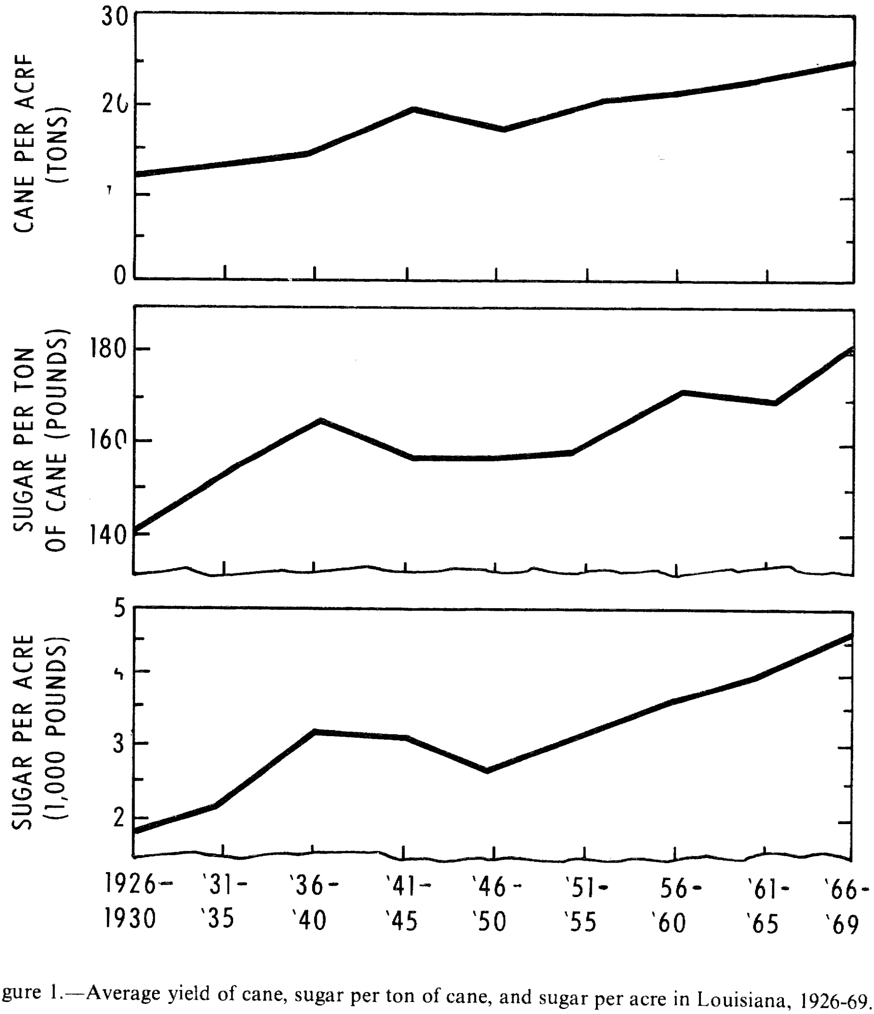

Figure 1.—Average yield of cane, sugar per ton of cane, and sugar per acre in Louisiana, 1926-69.

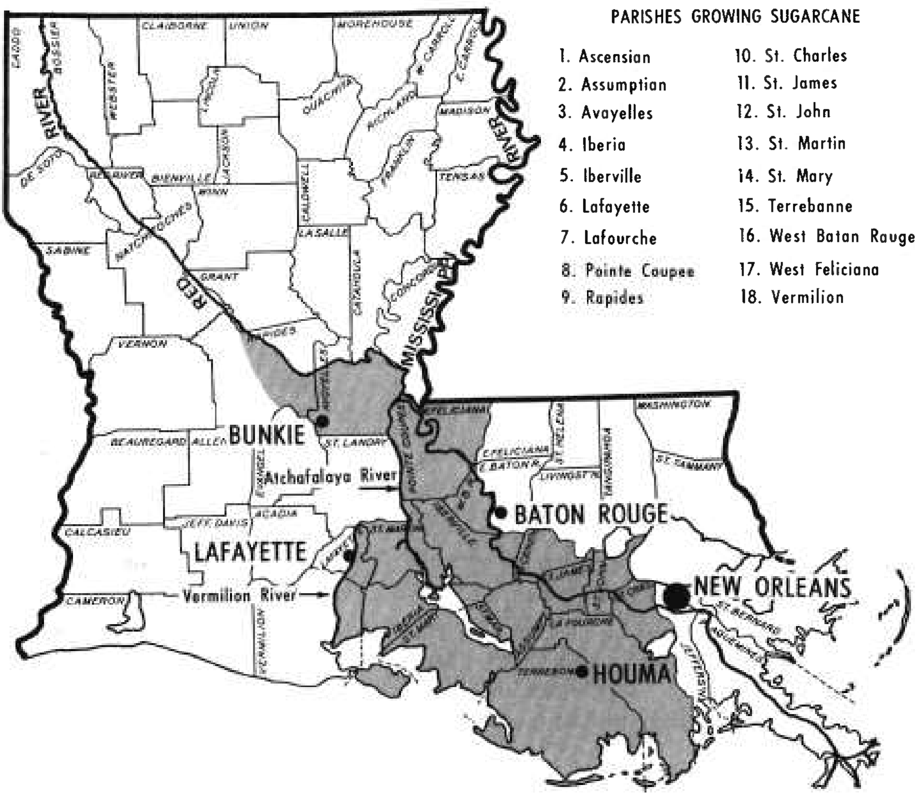

Figure 2.—Sugarcane culture for sugar production in Louisiana is primarily restricted to the shaded area.

the eastern and western boundaries of the recent alluvial deposits, which make up the largest portion of the sugarcane area. These terrace soils were developed from silty deposits washed from other terraces or loessial uplands some 3,000 years old. Other low-stream terrace deposits, within the area of recent alluvial soils, have undergone weathering for 2,000 to 5,000 years. Soils on the Pleistocene terraces have undergone more weathering and leaching than other sugarcane soils. Yields are somewhat lower, and response to applied phosphorous and potassium is more consistent.

Recent alluvial soils of the Mississippi flood plain have been weathering for a relatively short time. Some of the sandy soils now respond to phosphorous and potassium fertilization, and liming, as well as to higher rates of nitrogen. Recent alluvial soils of the Red River also have little profile development, and fertilizer recommendations are the same on these soils as on the recent alluvial soils of the Mississippi River.

Soil types within each of the three

TABLE 1.—*Average temperatures at Houma, Lafayette, and Bunkie in the Louisiana sugarcane area, 1921–50*

Month	Houma		Lafayette		Bunkie	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
January	66.6	46.1	63.5	44.1	63.3	41.2
February	69.4	48.2	66.4	46.5	66.7	44.2
March	73.0	52.2	70.6	51.1	71.9	48.7
April	79.3	58.4	78.2	58.8	79.2	56.2
May	84.8	64.1	84.1	66.4	85.2	62.5
June	89.7	70.1	89.7	72.4	91.6	69.3
July	90.7	71.8	91.4	73.9	93.2	71.2
August	91.2	71.4	91.8	73.3	93.8	70.7
September	88.2	68.5	88.9	68.9	89.9	65.9
October	82.2	58.7	83.0	59.1	82.5	55.1
November	72.5	49.4	71.8	49.5	71.7	45.5
December	67.1	46.5	64.5	44.6	65.1	42.2
Average	79.6	58.8	78.7	59.1	79.5	56.1

groups vary in texture from light sands to heavy clays. Sugarcane is grown most successfully on the moderately well-drained soils. Some years satisfactory crops are also grown on the poorly drained soils.

DESCRIPTION OF THE SUGARCANE PLANT

Sugarcane (*Saccharum* sp.) is a tall, thick-stemmed, perennial grass that stores sugar in the stem. Varieties grown in Louisiana are complex hybrids produced from crosses of slender wild canes (*Saccharum spontaneum* L.), slender Indian canes (S. barberi Jeswiet), and noble canes (S. *officinarum* L.). A few varieties also derive from the species S. *robustum* Brandes and Jeswiet ex Grassl. Mature stalks vary from 0.75 to 1.0 inch in diameter and from 50 to 130 inches in length with an average length of about 90 to 100 inches. They weigh from 2 to 3.5 pounds depending on growing conditions. Louisiana varieties are generally erect, but they sometimes lodge or fall.

The stalk is made up of joints or sections. There are from 10 to 16 joints above ground that vary from 4.5 to 7 inches in length. Each joint consists of a node and internode (fig. 5). At each node there is a bud or "eye" which contains beginning of a new plant. The buds may be oval, pointed, or flattened. As is typical of the grass family, the buds alternate in two rows on opposite sides of the stalk. When present, a bud furrow, or depression, in the joint immediately above the bud may be deep or shal-

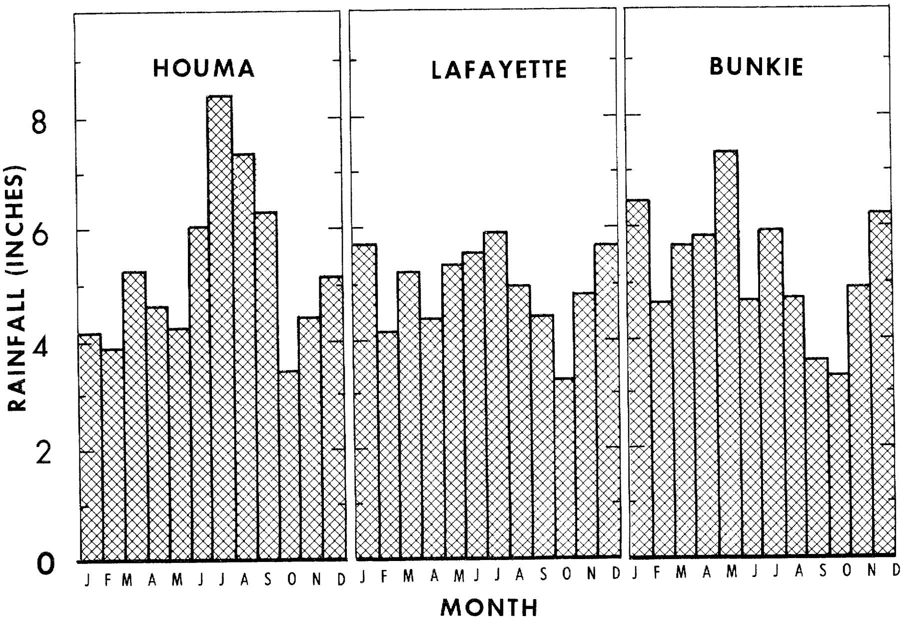

Figure 3.—Average rainfall at Houma, Lafayette, and Bunkie, La., 1921-50.

