AGRICULTURE HANDBOOK NO. 262

CULTURE OF SUGARCANE FOR SUGAR PRODUCTION IN LOUISIANA

AGRICULTURAL RESEARCH SERVICE ☒ U.S. DEPARTMENT OF AGRICULTURE

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CULTURE OF SUGARCANE FOR SUGAR PRODUCTION IN LOUISIANA

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Sugarcane has been a major crop on farms and plantations of southern Louisiana since 1820. At present it is the principal means of support of approximately 5,700 growers, who employ 20,000 workers in 18 producing parishes of Louisiana. The investment in land, machinery, and other equipment for growing and processing sugarcane in this State is conservatively estimated at $388 million.

Sugar production in Louisiana fluctuated from a low of 47,000 tons in 1926 to a high of 491,000 tons in 1938, as shown in figure 1 (*1*).[2] Yields of cane per acre varied from 6.8 tons in 1926 to 24.4 tons in 1955. Yields of sugar per ton of cane ranged from 108 pounds in 1926 to 176 pounds in 1956.

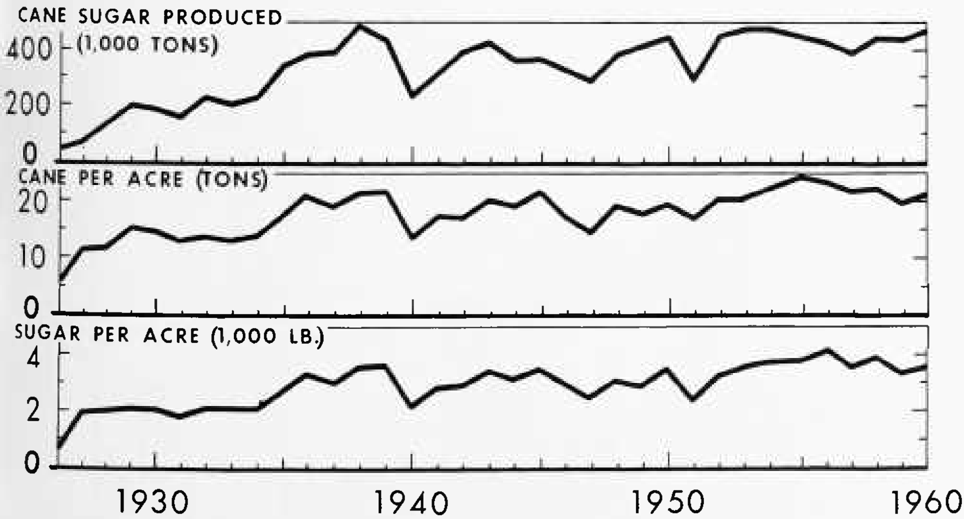

FIGURE 1.—Average yields of sugar and cane per acre and total sugar produced in Louisiana, 1926–60.

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[1] The technical data for this handbook were collected primarily through the research program conducted at the U.S. Sugarcane Field Station, Houma, La. Available statistical data for this area are mostly limited to the State of Louisiana. The principal sugar-production area is largely confined to southeastern Louisiana in the Mississippi Delta. Although the cultural, varietal, harvesting, and other recommendations described in this publication are for Louisiana, they could be applied to the small areas of production extending into southwestern Mississippi, southern Arkansas, and southeastern Texas.

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

GROWING CONDITIONS

The sugarcane area of Louisiana lies between latitudes 29°35′ N. at Houma and 30°57′ N. at 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 usually occur during the winter that kill all young growth of summer- and fall-planted cane and that damage mill cane standing in the field. Several freezes can be expected each year. They average 14 for the winter season, except in 1949–50 when there was no killing freeze. Some loss of mill cane due to cold damage occurs nearly every year. Table 1 gives the average temperatures at Houma in the extreme south, Lafayette in the west, and Bunkie in the north section of the sugarcane area (*24*).

FIGURE 2.—Sugarcane culture for sugar production in Louisiana is primarily restricted to the shaded area. Percentages indicate sugarcane acreage per parish in 1961.

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

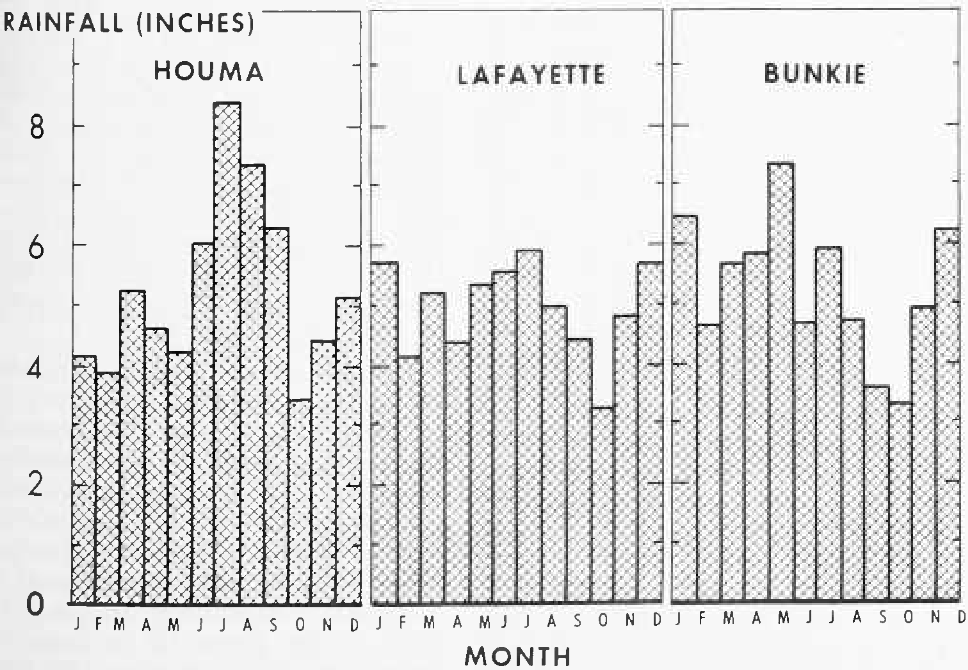

FIGURE 3.—Average rainfall at Houma, Lafayette, and Bunkie in the Louisiana sugarcane area, 1921–50.