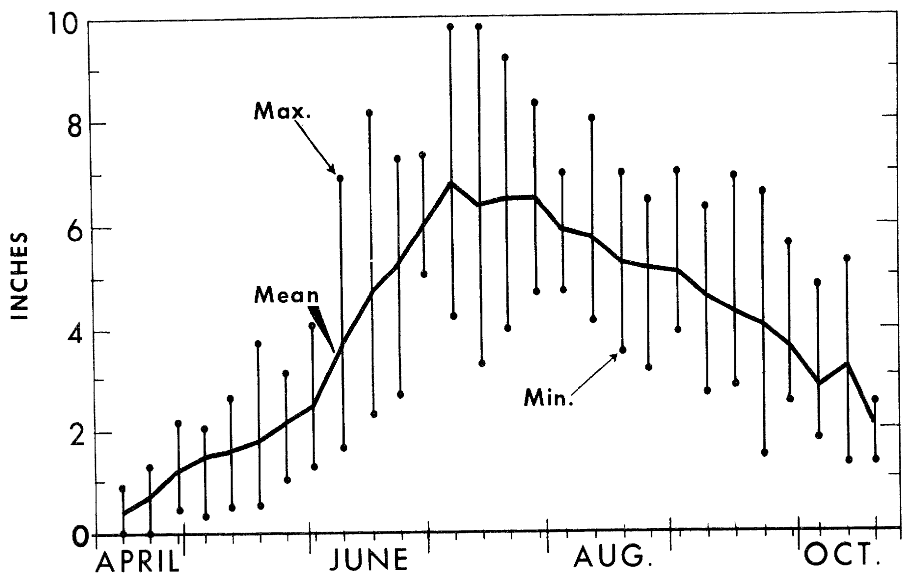

Figure 4.—Average weekly growth rate of plant and 1st stubble cane of CP 44-101 from 1957 through 1967.

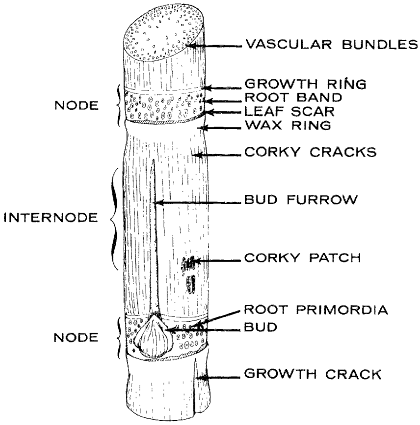

Figure 5.—Diagram of node and internode of sugarcane. (After Artschwager.)

low; it may be short or may extend the length of the internode. One to several rings of root primordia, or root buds, are located at the nodal zone. The growth ring is a narrow band just below the internode and above the root primordia. The usually well-defined leaf scar appears just below the root primordia. Sugarcane stalks are green, yellow, red, and purple or shades of brown or tan.

The leaf of the sugarcane plant consists of the sheath and the blade. The sheath may remain firmly attached to the stalk or may be loosely attached and fall off readily. The blade may be narrow or wide, long or short, and drooping or erect. The long drooping leaves form a spreading canopy, which combats weeds by shading the ground.

The underground part of the stalk is composed of many short joints, each with a node and an internode. At each node is a bud. A growing plant, known as a stool, consists of the primary, or original shoot, and the secondary shoots or tillers (fig. 6). The primary shoot develops from the bud of the mother stalk or seed piece. The secondary shoots develop from the buds on the underground part of the stalk. A tertiary shoot may also originate from a secondary shoot.

Each plant has a large number of buds. More shoots emerge above the surface in the spring than finally become mature stalks. It is not unusual to find 15 to 20 or more new shoots per plant early in the spring and only three to six mature stalks per plant at maturity because of shading or other causes.

Sugarcane rarely flowers in the field in Louisiana. Floral initiation occurs almost every year, but the

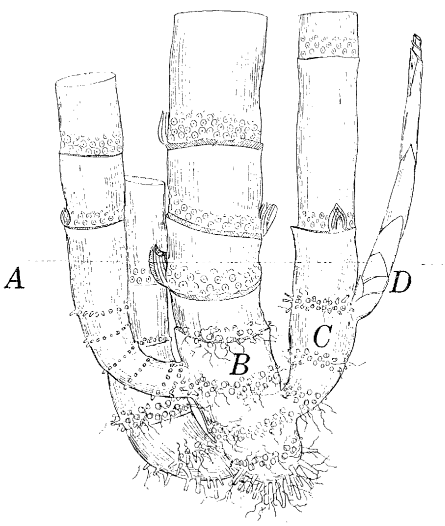

Figure 6.—Diagram of part of a sugarcane stool: *A*, Ground level; *B*, primary; *C*, secondary; and *D*, tertiary shoots. (After Artschwager.)

cane is either harvested or frozen before the tassels emerge. Under more tropical conditions, sugarcane flowers in the field and sometimes produces viable seed. Propagation in commercial plantings, however, is always by whole stalks or vegetative cuttings. The inflorescence (tassel or arrow) of sugarcane is an open-branched panicle. Seedling plants are grown from true seed to produce new varieties in breeding programs. They are extremely small, and infinite care and attention are required to establish and grow plants from the small seed. Seedling plants, unlike those from cuttings, are genetically different and show a wide range in size, color, juice quality, and other characteristics.

CULTURAL PRACTICES

Drainage

Since many sugarcane soils have poor internal drainage, good surface drainage is essential for the production of good sugarcane crops. In Louisiana, sugarcane is planted on ridges built to a height of about 12 inches. Two systems of drainage are in use: (1) Lateral ditches every 150 to 250 feet with quarter drains draining to the lateral ditches and (2) precision grading.

The first system has probably been in use since sugarcane was first planted in Louisiana. The area between two lateral ditches, called "squares" or "cuts," ranges from 500 to 1,000 feet in length. Quarter drains (small ditches), at right angles to the rows, drain the water from the cut to the ditches (fig. 7). Deeper ditches and canals drain the water from lateral ditches into bayous or swamps.

The use of heavy equipment on sugarcane lands causes soil compaction, which limits water intake, storage, and root development (*40*). Subsoiling and deep plowing (14 to 18 inches) crack or shatter the compacted areas and increase yields on some soil types. Increases in yield have been obtained on fine sandy loam and silty clay loam but not on clay alluvium and loess silt loam soils.

A system of precision grading that eliminates the quarter drains and many lateral ditches is now used to drain many Louisiana sugarcane fields (*43*). This is recommended for the sandy "light" soils. Lateral ditches are spaced 600 to 800 feet apart, so only about one-fifth as many ditches are required to drain the same area.

PN-2402

Figure 7.—Drain-cleaning machine.

The land is graded to slope towards one end of the cut (row drainage) and also towards one of the lateral ditches (side fall). Side fall should be 0.2 foot or less per 100 feet, and row drainage, from 0.3 to 0.5 foot fall per 100 feet. This may require the movement of considerable soil by scrapers, which move soil from the high spots and fill in the low spots. A land plane is used for the final smoothing operation (fig. 8).

A sample of four fields in Terrebonne Parish showed 73 percent of ditch footage was eliminated by precision grading. The lateral ditches and quarter drains are expensive to maintain and are a serious source of weed infestation. The resulting larger cuts also permit a more efficient operation of multirow equipment.

Crowning is recommended for the clay "heavy" soils. This is accomplished by sloping the land from the center of the cut towards the lateral ditches. The center of the cut is the high point, and the fall to each side is 0.3 foot per 100 feet.

Crop Rotation

Three crops of sugarcane are generally obtained from each planting (plant cane, first stubble, and second stubble). A cover crop is seldom used in rotation with sugarcane. Old stubble can be destroyed immediately after harvesting, but usually enough stubble is kept until spring so that only the poorest stubbling fields are destroyed. Stubbling ability depends upon variety, severity of the winter, and time of harvesting. After the stubble is destroyed, the fields are cultivated frequently (fallow plowing) throughout the summer as part of the weed control program and cane is planted again in the fall.

Organic matter content of the soil can be maintained even when sugarcane plant residues are the only

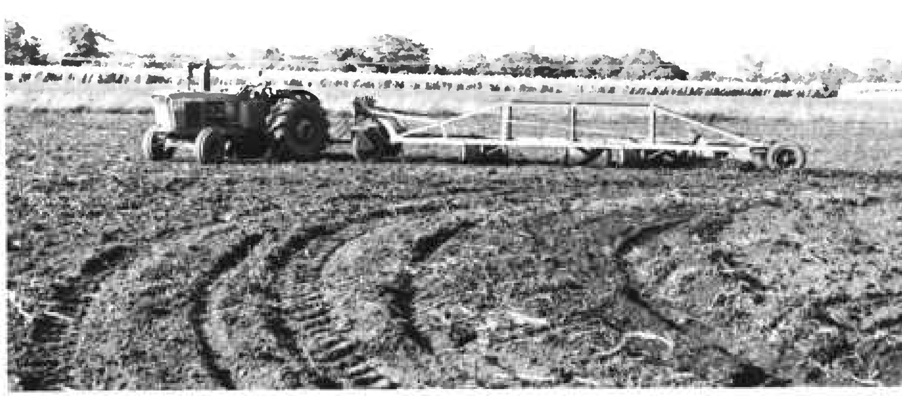

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Figure 8.—Land plane used for the final smoothing operation.

organic matter incorporated into the soil (*19*). Turning under a good soybean crop maintains the organic matter at about the same level, but has the added advantages of supplying about 40 pounds of nitrogen and assisting in the control of annual grasses and broadleaved weeds where johnsongrass is not present.

Planting

Planting season is from early August to mid-October. August and September plantings give the highest yields (*33*). Unfavorable weather conditions often make it necessary to plant through October and sometimes in November or December. Because of peak labor demands, it is extremely difficult to continue large-scale planting operations after harvesting begins in October.

Cane to be used for seed is given special attention, including heavy fertilization, to assure maximum growth. The cane is heat treated for control of ratoon stunting disease, checked frequently for varietal mixture, rogued for mosaic disease, and dusted for borer control. Approximately 3 to 4 tons of seedcane are planted to produce an acre of cane in Louisiana (*18*). Whole stalks, cut by mechanical harvester, are used as seedcane.

A well-prepared seedbed is of great importance. A good fallow plow program during the summer provides a seedbed in good tilth for final disking before planting. Sugarcane is planted on raised rows or banks to facilitate drainage during long wet periods. Rows are formed up to 12 inches high spaced 6 feet apart. Furrows are opened in the top of these rows to a depth of 4 to 10 inches, but always at least 2 inches above the water furrow (*23*). Seedcane is loaded into tractor-drawn carts and dropped into the open furrows (fig. 9). Two to three whole stalks are placed side by side, covered with 3 to 4 inches of soil, cultipacked, and sprayed with preemergence herbicides (*42*) (figs. 10 and 11).

Hand planting is gradually being replaced by planting machines. One fully automatic machine is commercially available (fig. 12). Other machines, called planters' aids (fig. 13), use a crew of four rather than the nine required if cane is planted completely by hand.

Fertilization

Fertilizers are usually applied during March and April. Generally,

PN-2404

Figure 9.—Planting seed cane into open furrows.

PN-2405

Figure 10.—Cultipacking rows after planting.

all fertilizers are applied at one time; however, if higher rates are used, a split application may be made. The last application can be made as late as July 15 (*17*). No significant variety and fertilizer inaction has been reported.

Recommended rates vary with soil type and for plant cane and stubble (*44*). The rates range from 80 to 120 pounds of nitrogen per acre for plant cane and 120 pounds to 140 pounds of nitrogen per acre for stubble. Forty pounds of phosphate (P_2O_5) per acre and 80 pounds of potash (K_2O) per acre are recommended for plant cane and stubble where the availability of these elements are in the medium or low range, as determined by soil analysis. Nitrogen can be applied in liquid or solid form, but anhydrous and aqua ammonia are almost exclusively used. Phosphate and potash are applied in liquid or solid form.

Liming is recommended if soil pH is below 6.0.

Cultivation

Cultivation of sugarcane in Louisiana differs from that used in most other sugarcane-producing areas. High rows or banks are maintained from the time the sugarcane is planted until the old stubble is plowed out.

Shaving, when practiced, is the first cultural operation of the year. Farmers shave to remove excess soil covering plant cane, to remove high stubble after harvesting, and to remove winter-killed "eyes" (buds) near the surface to permit lower viable eyes to germinate better, and to remove winter weeds. Some farmers practice "false shaving" which cuts off high stubble left after harvesting but removes little or no soil.

Shaving is harmful and reduces yield if appreciable early cane growth in a mild winter is cut off (*21*). Gaps in stand are sometimes caused by shaving too deeply.

The next cultural operation is "off-barring." Soil is removed on either side of the row of cane leaving a ridge or "bar" about 12 inches wide. Usually two sets of disk cultivators are used in tandem. The first set is reversed from its normal cultivating position and removes the soil from the row. The second set, left in its normal cultivating position, immediately brings the soil back. Some farmers leave the rows on the off-bar for a few weeks, but this is not necessary (*22*).

The off-bar operation leaves the row in good physical condition so that anhydrous or aqua ammonia can be applied without appreciable loss of nitrogen and provides a clean row for application of preemergence herbicides. Fertilizer is applied into the loose soil on either side and at the base of the off-bar.

To control weeds, the crop may be cultivated several more times until the cane leaves can grow over the middles of the rows. The last such cultivation is referred to as the "lay-by" cultivation. Experiments have shown no difference in cane yields with 1, 2, or 5 cultivations provided good weed control is maintained (*30*). Increased costs of production, labor scarcity, and better herbicides have brought about a gradual reduction in the number of cultivations.

PN-2406

Figure 11.—Sprayer and cultipacker.

PN-2407

Figure 12.—Sugarcane mechanical planter.

PN-2408

Figure 13.—Planting sugarcane with planters' aid.

PN-2409

Figure 14.—Three-row cultivators.

Some farmers with small acreages are using single row cultivators, but these are being replaced with multirow (three rows) cultivating equipment (fig. 14).

VARIETIES

The old noble varieties produced good crops for over a century before they failed, but the commercial life of the interspecific hydrids that have replaced them is much shorter (*31*). These varieties, although reproduced vegetatively and hence genetically stable, appear to become less productive after being grown a few years. This "running out" or yield decline is being intensively studied to determine its causes (*11*). An expanded breeding program that produces improved varieties at a more rapid rate also contributes to the short life span of commercial varieties. Figure 15 shows the succession of commercial varieties grown in Louisiana since 1926.

A particular kind of sugarcane variety has been bred to meet Louisiana's exacting and peculiar requirements. These varieties are early maturing, have good stubbling qualities, are resistant to disease and insect pests, and stand relatively erect at maturity. A degree of cold tolerance and resistance to inversion of sucrose is also characteristic of Louisiana varieties.

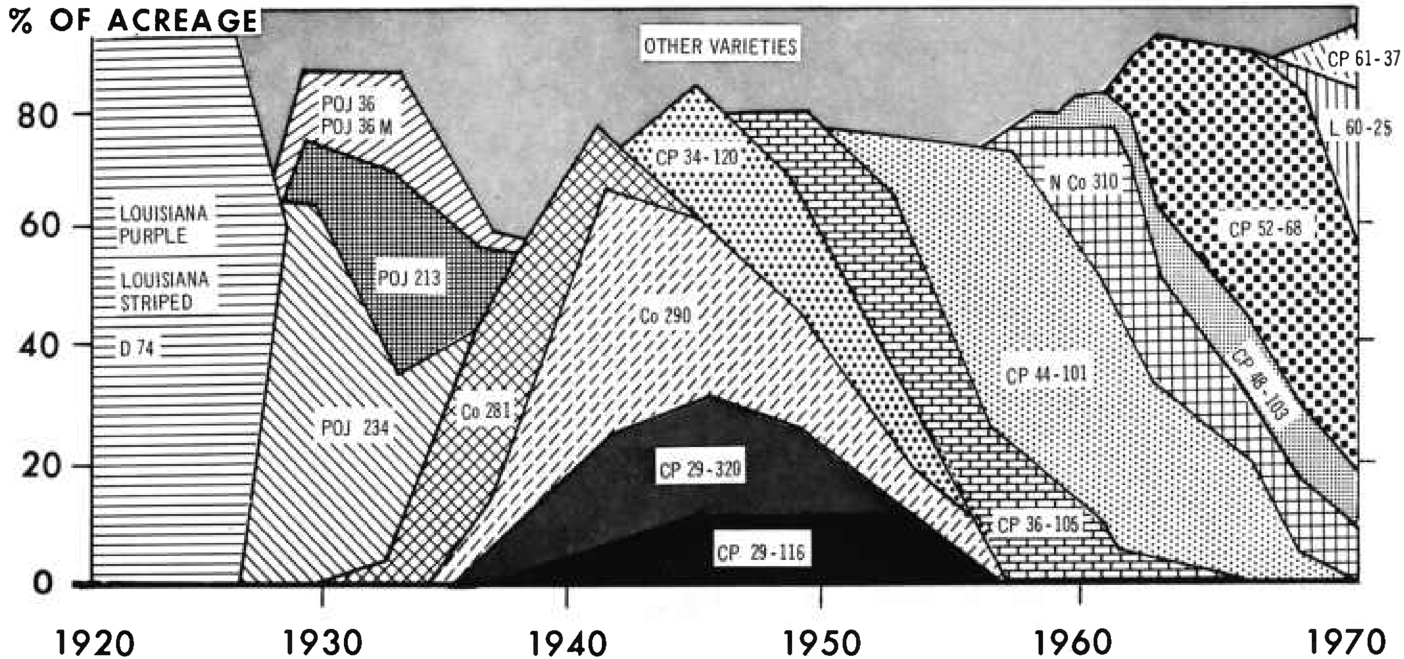

Figure 15.—Changes in sugarcane varieties based on acreage planted in Louisiana, 1920-70.

Commerical Varieties

Table 2 gives the commercial sugarcane varieties, country of origin, year of release, and highest acreage attained by each. Figure 15 shows the changes in varieties that have occupied at least 10 percent of the sugarcane acreage for the period of time.