Since the rainfall (fig. 3) is generally adequate and reasonably well distributed, the crop can be cultivated during the late winter and early spring. There is more rain usually 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 a[s] it reaches maturity. Sugarcan[e] grows faster during the relatively short growing season i[n] Louisiana than at any othe[r] place in the world, and averag[e] increases in height of 1 inch o[r] more a day are common from late June through August.

DESCRIPTION OF THE PLANT

Sugarcane is a tall, thick-stemmed, perennial grass of the genus *Saccharum*, which stores sugar in the stem. Although tropical in origin, it is adapted to the subtropical environment of southern Louisiana and produces high yields of cane and sugar in the relatively short growing season in that area.

Sugarcane hybridizes with sorghum and with such wild grasses as *Erianthus*, *Imperata*, and *Narenga*. The cylindrical stalks vary in diameter from 0.5 to 2.5 or 3.0 inches. Varieties now grown in Louisiana are complex hybrids produced from crosses made with slender wild canes (*Saccharum spontaneum* L.), slender Indian canes (*S. barberi* Jeswiet), and noble canes (*S. officinarum* L.). Mature stalks vary from 0.75 to 1.00 inch in diameter and from 50 to 90 inches in length, with an average length of 72 inches. They weigh from 2 to 3.5 pounds, depending on growing conditions and on the thickness of stands. The stalks of most varieties selected for commercial culture in Louisiana generally remain erect (fig. 4), but they sometimes lodge, or fall down, when the yield is heavy or there are high winds.

FIGURE 4.—Stripped stool of sugarcane C.P. 44–101, illustrating type of growth.

The stalk is made up of joints, or sections. There are from 10 to 16 joints above the ground. They vary from 4.5 to 7 inches in length. A mature stalk will usually have about 12 joints, each one approximately 6 inches long. Each joint consists of a node and internode (fig. 5). At each node there is a bud, or "eye," which contains the embryo of a new plant. The buds may be oval, pointed, or flat-

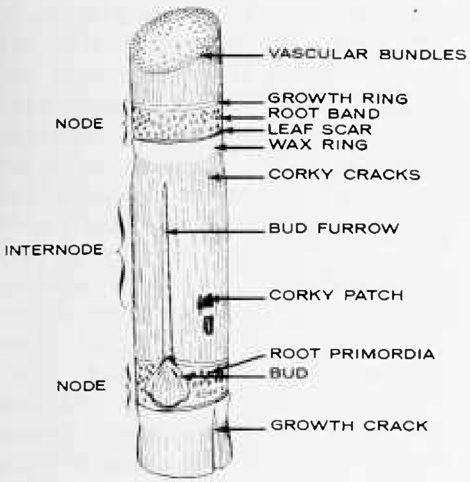

FIGURE 5.—Diagram of node and internode of sugarcane.

tened. Typical of the grass family, the buds are arranged in two rows, occurring alternately on opposite sides of the stalk. A bud furrow, or depression, in the joint immediately above the bud may be deep or shallow; 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 node 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, or purple. The color may be solid or striped. The varieties now grown in Louisiana are predominantly either green or red, with slight color variations where the internode is exposed to the sun. The amount of waxy bloom on the internode and the amount of exposure of the stalk to light affect the color intensity.

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. Long drooping leaves shade the ground and are desirable because they help combat weeds.

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 consists of the primary, or original, shoot, and the secondary shoots, or tillers, and is known as a stool (fig. 6). The primary shoot develops from the bud of the mother stalk or the seed piece, which is a short section of stalk. The secondary shoots develop from the buds on the underground part of the stalk. A tertiary shoot may also originate from a secondary shoot.

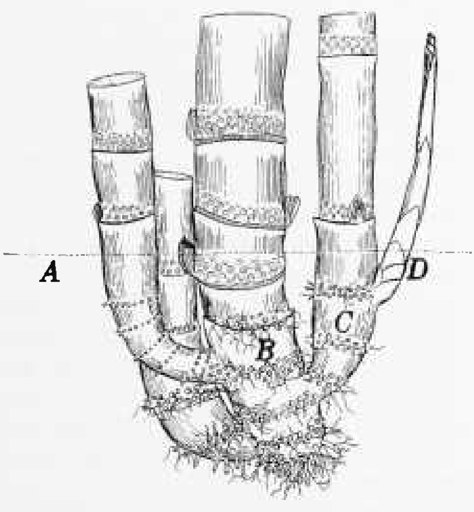

FIGURE 6.—Diagram of part of a sugarcane stool: *A*, Ground level; *B*, primary, *C*, secondary, and *D*, tertiary shoots.

Nature provides for the perpetuation of the species by supplying each plant with a large number of buds, many of which germinate and their shoots emerge above the surface. It is not unusual to find 15 to 20 or more shoots per plant early in the spring and only 3 to 6 mature stalks per plant at maturity because of shading or other causes.

Although sugarcane blooms, or arrows, and sometimes produces viable seed under tropical conditions, propagation in commercial plantings is always by whole stalks or vegetative cuttings. Seed is germinated and grown to produce new, improved varieties in breeding programs. Infinite care and attention are required in order to establish plants from the very small seed. The seedling plants are genetically different from one another and show a diverse range of size, color, juice quality, and other characters. The plants originating from stalks or cuttings are genetically alike and essentially similar in appearance.

VARIETIES

The development of new varieties is necessary to maintain production. The old noble varieties produced good crops for over a century before they failed. However, the succession of hybrids that replaced them, although reproduced vegetatively and hence genetically stable, appears to become less productive after being grown for a few years. This "running out" of varieties is not due to changes in the varieties themselves, since mutations rarely occur, but to new forms or races of disease-producing viruses and fungi, which are constantly arising. As a result, varieties considered resistant to a certain disease when released may become susceptible when a new biologic form of the causal organism appears, and therefore they will need to be replaced. Figure 7 shows that since 1926 the commercial life of the major varieties has been relatively short.

To meet the exacting requirements of the Louisiana sugar industry, a variety should be early maturing, have good stubbling qualities, be resistant to diseases and insect pests, and stand relatively erect at maturity. Early growth in the spring is desirable in order to shade the row and thus to help combat weeds. A certain degree of cold tolerance is essential when the plant is mature because of the constant danger of freezing weather at harvesttime. Resistance to inversion of sucrose to simple sugars, or keeping quality after cutting, is necessary because 3 or more days often elapse between the cutting and the milling of the cane. Varieties with rapid sucrose inversion may lose several pounds of sugar per ton of cane in that period of time.