From 1825 to 1926 three varieties, Louisiana Purple, Louisiana Striped, and D-74, occupied most of the acreage. From 1924, when the POJ

TABLE 2.—*Data pertaining to commercial sugarcane varieties released in Louisiana, 1924–68*

Year of release	Variety	Country of origin	Maximum acreage attained	
			Percent	Year
1924	POJ 234	Java	65	1928
1924	POJ 213	do	47	1931
1924	POJ 36	do	13	1933
1924	POJ 36 M	do	13	1933
1930	Co 281	India	47	1936
1930	CP 807	United States	11	1935
1933	Co 290	India	41	1940
1934	CP 28–11	United States	5	1942
1934	CP 28–19	do	13	1942
1935	CP 29–320	do	24	1940
1936	CP 29–116	do	13	1947
1939	CP 29–103	do	7	1945
1939	CP 29–120	do	10	1947
1941	CP 33–243	do	1	1945
1942	CP 34–120	do	25	1947
1943	CP 33–310	do	1	1947
1943	CP 33–425	do	1	1947
1945	CP 36–105	do	39	1952
1946	CP 36–13	do	7	1953
1947	CP 34–92	do	1	1951
1947	CP 36–19	do	1	1951
1947	CP 36–183	do	1	1951
1949	CP 44–101	do	53	1957
1949	CP 44–155	do	11	1955
1950	CP 43–47	do	4	1955
1952	CP 44–154	do	1	1954
1954	NCo 310	South Africa	25	1960
1955	CP 47–193	United States	4	1964
1955	CP 48–103	do	12	1968
1958	CP 52–68	do	49	1968
1963	CP 55–30	do	15	1968
1966	L 60–25	do	27	1970
1967	CP 61–37	do	9	1970
1969	L 62–96	do	1	1970

varieties were made available to the industry, until 1968, 34 varieties have been released to growers as follows: Four POJ, two Co, one NCo, 25 CP, and two L varieties. Some of the varieties were widely grown, and some did not gain good grower acceptance. Five varieties attained a maximum acreage of over 45 percent—POJ 234, POJ 213, Co 281, CP 44-101, and CP 52-68. Six varieties attained a maximum acreage of from 25 to 41 percent—Co 290, CP 29-320, CP 34-120, CP 36-105, NCo 310, and L 60-25.

POJ 234 was grown extensively because it was definitely superior to the noble canes. CP 44-101 occupied more than 50 percent of the acreage because of its high yields, satisfactory sucrose, disease resistance, cold tolerance, and general adaptability. CP 52-68 replaced CP 44-101 primarily because it had better juice quality. A continued and perhaps even more rapid succession of varieties is assured by the fact that many more promising varieties are under increase or in test at all stages in the breeding program (*7*).

Some Varietal Characteristics

In 1969, NCo 310, CP 48-103, CP 52-68, and L 60-25 occupied almost 80 percent of the sugarcane acreage in Louisiana (*32*). Two new varieties, CP 61-37 (released in 1967) and L 62-96 (released in 1969), are under rapid increase.

CP 52-68 (released in 1958) occupied 40 percent of the 1969 crop acreage and is still used as a basis for comparison of other varieties in the selection program. CP 52-68 is widely adapted, yields well, and is medium early in maturity. It is a very erect uniform variety, excellent for mechanical harvesting. The variety is resistant to ratoon stunting disease but susceptible and relatively intolerant to mosaic. It has become saturated with mosaic in many areas and acreage is declining.

NCo 310 (released in 1954) still occupied 13 percent of the acreage in Louisiana in 1969. It is grown primarily in the southwestern area where it produces good tonnage. It is also liked because of its nonbrittleness and cold tolerance. The variety is highly susceptible to mosaic, and its continued use is not recommended.

L 60-25 (released in 1966) is an early maturing, high sucrose variety with acceptable yield and is apparently widely adapted on heavy and light soils throughout the area (*16*). The variety is somewhat susceptible to borer, susceptible and intolerant to mosaic, and subject to lodging and brittleness.

CP 48-103 (released in 1955) is also an early maturing, high sucrose variety but is lacking in vigor, not as widely adapted as L 60-25, and should be planted only on the better light soils where weeds and grasses are not a problem. However, the variety is moderately resistant to mosaic and relatively cold tolerant.

CP 61-37 (released in 1967) is a high tonnage variety that has yielded well on both light and heavy soil. The variety has good cold tolerance and is moderately resistant to mosaic. It is medium to late in maturity and somewhat brittle when lodged.

L 62-96 (released in 1969) is a high sucrose variety that has outyielded CP 52-68 in sugar per acre. It is a large barrel variety by Louisiana standards and is tall, uniform, and erect which makes it well adapted to mechanical harvesting. The variety is moderately susceptible to mosaic and sometimes has a low population of stalks in plant cane.

VARIETY IMPROVEMENT

When the noble varieties failed, it was necessary to import varieties from Java and India that were tolerant to mosaic. The POJ and Co varieties restored the Louisiana sugar industry and maintained it until a breeding program was established for this area.

The development of high yielding, disease resistant varieties through breeding became the chief objective of the sugarcane investigations of the Agricultural Research Service. Field stations were established at Canal Point, Fla., to make crosses and produce seed, and at Houma, La., to test the promising new seedlings.

Sugarcane flowers infrequently in Louisiana, but true seed of sugarcane aided by photoperiod induction of flowering, are produced by the Louisiana Agricultural Experiment Station at Baton Rouge (*10*). Varieties bred in Florida are called CP (Canal Point) varieties, and those bred in Louisiana are called L varieties. The American Sugar Cane League cooperates in the production of new varieties by increasing seed supplies of promising new canes and by contributing funds to the two breeding programs.

Parent Material

CP and L varieties are mostly trispecies hybrids between the large barrel, soft, sweet noble canes (*Saccharum officinarum* L.), the commercially worthless but disease resistant, slender, nonsweet canes (S. *spontaneum* L.), and the small barrel, high-fibered, Indian canes (S. *barberi* Jeswiet). S. *robustum* Brandes and Jeswiet ex. Grassl, a progenitor of the noble canes, is also in the pedigree of a few Louisiana varieties. Generally, the characteristics of the interspecific hybrids are intermediate between, or combine the desired characteristics of each species.

Actually, only a few clones of the different species hybridized in Java and India provided most of the sugarcane varieties of the world (*5*). Plant explorers have searched areas of the world where the basic forms of sugarcane are native and assembled a large variety collection at Canal Point (*6,49*). These collections are presently being used as sources of new germ plasm (*13*).

Breeding

Crosses are made at Canal Point inside a large greenhouse because of low night temperatures and damaging winds and rain that occur during the floral initiation and crossing season. Several weeks before setting up the cross, canes to be used as female parents are air-layered. At least two nodes of the stalk are wrapped first with sphagnum moss and then with polyethylene to keep the moss from drying out. When the flowers have developed well enough to make the cross, the stalk is cut immediately below the air layer, the polyethylene is removed, and the stalk is placed in a trough of running water. At this stage, the roots have grown enough to keep the plant alive.

Canes to be used as male parents are grown in cans on railroad carts. Low night temperatures interfere with pollen production, so these canes are kept inside the heated greenhouse at night and outside during the day. The male tassels are cut and preserved in a dilute sulfurous, phosphoric acid solution.

The cross is set up in polyethylene cubicles inside the crossing house to prevent contamination from outside pollen. Stalks bearing pollen-producing arrows are raised above those bearing the seed-producing arrows. Although sugarcane has a perfect flower, many varieties do not produce viable pollen. Pollen-producing parents can be identified by examining the anthers for pollen grains. Quality of the pollen is determined by the iodine test. For the next 7 to 10 days pollen-bearing stalks are tapped each morning so that they shed pollen. When pollination is complete, the pollen parents are removed and seed are matured on the female parents. About 30 days after the cross is set up, the fuzz containing the ripe seed is stripped from the tassel. The fuzz is dried several days and is then ready to plant. Seed can be stored for a short time at room temperature or for several years at below freezing temperature.

The application of indoor crossing techniques resulted in a tremendous increase in the production of viable seed at Canal Point to over 1 million a year (*12*). Photoperiod treatments that delay certain early flowering clones and enhance late-flowering ones make it possible to synchronize early and late-flowering varieties to make certain crosses not possible under natural conditions (*27*). Cold-room treatments have also been used at the Louisiana Agricultural Experiment Station to prevent pollen production in highly male-fertile varieties. It is now possible by manipulation and application of one or more of the above techniques to effect almost any desired cross for varieties to be grown in Louisiana.

Testing

Commercial varieties occur very infrequently in sugarcane seedling progenies and are difficult to distinguish, particularly during the early stages of testing. It takes 12 years to determine whether a variety is suitable for commercial culture in Louisiana. The seedlings progress through a test system where they are evaluated in single stool nurseries, unreplicated line trials, replicated infield variety trials, and replicated outfield variety trials.

No selection for yield, as such, is practiced in single stools or unreplicated line trials. Instead, a subjective selection is practiced for the heritable components of sugar per acre yield. Stalk diameter and height and hand refractometer Brix are the most important selection criteria in single stools. Selection for stalk number and erectness, which are low in heritability in single stools, is delayed until the 6-foot and 15-foot line trial stages (*20*). Selection in these initial stages is to raise the frequency of commercial varieties so that they occur even in the small number of varieties that are critically evaluated, rather than to identify the individual varieties with commercial potential.

About 100 new CP and L varieties advance to replicated yield trials at Houma and Baton Rouge each year. Of these varieties, 20 to 30 are sent to 14 test field locations on cooperating plantations throughout the sugar-producing area for further testing. The out-field test program is conducted cooperatively by the USDA and the Louisiana Agricultural Experiment Station. Eight test fields are on light and heavy Mississippi alluvial soils, five are in Pleistocene soils west of the Atchafalaya River and one is on Red River alluvial soil. Yield data are obtained first from the plant cane crop and then from the first and second stubble crops at all locations before a variety is released.