Commercial Varieties

Table 2 gives the commercial sugarcane varieties, country of origin, year of release, and highest acreage attained by each. Figure 7 shows the changes in varieties that have occupied at least 10 percent of the sugarcane acreage for a period of time.

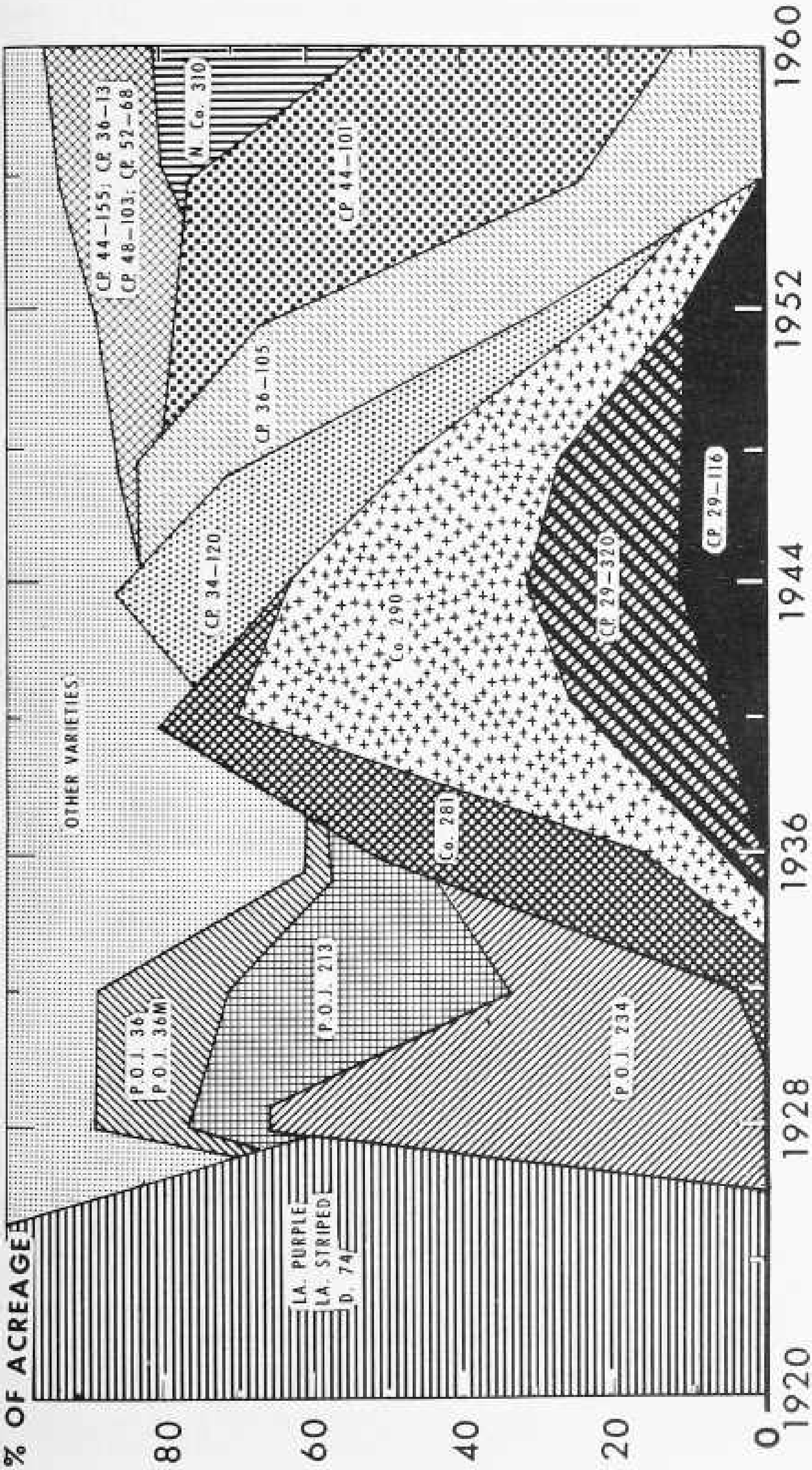

FIGURE 7.—Relative changes in sugarcane varieties based on acreage planted in Louisiana, 1920–60.

TABLE 2.—*Data pertaining to commercial sugarcane varieties released in Louisiana, 1924–60*

Variety	Country of origin	Year of release	Maximum acreage attained	
			Percent	Year
P.O.J. 234	Java	1924	65	1928
P.O.J. 213	.....do	1924	47	1931
P.O.J. 36	.....do	1924	13	1933
P.O.J. 36M	.....do	1924	13	1933
Co. 281	India	1930	47	1936
C.P. 807	United States	1930	11	1935
Co. 290	India	1933	41	1940
C.P. 28–11	United States	1934	5	1942
C.P. 28–19	.....do	1934	13	1942
C.P. 29–320	.....do	1935	24	1940
C.P. 29–116	.....do	1936	13	1947
C.P. 29–103	.....do	1939	7	1945
C.P. 29–120	.....do	1939	10	1947
C.P. 33–243	.....do	1941	1	1945
C.P. 34–120	.....do	1942	25	1947
C.P. 33–310	.....do	1943	1	1947
C.P. 33–425	.....do	1943	1	1947
C.P. 36–105	.....do	1945	39	1952
C.P. 36–13	.....do	1946	7	1953
C.P. 34–92	.....do	1947	1	1951
C.P. 36–19	.....do	1947	1	1951
C.P. 36–183	.....do	1947	1	1951
C.P. 44–101	.....do	1949	53	1957
C.P. 44–155	.....do	1949	11	1955
C.P. 43–47	.....do	1950	4	1955
C.P. 44–154	.....do	1952	1	1954
N. Co. 310	South Africa	1954	25	1960
C.P. 47–193	United States	1955	[1] 3	1959
C.P. 48–103	.....do	1955	[1] 6	1960
C.P. 52–68	.....do	1958	[1] 13	1960

[1] Still increasing.