In addition to yielding ability, varieties are tested and classified for other important characteristics. For example, even a high-yielding variety may be unfit for growth in Louisiana if it has one undesirable character. Data are collected on erectness and brittleness which largely determine the suitability of a variety to mechanical harvest (*15*). Extremely brittle varieties that frequently lodge are discarded. Milling quality of a variety is also considered, and high-fibered varieties are discarded from the test program. Pathologists classify varieties in test according to their resistance and tolerance to the major diseases, and entomologists determine their borer resistance. Physiologists also study and classify the varieties for leaf and stalk cold tolerance and inversion rate, which are important economic considerations in growing the crop in Louisiana (*24*).

Increase and Release to Growers

The American Sugar Cane League conducts a seed increase program of promising new varieties. Seed cane is increased under terms of written agreements between the league and growers at three primary and 42 secondary increase stations. A release statement is prepared jointly by the three agencies involved in variety development when sufficient data are available to release a new variety. This statement describes the new variety and lists its advantages and disadvantages (*2*). The League then arranges for the allocation, sale, and distribution of the available seed cane.

WEED CONTROL[2]

Weeds abound in sugarcane fields throughout the year and can be damaging to a crop if not controlled. Effective control of weeds is unlikely unless both herbicides and timely cultivation are used judiciously. Weed control treatments mentioned herein have appeared satisfactory in research with respect to both weed control and crop tolerance.

Important Weeds

Weeds in sugarcane may be grouped into those that grow during the cool season or winter months and those that grow during the warm season or summer months. Winter weeds are primarily broadleaf annuals such as chickweed (*Stellaria media* (L.) Cyrillo), henbit (*Lamium amplexicaule* L.), Carolina geranium (*Geranium carolinianum* L.), and Virginia pepperweed (*Lepidium virginicum* L.). Canarygrass (*Phalaris* spp.) is one of the few grassy weeds that are problems in the winter. In the spring and summer, the main weed problems are annual and perennial grasses: Johnsongrass (*Sorghum halepense* (L.) Pers.), *Rottboellia exaltata* L.f. (called itchgrass locally), crabgrass (*Digitaria sanguinalis* (L.) Scop.), junglerice (*Echinochloa colonum* (L.) Link), and bermudagrass (*Cynodon dactylon* (L.) Pers.). In late summer, annual broadleaf vines such as scarlet morningglory (*Ipomoea coccinea* L.) and cypressive morningglory (*Ipomoea quamoclit* L.) are troublesome.

The most widespread and most economically important weed in sugarcane is johnsongrass. It is well adapted for competition with sugarcane since it thrives under the cultural conditions suitable for sugarcane, and can reproduce as an annual from seed or as a perennial from rhizomes (fig. 16). Seedlings of johnsongrass produce rhizomes within a few weeks after germination and thereafter become increasingly hard to control with herbicides. Many of its seed are dormant and can survive to reinfest fields even after one or more years of fallowing. Johnsongrass infestations usually increase from relatively low levels in newly planted cane to very high levels in the stubble crops. Heavy infestations may reduce yields 25 to 50 percent.

Itchgrass is a relatively new weed in sugarcane in Louisiana. It is very competitive and difficult to control (*35*). It grows over 6 feet tall and may be recognized by the short, stiff hairs that cover the leaf sheaths, the cylindrical spikelike inflorescence, and the large cylindrical seed that fall from the mature inflorescence (fig. 17). Itchgrass is an annual, but individual plants mature many seed almost continuously throughout the growing season. The seed germinate periodically during the spring and summer

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[2]This section was prepared by R. W. Millhollon.

PN-2410

Figure 16.—Johnsongrass plant showing extensive Rhizome system.

and can emerge from a depth of 6 inches in soil.

Annual grasses such as crabgrass and junglerice and broadleaf vines will severely stunt sugarcane if not controlled. They become a problem particularly after layby if sugarcane stands are sparse. Annual grasses may overrun the cane; vines may tie up cane and interfere with efficient mechanical harvesting.

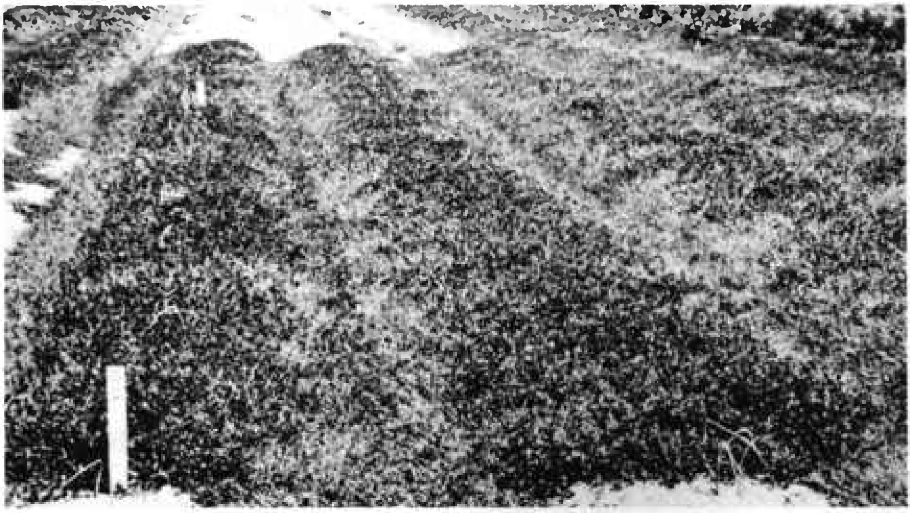
At one time, winter weeds were not considered competitive with sugarcane since they grow when sugarcane is relatively dormant and are removed by cultivation early in the growing season. Recent research, however, has shown that heavy infestations of winter weeds reduce both the stand and yield of newly planted sugarcane, even when removed 8 months before harvest (*39*) (fig. 18). These weeds are usually more of a problem in newly planted cane than in stubble ratoon crops. Winter weeds must be removed in the spring before herbicides can be applied to the soil surface for pre-emergence control of summer weeds.

Weed Control Programs

Weeds are most competitive when sugarcane is becoming established after planting or stubbling. Without weed competition, young sugarcane

PN-2411

Figure 17.—Inflorescence and individual seed of itchgrass.



PN-2412

Figure 18.—Weed infestation in the winter on newly planted sugarcane. Plot in background was sprayed in the fall with simazine to control weed before emergence.

plants will grow vigorously and within a few months will be tall enough to shade the row and prevent much weed growth. Therefore, an effective weed control program involves timely control of weeds and the use of cultural practices that promote good growth of sugarcane.

Fallowing

After a crop of sugarcane has been grown for its 3-year crop cycle, it may be severely infested with johnsongrass. Fallowing the land by frequent plowing for one spring and summer effectively kills the majority of johnsongrass rhizomes and reduces the population of seed in the soil. Fields are effectively fallowed by plowing under johnsongrass when it is approximately 14 inches tall; six or more plowings may be needed during one fallow season.

Herbicide programs in sugarcane

Herbicides used in sugarcane during 1970 were 3-*tert*-butyl-5-chloro-6-methyluracil (terbacil), (2,3,6-trichlorophenyl) acetic acid (fenac), *a,a,a,*-trifluoro-2,6-dinitro-*N,N*-dipropyl-p-toluidine (trifluralin), sodium salt of trichloroacetic acid (TCA), sodium salt of 2,2-dichloropropionic acid (dalapon), 2-(2,4,5-trichlorophenoxy) propionic acid (silvex), (2,4-dichlorophenoxy) acetic acid (2,4-D), and 2-chloro-4,6-bis-(ethylamino)-*s*-triazine (simazine). In commercial practice, herbicides are usually applied to a 30-inch band over the top of the sugarcane row, and the remaining strip of 36 to 42 inches is cultivated with disk plows to control weeds. Most of these herbicides do not injure sugarcane excessively when used as described in table 3. Any slight, temporary injury is usually more than offset by the benefits of weed control. Sugarcane has marginal tolerance, however, for some of the treatments, and varying degrees of injury may result from their use. Dalapon, for example, is more likely to injure sugarcane if the foliage is sprayed or if applications are repeated several times. Also, some varieties of sugarcane are more sensitive than others to certain herbicides (*39*).

After fallowing and replanting, one of several herbicides can be applied to soil for preemergence control of weeds (table 3). By reapplying herbicides annually, preemergence control can be extended throughout the 3-year crop cycle. For many years, mixtures of TCA plus 2,4-D or TCA plus silvex were the only treatments available for general preemergence weed control. In the 1960's, however, fenac and terbacil were found to control johnsongrass seedlings and many other weed species more effectively than the TCA treatment (*34,41*). Terbacil and fenac persist in soil long enough for a single application to control weeds residually for several months. Simazine controls annual weeds residually and is exceptionally nonphytotoxic to sugarcane. Trifluralin is the only herbicide that effectively controls itchgrass, but it seldom persists enough to control heavy infestations for more than 60 days.

Herbicides for preemergence control and cultivations seldom control all weeds, but other herbicides can be applied for postemergence control (table 3). Herbicides may be applied either as spot treatments or as general treatments depending on weed density. Stubble crops frequently have heavy infestations of johnsongrass, vines, and other weeds. A mixture of TCA and dalapon inhibits the growth of johnsongrass, but the plants tend to recover.

Herbicide programs for ditchbanks

Drainage ditchbanks occupy approximately 10 percent of sugarcane fields and are a primary source for the dissemination of johnsongrass, and other weeds. The control of johnsongrass on ditchbanks involves two basic steps—initial control of established johnsongrass and annual control of new growth, particularly seedlings. The treatments described in table 4—applications of MSMA, dalapon, or sodium chlorate—control established johnsongrass about equally well (*36*); however, the plant species that becomes dominant after johnsongrass is controlled varies with the herbicide used. Bermudagrass rapidly covers ditchbanks treated with MSMA; broadleaf plants grow sparsely on ditches treated with dalapon; and various weed grasses grow sparsely on ditches treated with sodium chlorate. The rapid regrowth of plants on ditchbanks prevents erosion, and desirable species compete with new infestations of johnsongrass.

TABLE 3.—*Herbicide treatments that have effectively controlled weeds in sugarcane fields*

Herbicide	Rate of application [1]	Method of application	Weeds controlled
	Pounds per acre		
Terbacil	1.6—3.2	Preemergence or postemergence to weeds approximately 1 inch tall, applied to soil surface as basally directed spray if sugarcane has emerged. In newly planted cane, 1.6 lb./acre applied after planting in fall and reapplied after first cultivation in early spring. In stubble cane, approximately 3.2 lb./acre applied after first cultivation in early spring.	Seedling johnsongrass and most annual broadleaf and grass weeds.
Fenac	3.6—6.0	Preemergence to weeds, applied to soil surface as basally directed spray if sugarcane has emerged. In newly planted cane, 3.6 lb./acre applied after planting in fall and reapplied after first cultivation in early spring. Usually more effective if mixed with silvex or 2,4–D at 2.4 lb./acre. In stubble cane, approximately 6.0 lb./acre applied after first cultivation in early spring.	Seedling johnsongrass and most annual broadleaf and grass weeds.
Simazine	3.0	Preemergence to weeds, applied to soil surface as basally directed spray if sugarcane has emerged. Applied in fall after planting, in following spring, and in spring on stubble cane.	Annual broadleaf and grass weeds.

See footnote at end of table.

TABLE 3.—*Herbicide treatments that have effectively controlled weeds in sugarcane fields*—continued

Herbicide	Rate of application [1]	Method of application	Weeds controlled
	Pounds per acre		
TCA + silvex	10.0 + 2.4	Preemergence or postemergence to weeds (grasses under 2 inches tall and large broadleaf weeds), sprays applied to soil surface and weed foliage either directed to the base or over-the-top of sugarcane. Applied after first cultivation in spring and reapplied after fertilization.	Seedling johnsongrass and most annual broadleaf and grass weeds.
Trifluralin	1.0—2.0	Preemergence to weeds, incorporated in soil over sugarcane before or shortly after it emerges in early spring.	Seedling johnsongrass, itchgrass, and most annual grasses.
Dalapon	4.5	Postemergence to weeds, sprays directed to weed foliage at base of sugarcane.	Seedling johnsongrass, bermudagrass, and most annual grasses.
TCA + dalapon	15.0 + 4.5	Postemergence to weeds, sprays applied in early spring over-the-top of johnsongrass and sugarcane in stubble crops only.	Johnsongrass from rhizomes and most grasses.
Silvex or 2,4–D	1.0—2.0	Postemergence to weeds and sugarcane in spring or summer.	Broadleaf weeds and vines.

[1] Rates of application of herbicides are stated in terms of a broadcast application of the active ingredient or acid equivalent, whichever is required, for a single application. Based on 72-inch rows, the rate required for a 30-inch band application per acre of sugarcane would be 5/12 of the broadcast rate.

TABLE 4.—*Herbicide treatments that have effectively controlled weeds on drainage ditchbanks in sugarcane*

Herbicide	Rate of application [1]	Method of application	Weeds controlled
	Pounds per acre		
MSMA	4.0	Postemergence, sprayed on foliage initially in spring, and resprayed repeatedly on new growth 14 to 24 inches tall.	Johnsongrass from rhizomes or seed and itchgrass.
Dalapon	7.4	Postemergence, sprayed on foliage initially in spring, and resprayed repeatedly on new growth 14 to 24 inches tall.	Johnsongrass from rhizomes or seed.
Sodium chlorate	300-600	Postemergence or preemergence, applied to plants and soil in spring. High rate for established johnsongrass; low rate for johnsongrass seedlings or itchgrass.	Johnsongrass from rhizomes or seed and itchgrass.

[1] Rates of application of herbicides are stated in terms of a broadcast application of the active ingredient or acid equivalent, whichever is required for a single application.

SUGARCANE DISEASES

The Louisiana sugarcane industry has been constantly plagued by diseases. In 1926 it was almost destroyed by a combination of diseases. The breeding program has usually succeeded in providing varieties resistant or tolerant to the major diseases and plant pathologists have provided other control measures.

Mosaic

Mosaic, a virus disease, is recognized by the presence on the leaves of pale-green or yellowish stripes surrounded by areas of normal green color (fig. 19). Generally the stripes are diffuse and indistinct, but on some varieties or with certain strains of the virus they are sharply defined. Usually the chlorotic areas predominate over the normal green and are rather uniformly distributed over the leaf. Mosaic is transmitted in stalk cuttings used for seedcane and from diseased to healthy plants by aphids.

The most effective control of mosaic is growing resistant varieties, but existence of strains of the virus complicates breeding for resistance. The development of resistant varieties made mosaic a minor disease problem in Louisiana from about 1940 until the early 1960's when a strain of the virus, designated strain H, began to spread in the principal commercial varieties which were susceptible to this strain (*4*). A new strain of mosaic, designated strain I, was reported in 1968 (*46*). Losses in yield from strain H vary with different varieties from about 15 percent in mildly infected crops to 50 percent in completely infected crops. In field tests, strain I produced even greater reductions in germination and yield than strain H (*47*).

Mosaic is widespread throughout the sugarcane belt, but high yields are still being produced. Losses are kept to a minimum in light spread areas by roguing of seed plots. Infection can be kept below a harmful level even in susceptible varieties. In heavy spread areas, particularly the western area, however, roguing in susceptible varieties is futile. Clean seed is introduced into this area to minimize losses, and tolerant susceptible varieties like NCo 310 are grown here. Varieties which are resistant enough

Healthy A D H

Figure 19.—Leaves of sugarcane showing a healthy leaf (left) and 3 different strains of mosaic disease (right).

to rogue, like CP 61-37, CP 65-350, and L 65-69, are beginning to emerge from the breeding program (*8*).

In recent years, mosaic has become widespread on johnsongrass. This mosaic is different from any of the known strains of sugarcane mosaic and is transmissible to sugarcane by artificial inoculation and aphids (*28*). The mosaic on johnsongrass has been identified as Maize Dwarf Mosaic Strain A (MDMV-A). The present commercial varieties appear to be highly resistant to MDMV-A, but it could become a serious problem to sugarcane in Louisiana if a susceptible variety were grown.

Ratoon Stunting Disease

Ratoon stunting disease is caused by a virus. This disease has no clear-cut external symptoms and is therefore difficult to recognize. The internal symptoms consist of discolored vascular bundles at the nodes (pl.I). Cane grown from seed pieces treated with hot air at 54° C. for 8 hours or with hot water at 50° C. for 2½ to 3 hours show definite improvement in yields and growth characteristics as a result of eliminating the virus (fig. 20). Some varieties show a greater increase in yield after heat treatment than others. It is now standard practice in Louisiana to plant seed plots with heat-treated cane.

No insect vector of this disease has been found. Ratoon stunting disease is transmitted from the stem and leaves of diseased cane to healthy cane by cane knives and farm machinery (e.g., mechanical harvesters and stubble shavers).

Red Rot

Red rot is caused by the fungus *Physalospora tucumanensis* Speg-azzini. This disease affects primarily the sugarcane stalk. The internal tissues become dull red with whitish patches (pl.II).

Although red rot causes losses of sugar in mill cane in Louisiana, it is much more serious as a disease of seedcane. During the long winter, the seedcane remains relatively dormant because temperatures are too low for growth to take place. Seedcane diseases, of which red rot is the most important, damage the seed pieces to such an extent that stand reductions or even failures might occur, especially on poorly drained heavy soils. Varieties that once occupied a high percentage of the State acreage have failed because of red rot. All seedlings considered for advanced agronomic testing are screened for their reaction to this fungus disease.

Root Rot

Root rot is caused by fungi belonging to the species of *Pythium* It was one of the combination of diseases that resulted in the failure of the noble cane varieties in Louisiana in the mid-1920's. With the development of more resistant varieties and improved drainage since that time, losses from root rot have been greatly diminished. However, the disease still causes injury during cold, wet winters and together with seed-

A B

Internal symptoms of ratoon stunting disease on sugarcane:
A, Diseased, note discoloration in nodes; *B*, healthy.