From 1825 to 1926 only three varieties occupied most of the acreage. Louisiana Purple (Black Cheribon) and Louisiana Striped were grown from 1825 to 1926 and D. 74 from about 1900 to 1926. From 1924, when the P.O.J. varieties were made available to the industry, until 1960, 30 varieties have been released to growers as follows: 4 P.O.J., 2 Co., 1 N. Co., and 23 C.P. Some were generally adapted for the entire sugarcane area and widely grown, whereas others were suitable for certain localities only.

P.O.J. 234 and C.P. 44–101 were each grown on more than 50 percent of the land planted to sugarcane at some time during 1926–60. P.O.J. 213, Co. 281, Co. 290, and C.P. 36–105 were each grown on more than 25 percent of the acreage. C.P. 29–320, C.P. 34–120, and N. Co. 310 were each planted on more than 15 percent of the acreage. P.O.J. 36 and 36M and 10 C.P. varieties were each grown on 5 to 15 percent and 9 C.P. varieties on less than 5 percent of the planted acreage. Several of the latter were released for some specific locality or for some specific purpose and were not expected to meet with widespread acceptance (*12*).

P.O.J. 234 was grown extensively because it was definitely superior to the noble canes. On the other hand, C.P. 44–101 occupied more than 50 percent of the acreage, primarily because of its high yields, satisfactory sucrose, disease resistance, cold tolerance, and general adaptability. It has met with favor in practically every parish of the sugarcane area. Other widely grown varieties, such as Co. 281, Co. 290, C.P. 29–320, C.P. 34–120, and C.P. 36–105, were best adapted to certain areas only.

Some Varietal Characteristics

In 1960, C.P. 44–101, N. Co. 310, and C.P. 36–105 together occupied nearly 80 percent of the sugarcane acreage in Louisiana. C.P. 44–101 (pl. I, *B*), a green medium-barrel variety, which was planted on 48 percent of the acreage in 1960, is generally adapted to most soil types and to each of the three sections of the sugarcane area (*12*, *20*). It produces well on both light and heavy soils, is erect growing, is reasonably early in maturing qualities, is relatively tolerant of cold temperatures, and has good milling qualities. It is medium high in sucrose. Its ability to produce well as plant cane and as stubble makes it the preferred variety on many farms. It is susceptible to a prevalent strain of mosaic and to sugarcane borer injury (*2*, *20*).

N. Co. 310 (pl. I, *D*), a green large-barrel cane with spreading top, was planted on 21 percent of the acreage in 1960. Like C.P. 44–101, it is also adapted to both light and heavy soils in the three sections of the sugarcane area (*20*). The variety has good milling qualities, is moderately resistant to sugarcane borer damage, and is tolerant to cold injury (*7*). It is susceptible to mosaic, moderately susceptible to red rot, and late maturing; it lodges severely under certain conditions. It is moderately high in sucrose after the first few weeks of harvest. Lodged cane can be harvested by machines now in use, because the variety is not brittle and the lodged stalks do not break when straightened by pickup attachments.

C.P. 36–105 (pl. I, *A*), a red small-to-medium-barrel variety, was planted on slightly more than 10 percent of the acreage in 1960, but, unlike C.P. 44–101 and N. Co. 310, it is not generally adapted to all soil types (*20*). It is most extensively planted in the northern section of the sugarcane area and on Red River alluvial soils. It is not well adapted to the terrace soils of the western section. The variety is medium early in maturity, erect, and moderately resistant to mosaic (*2*). It compares favorably with C.P. 44–101 in average sucrose and purity. It is very brittle, lacks cold tolerance, and has relatively poor milling and processing qualities.

C.P. 48–103 is a green medium-to-large-barrel variety, which is very high in sucrose. It is very early maturing, moderately resistant to mosaic, and resistant to sucrose inversion; it has good milling qualities (*20*). However, it is not adapted to all soil types and is recommended for the lighter soils only. It occupied approximately 6 percent of the acreage in 1961 (*12*).

C.P. 36–13, C.P. 44–155, and C.P. 47–193 in the aggregate occupied approximately 10 percent of the acreage in 1960. Both C.P. 36–13 and C.P. 44–155 are green large-barrel canes that are relatively high in sucrose, but they are not generally adapted to all soil types (*20*). C.P. 36–13 is resistant to mosaic and C.P. 44–155 moderately resistant (*2*). C.P. 44–155 shades the row well but frequently lodges. C.P. 36–13 is erect growing and does not shade the row well. Both varieties are recommended for planting on the better soils only. C.P. 47–193, a reddish small-barrel variety, is high in sucrose, early maturing, resistant to mosaic, and adapted to both light and heavy soils. It is susceptible to cold injury and to sucrose inversion after cutting.

The newest commercial variety, C.P. 52–68 (pl. I, *C*), was released to the industry in 1958 and occupied less than 13 percent of the acreage in 1961. Indications are that plantings of this variety will be expanded in the future. The stalk is medium to large in diameter and usually green but often turns reddish when exposed to light. It is a high-yielding, relatively early-maturing cane, with good milling qualities (*20*). It is adapted to both light and heavy soils in most sections of the sugarcane area. C.P. 52–68 is relatively high in sucrose, with slightly more than either C.P. 44–101 or N. Co. 310. It is susceptible to mosaic (*2*) and does not withstand cold as well as C.P. 44–101 and N. Co. 310.

IMPROVED VARIETIES

The ravages of diseases made it impossible to grow dependable crops from the old varieties after 1925, and other varieties were accordingly introduced to replace them. Varieties from Java and India were grown because they were tolerant of mosaic. When they in turn became infected with diseases, new varieties were bred to replace them.

The development of high-yielding, disease-resistant varieties through breeding and agronomic testing is the chief objective of the sugarcane investigations of the Agricultural Research Service. This work is carried on at Plant Industry Station, Beltsville, Md., and at four field stations—Canal Point, Fla., Houma, La., Cairo, Ga., and Meridian, Miss. The breeding of improved sugarcane varieties for Louisiana is conducted by the U.S. Department of Agriculture at Canal Point and by the Louisiana Agricultural Experiment Station at Baton Rouge, La.