PN-2413

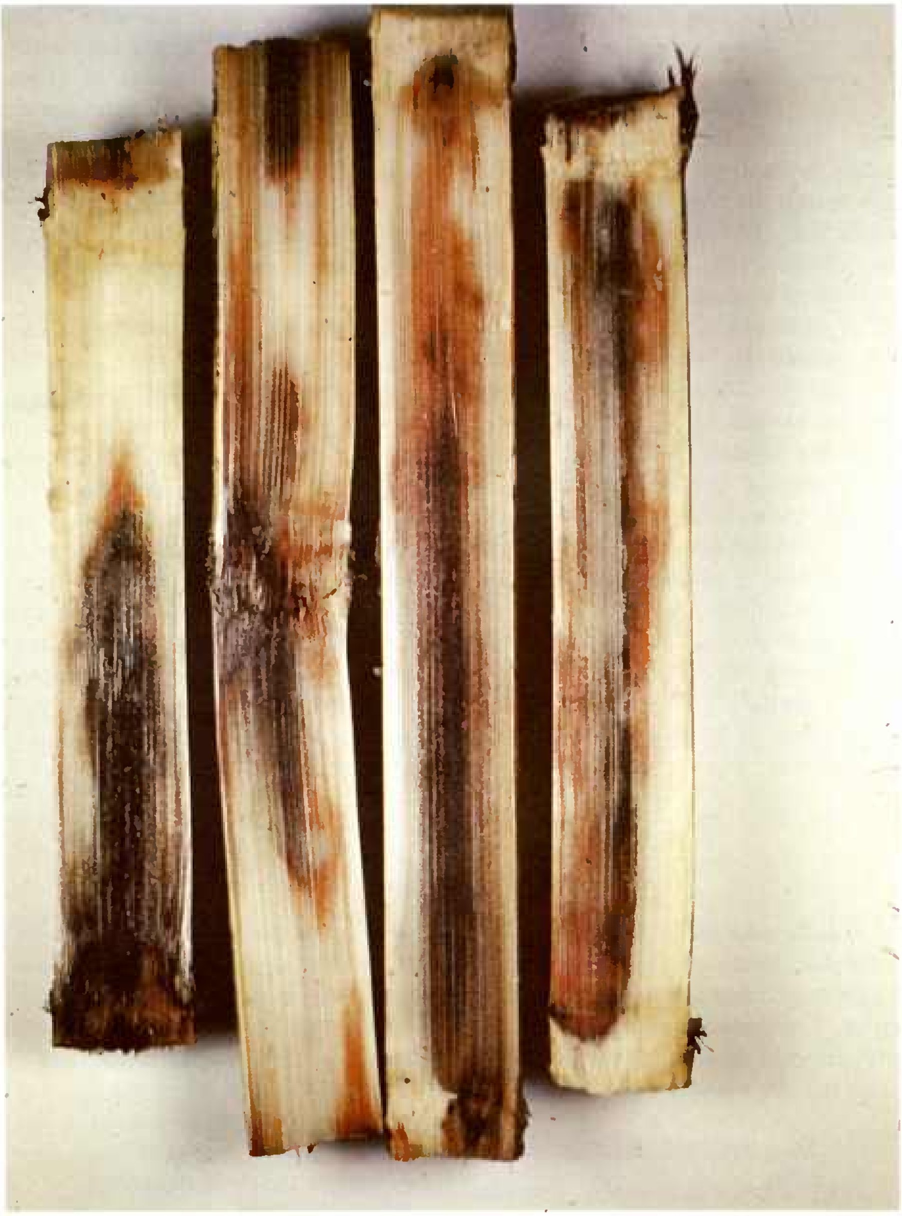
Figure 20.—Heat treatment of sugarcane for control of ratoon stunting disease.

rotting diseases contributes toward stand failures in the spring. Rotting of young rootlets in both plant cane and stubbles interferes with the establishment of the young plants, particularly those grown from seed pieces or stubbles weakened by red rot or other diseases. Unthrifty appearance of young plants with yellowing and wilting of leaves during periods of drought are usually indications of root rot injury. When plants affected by root rot are dug up, marked deficiency of the root system will be found. Flabby, brownish water-soaked rootlets are characteristic symptoms of the disease.

The most effective control for root rot is the use of resistant varieties. The present commercial varieties of cane in Louisiana are at least moderately resistant to the disease. Since the root rot fungus is favored by high soil moisture, good drainage, particularly in heavy soils, is necessary to reduce damage by the disease.

Interaction Between Diseases

The combined effects of diseases on plants may sometimes be greater than those of each disease individually. Sugarcane mosaic (strain H) and the root rot fungus *Pythium graminicola* Subr. in combination caused greater reductions in growth of some commercial varieties than each disease individually (*29*). There are indications that greater reductions in growth of some varieties may also result when mosaic and ratoon stunting disease are present in combination. Under certain conditions, some varieties are affected by the combined effects of three or more diseases, for example mosaic, ratoon stunting disease, root rot, and fungus leaf spots.



Split sections of sugarcane showing red rot.

Diseases of Minor Importance

Other fungus seed-rotting diseases have caused some concern in Louisiana from time to time but seldom do much damage to present-day varieties. These diseases are Phytophthora rot caused by *Phytophthora megasperma* Dreschler and P. *erythroseptica* Pethybridge; black rot caused by *Ceratocystis adiposa* (Butler) C. Moreau; and pineapple disease caused by *Ceratocystis paradoxa* (de Seynes) C. Moreau.

Chlorotic streak, believed to be caused by a virus, caused losses in some susceptible varieties formerly grown but is rarely found in Louisiana cane fields today.

Pokkah boeng, or tangle-top, disease occurs frequently in Louisiana during periods of rapid growth after rainy spells. It is caused by the fungus *Gibberella moniliformis* (Sheldon) Wineland. Losses are usually minor because most varieties are resistant.

An occasional outbreak of brown spot occurred in Louisiana on certain varieties when there was no late spring freeze. The leaf spotting disease is caused by the fungus *Cercospora longipes* Butler. It seldom occurs on present commercial varieties.

Mottled stripe, caused by the bacterium *Pseudomonas rubrisubalbicans* (Christopher and Edgerton) Hayward is commonly seen on leaves of many varieties in the spring and early summer. The disease is seldom observed on older cane.

Red stripe disease is occasionally seen on the leaves of some varieties, especially in the summer, but the top rot stage of the disease has not been observed for many years. The disease is caused by the bacterium *Xanthomonas rubrilineans* (Lee et al.) Starr et Burkh.

INSECTS[3]

Insects and allied pests cause considerable losses every year by damaging sugarcane and transmitting diseases. Continuing research programs are directed toward developing controls for the various pests.

Sugarcane Borer

The sugarcane borer, *Diatraea saccharalis* (Fabricius), is the most important and destructive insect attacking sugarcane in Louisiana. Injury is caused by the larvae feeding and tunneling within the stalks. Reductions in both cane tonnage and in purity of the juice result. Larval tunneling also weakens the stalks, which then lodge or break in high winds. Borer attacks also destroy vegetative buds in seedcane and allow easy entry of disease organisms.

Biological control of the sugarcane borer is not as effective in Louisiana as in more tropical areas. The sugarcane borer can be effectively controlled with azinphosmethyl (Guthion) and carbaryl (Sevin), which is

[3]This section was prepared by R. D. Jackson.

frequently applied by airplane. Other methods that assist in control include (1) destroying infested plant residues (trash) by burning or removing it from canefields after harvest, (2) shaving and burning heavily infested early plant cane in late winter, (3) planting borer-free seedcane, and (4) using borer-resistant varieties.

Sugarcane Beetle

The sugarcane beetle, *Euetheola rugiceps* (Leconte), injures sugarcane in the spring by gnawing ragged holes in the young plant just below the soil surface. There are cycles of abundance and scarcity of the insect. Early planting and light trapping have been of value in decreasing injury to sugarcane.

Wireworms

Wireworms (*Melanotus, Conoderus,* and *Aeolus* spp.) destroy the vegetative buds of the planted seedcane before germination and bore into young plants below the surface of the soil and kill them. Infestations are restricted to the well-drained sandy soils. Wireworms can be effectively controlled with Diazinon.

Soil Arthropods

Several species of soil arthropods cause injury to sugarcane by pruning off root hairs and gnawing into cane roots. The resulting wounds provide entrances for fungus pathogens. Injury has been most serious in the heavy, poorly drained soils where root rots have been prevalent and during winters when cane remained dormant. These pests include symphylans (*Hanseniella unguiculata* (Hansen)), springtails (*Pseudosinella violenta* (Folsom)), *Lepidocyrtus cyaneus* (Tullberg), *Onychlurus armatus* (Tullberg), and bristletails (*Japyx* sp.). August planting and improved drainage have markedly reduced injury by soil arthropods.

Miscellaneous Pests

Other pests that attack sugarcane but usually cause minor injury are the yellow sugarcane aphid, *Sipha flava* (Forbes); gray sugarcane mealybug, *Dysmicoccus* (*Pseudococcus*) *boninsis* Kuwana; the sugarcane weevil, *Anacentrinus subnudus* Buch.; lesser cornstalk borer, *Elasmopalpus lignosellus* Zell.; West Indian sugarcane fulgorid, *Saccharosydne saccharivora* Westwood; the pink borer, *Meropleon cosmion* Dyar; another borer, *Schoenobius* sp.; the scale, *Pulvinaria elongata* Newstead; and various species of cutworms and grassworms. No methods of controlling these pests have been developed.

HARVESTING

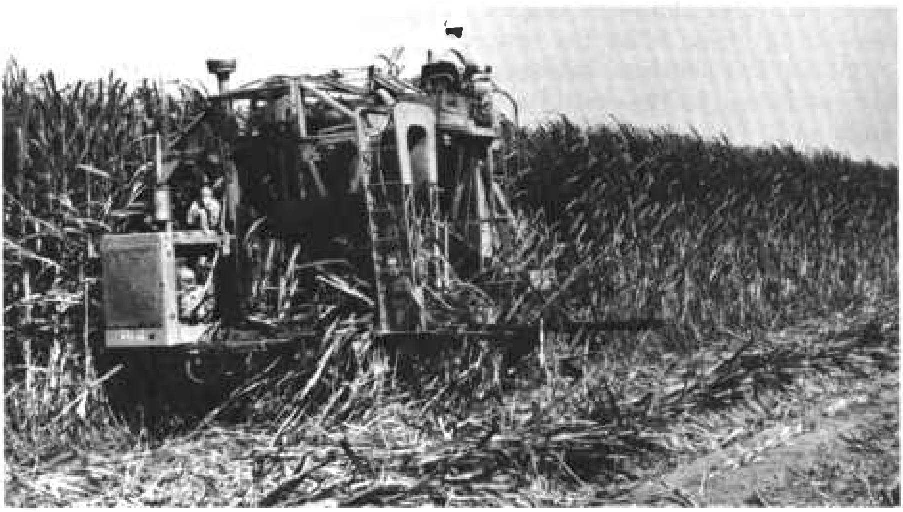
Harvesting of sugarcane in Louisiana begins in mid-October and ends in late December. The crop is only 7 to 8 months old when harvesting begins. It increases in value, particularly in sucrose content, during October and November. However, the grower cannot wait for his crop to reach peak maturity because he would risk losing much of it due to killing freezes. Light freezes (26° to 28° F.) sometimes occur as early as late October or early November. They kill most of the leaf tissue and stop sugar accumulation. Freezes with minimum temperatures as low as 24° severely damage tissue in the upper part of the stalk which must be topped off and left in the field. Sustained temperatures below 23° freeze the whole stalk, and this is generally followed by a rapid deterioration of cane remaining in the field (*25*).