Plant explorers have searched areas of the world where forms of sugarcane are native to discover those with qualities desired in commercial varieties (*5*, *25*). In order to assemble in one variety disease resistance, high yield, cold tolerance, desirable stubbling qualities, and other special requirements of the Louisiana sugar industry, it was necessary to combine by crossbreeding many diverse forms of sugarcane, such as the large-barrel, soft, sweet noble canes (*Saccharum officinarum*), the commercially worthless, slender, nonsweet canes (*S. spontaneum*), and the small-barrel, high-fibered Indian canes (*S. barberi*). *S. robustum* Brandes & Jeswiet, a progenitor of the noble canes, was also used in breeding.

Breeding

A large greenhouse high enough (26 feet) to accommodate the tall cane stalks is used for hybridization (fig. 8). Several weeks before setting up the cross, the canes to be used as parents are marcotted or air layered. When marcotted, the stalk is placed inside a 30-inch earth-filled stovepipe. When air layered, the stalk is wrapped first with wet sphagnum moss so as to cover two nodes and then with polyethylene to keep the moss from drying out. When the flowers have developed enough to make the cross, the stalk is severed immediately below the part that has been marcotted or air layered and the stalk cutting is placed in a trough of running water in the greenhouse. At this stage the roots have grown enough to keep the plant alive.

Polyethylene-enclosed cubicles inside the greenhouse prevent promiscuous dissemination of pollen outside the compartment. The stalks bearing the pollen-producing arrows, or flowers, are raised above those bearing the seed-producing arrows. Although sugarcane produces perfect flowers, most varieties are self-sterile, and many varieties do not produce viable pollen. The breeder

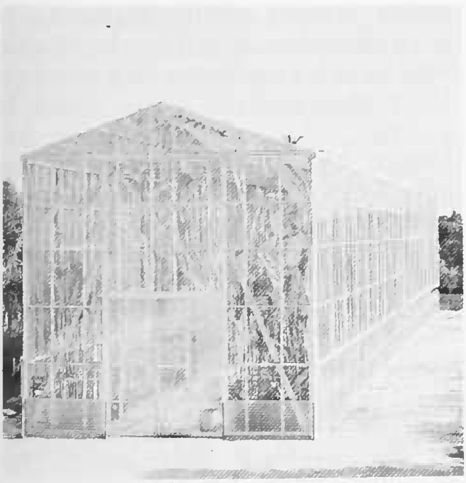

FIGURE 8.—Greenhouse at Canal Point, Fla., in which sugarcane hybridization is conducted.

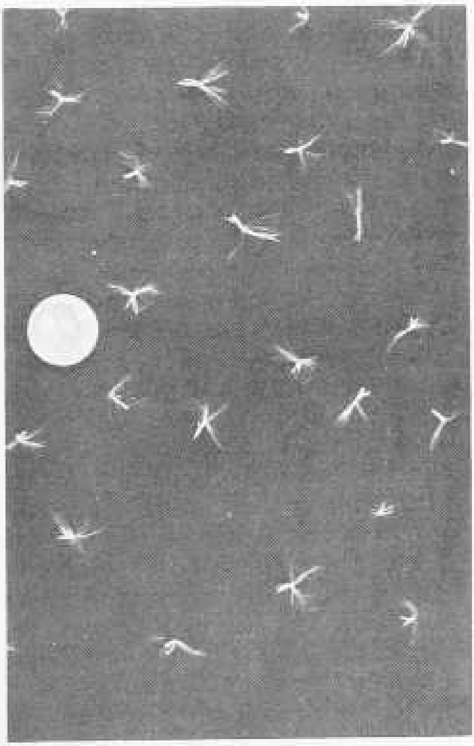

FIGURE 9.—Sugarcane fuzz containing tiny seed.

identifies the pollen-producing parent by examining the anthers for pollen grains or by the iodine test. For the following 2 or 3 days the pollen-bearing stalks are tapped each day so that they will shed the pollen. When the flowers have been fertilized, the pollen parents (male) are removed and the seed-producing parents (female) are left for the seed to ripen. In about 21 days the fuzz containing the ripe seed (fig. 9) is stored overnight in a drying chamber before planting the seed.

In basic studies now in progress many other forms of related plants are used in an attempt to produce sugarcane varieties better adapted to conditions in Louisiana. There are over 3,000 sugarcane clones and related grasses in the collection maintained at Canal Point. Facilities at that station are adequate to produce almost unlimited quantities of sugarcane seed for testing at the four stations (*9*). In the 1958 breeding season more than 2 million viable seeds were produced from 263 crosses considered desirable for Louisiana conditions. These seeds were tested by the U.S. Department of Agriculture at the Houma and Canal Point stations and by the Louisiana Agricultural Experiment Station at Baton Rouge for possible adaptability for sugar production. Some were tested at the Meridian and Cairo stations to determine their value for sirup varieties. Seedlings grown at Meridian and Cairo were also selected for sugar qualities, and the promising ones were transferred to Houma for possible use as sugar-producing varieties.

Testing

Evaluation of large numbers of seedlings involving greatly diverse genetic material is a large undertaking. The land, labor, and time required for such a project are considerable, and it is important that methods be devised for the most efficient use of the seedlings (*14*, *17*).

A system is being studied at Houma to evaluate more efficiently a large number of seedlings. This entails planting the seedlings 15 inches apart in rows spaced 6 feet apart for the most promising crosses, and combining or bunching two, three, or even five seedlings per hill (*6*, *14*), with the same spacing between rows, for the untried crosses.

Some characters, such as erectness of stalks and number of stalks per stool, do not always perform in the clones in the same manner as they perform in the seedlings (*17*). Such characters, although considered in the initial selection, are not given the emphasis that they once were. On the other hand, stalk diameter is considered highly heritable and more emphasis is placed on that character. Since there is a low order of association between the performance of the seedling and of the clone, it is necessary to select many more plants in the seedling stage to establish as clones than formerly were taken. In a step-by-step elimination process, varieties are systematically selected and advanced in the testing program and finally sent to cooperating plantations for further testing.

There are 12 test fields in the Louisiana sugarcane area where work on varieties is conducted cooperatively by the U.S. Department of Agriculture, the Louisiana Agricultural Experiment Station, and the American Sugar Cane League, an organization of sugarcane growers and processors. Six of them are on light and heavy soils formed by recent alluvial deposits of the Mississippi River, five are on Pleistocene soils west of the Atchafalaya River, and one is on soil formed by recent deposits of the Red River. Two of the twelve are in the northeastern, five in the western, and five in the southeastern section of the sugarcane area.

Simultaneously with the testing for yield performance and disease resistance, seed-increase stations, supervised by the American Sugar Cane League, propagate the most promising varieties, so that when sufficient information is obtained to justify commercial release of a new variety, a quantity of seed is available for distribution to the growers. Approximately 10 years is required from the time a cross is made until a variety is evaluated and ready for release to the industry.

Inversion of Sucrose and Cold Tolerance

Inversion of sucrose to simple sugars occurs more rapidly in the new canes because of their wild parentage and sometimes causes considerable loss of sugar when the crop is not processed soon after cutting. Varieties vary in the degree of inversion. One of the objectives of the breeding program is the production of varieties more resistant to inversion.

Damage to sugarcane from cold injury is an economically important consideration in growing this crop in Louisiana. Under Temperate Zone conditions, where freezes can be expected at the beginning of the growing season and also in the fall before harvesting of the crop is completed, tolerance to cold is one of the major considerations in selecting varieties for commercial culture. Although hybrid varieties grown at the present time vary in some degree, they are much more tolerant of cold weather than the noble varieties, and some of them can withstand freezing temperatures with little or no injury to the foliage or other growing parts (*7*). They remain in sound condition longer after killing freezes than the noble canes, which did not contain the genic complement of the wild canes.

Probably of equal economic importance is the ability of the new hybrids to begin growing much earlier in the spring to establish a protective cover before summer weeds begin to grow, and thereby the cost of cultivation is reduced. This longer period of growth gives the new varieties a decided advantage in the production of sugar and they are more mature at harvest than the noble varieties.

Release to Growers

When a variety appears to be promising after undergoing a series of agronomic and other tests, it is released to the growers. The three agencies concerned in the variety program agree to make it available for general planting, and the American Sugar Cane League is responsible for equitable distribution of seedcane to the growers.

SUGARCANE DISEASES [3]

From 1926, when the sugarcane industry was almost totally destroyed by a combination of diseases, until the present, Louisiana has been constantly plagued by sugarcane diseases. The breeding program has usually succeeded in providing resistant varieties and the plant pathologists have contributed toward providing other control measures when no resistance was found.

The ideal disease-control measure is to grow resistant varieties. However, this is not always possible. Some of the other recommended practices are as follows: (1) Roguing, or removing diseased plants from seed plots, whenever possible; (2) isolating seed plots to minimize the spread of disease to healthy cane; (3) treating cane to be used in seed plots with hot air at 58° C. for 8 hours; (4) preventing growth of volunteer cane in areas to be used as seed plots; and (5) providing good drainage to prevent seed-rot diseases.

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 (pl. II). 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 (see p. 18).

Development of resistant varieties made mosaic a minor disease problem in Louisiana from about 1940 until 1956, when a new strain of the virus appeared to which the principal commercial varieties are susceptible. Losses in yield from this strain vary with different varieties from about 15 to 30 percent in completely infected crops. The most effective control is growing resistant varieties, but existence of strains of the virus complicates breeding for resistance. Roguing of seed plots is necessary for control in susceptible varieties.

Ratoon Stunting Disease

Ratoon stunting disease (fig. 10) is caused by a virus. This disease has no clear-cut external symptoms and is therefore difficult to recognize. The internal symptoms appear as orange vascular bundles at the nodes (pl. III). Cane grown from seed pieces treated with hot air at 58° C. for 8 hours or with hot water at 50° for 2½ to 3 hours shows definite improvement in yields and growth characteristics as a result of eliminating the virus. 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 diseased to healthy cane by cane knives or mechanical harvesters.

[3] Information supplied by E. V. Abbott, plant pathologist, Crops Research Division.

FIGURE 10.—Stunting of sugarcane due to ratoon stunting disease. *A*, Diseased; *B*, healthy.

Red Rot

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

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

Root Rot

Root rot is caused by the fungus *Pythium arrhenomanes* Drechsler. 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 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-rotting diseases contributes toward stand failures in the spring. Rotting of young rootlets of 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.

Gappy stands and 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 with 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 to grow resistant varieties. The present commercial varieties of cane in

710-850 O-64-3

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.

Other Seed-Rotting Diseases

A rot of seed pieces known as Phytophthora rot is caused by the fungi *Phytophthora megasperma* Drechsler and *P. erythroseptica* Pethybridge. This disease has been found only in Louisiana. Affected cuttings appear water soaked at first. Later they become reddish brown and sometimes have salmon-colored streaks through the rotted area. On varieties with light-green or yellow stalks, these streaks may show through the rind and are a characteristic symptom of the disease. The disease sometimes reduces stands in poorly drained fields, particularly during cold, wet winters. C.P. 36–13 is the most susceptible of the commercial varieties. Growing resistant varieties and providing good drainage are important in control.

Black rot caused by *Ceratocystis adiposa* (Butler) C. Moreau occurs rarely. The ends of affected seed pieces are covered with the black fuzzy growth of the fungus. The internal tissues become black, soft, and watery and have an odor similar to that of fermented pineapples. This disease was more prevalent on seedcane that was banked or windrowed in the fall for spring planting and when the P.O.J. varieties were grown commercially, but it is seldom seen on the present varieties.

Pineapple disease caused by *Ceratocystis paradoxa* (de Seynes) C. Moreau results in a rotting of seed pieces similar to black rot. The fungus lives in the soil and infects the seed pieces through the cut ends. The tissues first become reddened, then black, and finally break down so that the interior of the cutting becomes hollow. There is a strong odor of fermenting pineapples. This is a major disease in some countries, but it is rarely found in Louisiana.

Chlorotic Streak

Chlorotic streak, believed to be caused by a virus, is not a major disease of the present commercial varieties of sugarcane in Louisiana, but it caused important losses in some susceptible varieties formerly grown. The characteristic symptom is the production on the leaves of pale yellow to white stripes with wavy, irregular margins. The short hot-water treatment (52° C. for 20 minutes) of the seed pieces is effective in controlling this disease. The treatment recommended for controlling ratoon stunting disease (p. 14) is more than adequate to control chlorotic streak.