The crop is harvested entirely by machinery (fig. 21). Erect Louisiana varieties permit the use of what is generally known as the Louisiana "soldier type" harvester. The machine cuts the cane at the bottom and top and piles it on "heap rows." About six rows are placed on each heap. The machine does not clean or strip the cane, although some experimental machines can clean the cane of trash. Leaves and adhering trash are burned after 2 to 4 hours of drying on the heap row.

A sugarcane harvester is capable of cutting 30 tons of cane per hour in erect cane. Heavy rainfall or high winds often cause high tonnage cane to lodge. In this case, the cutting rate drops to 15 tons.

The cut, burned cane is loaded into tractor-drawn carts (fig. 22). A typical grab-type loader can load 60 tons of cane per hour, and a tractor with two wagons can haul about 11 tons of cane per hour from the field. Cane is hauled directly to the mill in the tractor wagons, or loaded into trailer trucks at field transfer stations for longer hauls.

Until recently, cane was handled and transported entirely in bundles held together with chains or "slings."



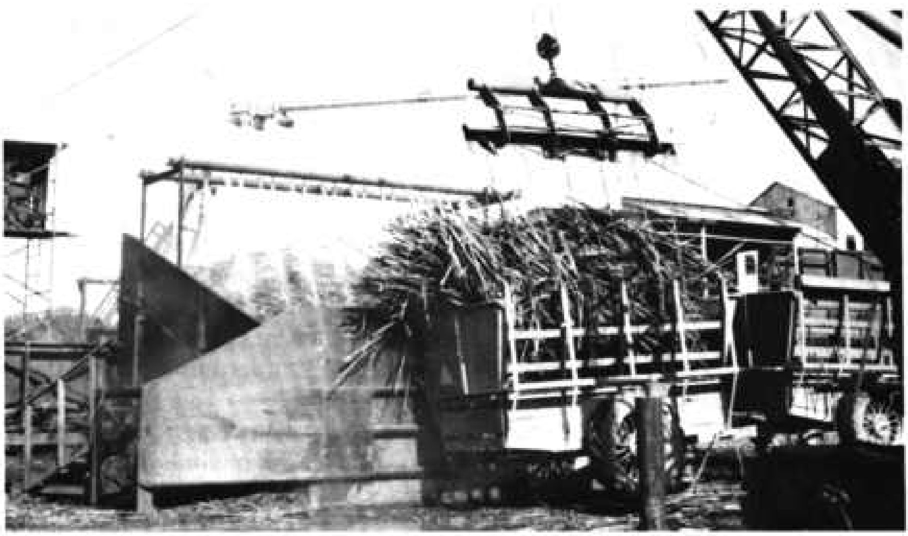
PN-2414

Figure 21.—Sugarcane harvester cutting sugarcane.

This practice has yielded almost completely to bulk handling systems (*14*). Many systems of bulk handling are used, but all are variants of the chain-net or side dump systems (figs. 23 and 24). Bulk handling has resulted in significant cost reductions when cane is hauled directly from the field to the mill (*45*).

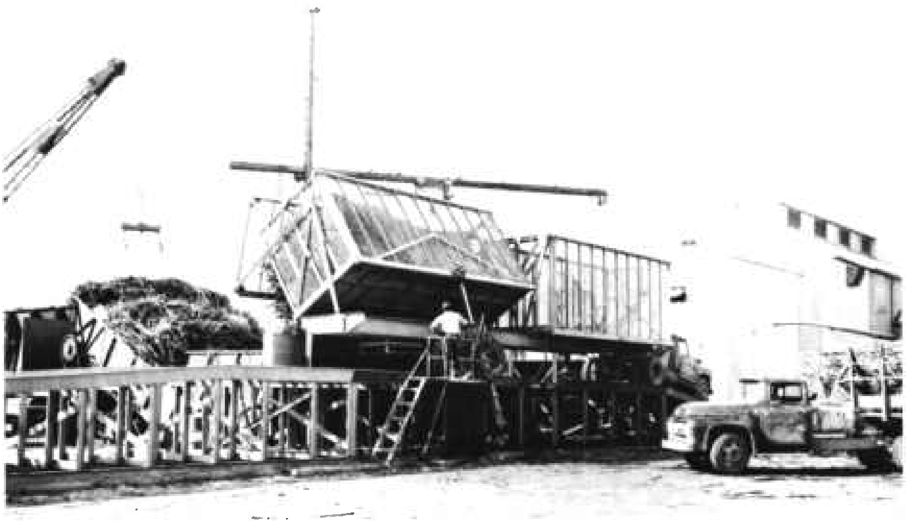
PN-2415

Figure 22.—Loading sugarcane into tractor-drawn carts.



PN-2416

Figure 23.—Unloading sugarcane tractor wagon at the mill.



PN-2417

Figure 24.—Unloading sugarcane truck at the mill.

MANUFACTURING OF SUGAR

Sugar is manufactured in large factories near the cane fields. There were 44 factories operating in Louisiana during the 1969 season. Three of them produced refined as well as raw sugar, and 41 produced raw sugar only. In addition, there are three refineries that process raw sugar into refined sugar. The raw sugar factories differ in size, but most of them can process 100 tons of cane or more per hour. The average capacity of factories operating in 1969 ranged from 1,400 to 6,000 tons of cane for each 24-hour period.

Approximately 54 percent of the Louisiana sugarcane crop is grown by factory or mill owners who process and market their own product, and the remainder of the cane is produced by farmers who do not own factories and are not members of cooperative sugar mills. This latter group sells cane to the nearby factories for the production of sugar. Existing agreements between factory owners and growers provide for payment of cane to be made on the basis of (1) the net weight of the cane after deduction for trash and (2) the level of sugar content. Trash consists of leaves, suckers, sugarcane tops, and all other extraneous materials. In the event damaging freezes occur, acidity tests of the juice are run and appropriate deductions can be made.

When cane arrives at the factory, it is piled in the factory yard by huge derricks for milling during the night (fig. 25) or moved immediately onto the feed table by derrick, bridge crane, or front-end loader. The samples for sucrose and trash determinations are collected on the feed table at most factories. The cane is leveled and washed with from 2,000 to 10,000 gallons of water per minute. The washed cane discharges from the feed table to the carrier. The cane is prepared for milling by revolving knives and, at some factories, additional preparation is accomplished by shredders.

The mill tandem has one or two 2-roller crushers or one 3-roller crusher followed by three or more 3-roller mills. All juice extraction is done by the mill tandem. The crushers have two or more huge, grooved rollers, which range in width from 4 to 7 feet. Each mill has three grooved rollers, as large as the crusher rollers, which are mounted in a triangular fashion.

Hydraulic pressure is exerted on the top mill roller, and the cane is compressed between the top roller and the bottom rollers for juice extraction. Maceration or imbibition water, or water plus juice, averaging 20 percent by weight is injected into the mass of crushed cane as it leaves each mill except the last one. The purpose of this water, or mixed juice, is to diffuse as much sugar and to extract as much juice as possible from the cane. Some mills remove 90 percent or more of the sugar in the cane. Juice extraction varies with the efficiency of the equipment.

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Figure 25.—Sugarcane stockpiled at the mill for night milling.

The pulp or residue containing the fiber after juice extraction is called bagasse (fig. 26). Some of it is used to generate steam to operate the factory. Some bagasse is used in making paper, building and insulating board, plant mulches, and litter for animals.

The juice from the mill tandem is weighed or measured for factory control purposes. The extracted juice is acid with a pH of 5 to 5.5. The pH is raised to 6 or 6.5 with lime to precipitate some of the colloids and other nonsugars and to prevent inversion or degradation of sucrose when the juice is heated. Defecation or clarification of the heated limed juice takes place in large vessels called clarifiers. Precipitates that settle to the bottom of the clarifiers are drawn off and run through rotary vacuum filters to remove more juice containing sucrose. The clear juice is continuously drawn out or decanted from the top of the clarifiers and sent to the evaporators.

The juice contains natural water which was extracted from the cane together with the added maceration water. This water must be removed. This is accomplished in multiple evaporators. The juice enters the

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Figure 26.—Piles of bagasse—a byproduct of sugarcane.

evaporator with a 16° to 18° Brix and leaves at about a 60° Brix.

The sirup goes to the "boiling pans" which are units heated under vacuum and their function is to develop and grow sugar crystals. When the sirup has been evaporated until saturated with sugar crystals or "grains," its density is approximately 92° Brix, and it is ready to be "dried" or centrifuged. A centrifugal machine spins the thick sirup or "massecuite" to remove most of the molasses. The remaining light brown, raw sugar crystals are ready for refining. The refining process includes melting the raw sugar, decoloring the liquid by means of carbon filter, crystalizing it in the vacuum boiling pans, and drying it by centrifugal force. The centrifuged dried sugar is then ready for direct consumption and industrial use.

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