Pokkah Boeng

Pokkah boeng, or tangled-top disease, is caused by *Gibberella moniliformis* (Sheldon) Wineland. It occurs frequently in Louisiana during periods of rapid sugarcane growth after rainy spells. The fungus spores grow at the base of the sheath where moisture accumulates. The tissues die, the leaves fail to develop, and the tops are easily broken. In severe cases the fungus invades the stalk and it dies, but this seldom occurs. Losses are usually minor. Growing resistant varieties is the only practical control measure.

Brown Spot

Brown spot, a leaf-spotting disease, is caused by the fungus *Cercospora longipes* Butler. It produces small, oval, reddish-brown spots on the leaves. It is more widespread when there are no late spring freezes and more prevalent in certain varieties than in others. In years of heavy infection, yields of sugar per ton have been reduced. Use of available fungicides is not economical, although they have given satisfactory control in experimental work.

INSECTS AND OTHER PESTS[4]

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

Sugarcane Borer

No other insect causes as much damage to sugarcane in Louisiana as the sugarcane borer (*Diatraea saccharalis* (F.)). The feeding of the larvae in the stalks interferes with the translocation of plant-food substances. Yields are reduced because the size and weight of the stalks and the sucrose content of the juice are decreased. Borer tunneling also weakens the supporting tissues and the stalks lodge or are broken by high winds. It is difficult for a mechanical harvester to pick up broken or stunted stalks. Much of the infested cane is left in the field and serves as a source of infestation for the next cane crop. In addition to other damage, tunnels made by borers injure lateral buds and also allow easy entry of disease organisms, such as fungi causing red rot and certain bacteria. This damage causes poor stands and even stand failures in some years.

Biological control as used in many tropical countries is not effective in Louisiana. The best method of controlling the borer in this State is to apply 2-percent endrin granules at the rate of one-third pound per acre. Excellent control can be obtained with three or four applications at 2-week intervals beginning when 2 percent of the stalks have young second-generation borers. Other recommended control methods include scrapping sugarcane fields, i.e., removing pieces of cane left in the fields, burning leaves and other cane trash, planting borer-free seedcane, and using borer-resistant varieties.

Sugarcane Beetle

The sugarcane beetle (*Euetheola rugiceps* (LeConte)) injures young cane shoots in the spring and sometimes may cause serious damage on the lighter soils. Aldrin or heptachlor applied either as granules

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[4] Contributed by Entomology Research Division, Agricultural Research Service.

or in an emulsion at the rate of 1 pound per acre on top of the row at planting time is recommended for this insect on corn. Endrin has looked very promising in some experiments on sugarcane. Trapping is of some value in decreasing the insects in the next generation. The most effective means of control is planting sugarcane in August to get a good stand established before the beetle can cause much damage.

Wireworms

Wireworms (*Melanotus*, *Conoderus*, and *Aeolus* spp.) bore into the buds of planted cane and into young plants below the surface of the ground and kill the cane. Damage has been severe enough in late-planted fields to cause near stand failures. Recommended control measures include planting in August for early emergence and tillering, and applications in the fall of 2 to 4 pounds of chlordane per acre on seedcane in the planting furrow before covering.

Small Soil Animals

Several small soil animals cause some direct damage by feeding on buds and roots and thus they affect plant growth and permit entrance of fungus pathogens through injuries. These pests include symphylans (*Hanseniella unguiculata* (Hansen)), springtails (*Pseudosinella violenta* (Folsom), *Lepidocyrtus cyaneus* (Tullberg), *Onychiurus armatus* (Tullberg)), bristletails (*Japyx* sp.), and snails (*Zonitoides arboreus* (Say)). Recommended control measures include application of 2 pounds per acre of chlordane to the seedcane in the furrow at planting time. This treatment is especially recommended for plantings on heavy soils, where these animals often cause damage.

Insects That Transmit Sugarcane Diseases

Sugarcane mosaic is spread by certain insect vectors of the virus. Four species of plant lice are known to carry sugarcane mosaic from diseased to healthy plants. They are the rusty plum aphid (*Hysteroneura setariae* (Thomas)), the corn leaf aphid (*Rhopalosiphum maidis* (Fitch)), the greenbug (*Toxoptera graminum* (Rondani)), and the sedge aphid (*Carolinaia cyperi* Ainslie). Control of weeds that harbor insect vectors and isolation of seed plots from plant hosts of mosaic are probably the best ways of preventing these insects from spreading mosaic.

Safety Procedures

Insecticides are poisonous. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the container label.

Insecticides should be kept in closed, well-labeled containers in a dry place where they will not contaminate food or feed and where children and pets cannot reach them.

Avoid repeated or prolonged contact of insecticides with the skin. Do not inhale dusts or mists. Wear clean, dry clothing and wash hands and face before eating or smoking. When handling concentrates, avoid spilling them on the skin and keep them out of the eyes, nose, and mouth. If any is spilled, wash it off the skin and change the clothing immediately. If it gets in the eyes, flush with plenty of water for 15 minutes and get medical attention.

To protect fish and wildlife, be careful not to contaminate streams, lakes, or ponds with insecticides. Do not clean spraying equipment or dump excess spray material near such water.

Avoid drift of insecticide sprays or dusts to nearby crops or livestock, especially from applications by airplane and other power equipment.

Do not feed bagasse (p. 38), field trimmings, or cane treated with endrin to livestock. Do not harvest sugarcane for 45 days after treatment with endrin.

SOIL TYPES

The soils on which sugarcane is grown in Louisiana can be classified into three general groups: (1) Recent alluvial of the lower Mississippi River, (2) Recent alluvial of the Red River, and (3) Pleistocene terrace. More than 60 percent of the acreage lies east of the Atchafalaya River in the flood plains of the Mississippi River and Bayou Lafourche. Like most alluvial soils deposited by slow-moving streams, the sandy well-drained soils are near the stream and the clayey poorly-drained soils lie at a distance from the stream. Slightly more than 36 percent of the cane area lies west of the Atchafalaya River on terrace soils, part of which was deposited during the Pleistocene era and the remainder during the later Pleistocene or the early Recent era.

The Recent alluvial soils, ranging from well-drained silt and sandy loams to poorly-drained heavy clays, are inherently rich in plant-growth elements and seldom respond to fertilizers other than nitrogen. The geologically older terrace soils are lower in nitrogen, as well as in both phosphorus and potassium, and sugarcane responds to additions of these mineral constituents as well as to nitrogen. Less than 4 percent of the sugarcane acreage is located on soils formed by Recent alluvial deposits of the Red River. These soils are some of the most productive in Louisiana.

CULTURAL PRACTICES

Drainage

The relatively level, low-lying land on which sugarcane is grown in Louisiana requires drainage for best results in growing sugarcane. In order to insure proper drainage, the cane is planted in ridges built to a height of 12 inches with turning plows and disk cultivators, or choppers. A lateral ditch is cut parallel to the ridges every 100 to 150 feet. The area between two ditches is a "square," or "cut." The cuts are commonly about 700 feet long, with a field

FIGURE 11.—Conventional square-cut ditch in sugarcane field.

road or headland on each end. Two or three "quarter drains," or ditches at right angle to the ridges, drain the water from the cuts to the lateral ditches. Deeper ditches connecting the lateral ditches with the bayous drain the water into these streams.

A lateral ditch is a square-cut ditch (fig. 11) made with a dragline and special buckets designed to cut a ditch approximately 30 inches deep, 18 inches wide at the bottom, and 38 inches wide at the top. The slope on each side prevents excessive caving. A V-shaped ditch (fig. 12) is cut with a ditch plow to the required depth but with a much flatter slope. Both types of ditches require approximately the same acreage.

FIGURE 12.—V-shaped ditch in sugarcane field.

FIGURE 13.—Opening a quarter drain with a tractor plow.

Quarter drains require cleaning after every cultivation and are expensive to maintain. The most common method of cleaning them is to open them with a tractor plow (fig. 13) and to open the middles with a hand shovel. Some of the farm-machinery manufacturers in Louisiana are experimenting with self-propelled machines to clean these drains and several are meeting with success. Mechan-

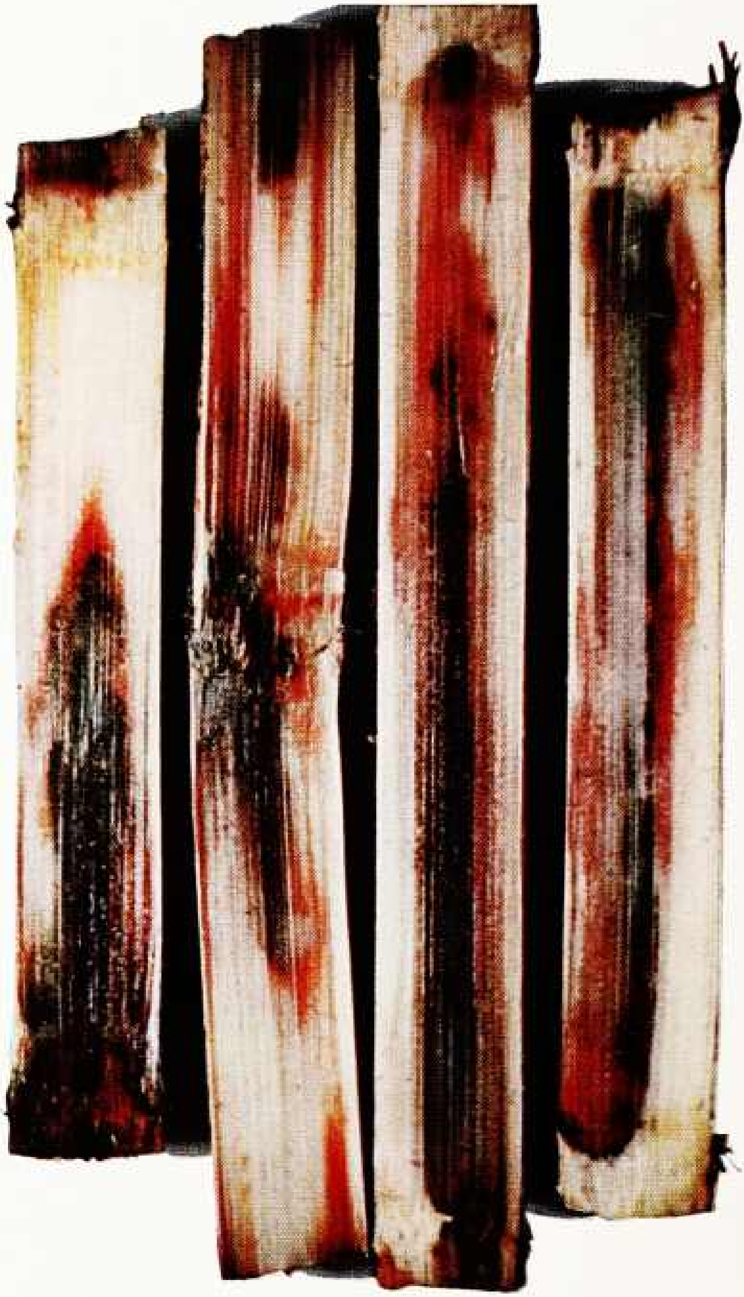
A B C D

Four sugarcane varieties: *A*, C.P. 36–105; *B*, C.P. 44–101; *C*, C.P. 52–68; *D*, N. Co. 310.

Leaf of sugarcane showing mosaic disease.

A B

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



Split sections of sugarcane showing red rot.

ical cleaning of drains results in better drainage at less cost.

Crop Rotation

Sugarcane in Louisiana is usually grown in rotation with soybeans or soybeans and corn. One plant-cane and two stubble crops are harvested from one planting, and either soybeans or soybeans and corn are grown during the fourth year (fig. 14). Where poor stubble makes it unprofitable to grow a second stubble crop, particularly in heavy johnsongrass (*Sorghum halepense* (L.) Persoon) infestations, the fields are plowed after one stubble crop and the area is fallow plowed for 1 year to eradicate the weeds (fig. 15). No soybeans are grown under these circumstances to permit frequent plowing of the area.

FIGURE 14.—Soybean crop grown in rotation with sugarcane.

Organic-Matter Accumulation

Incorporation of cane leaves and tops into the soil and

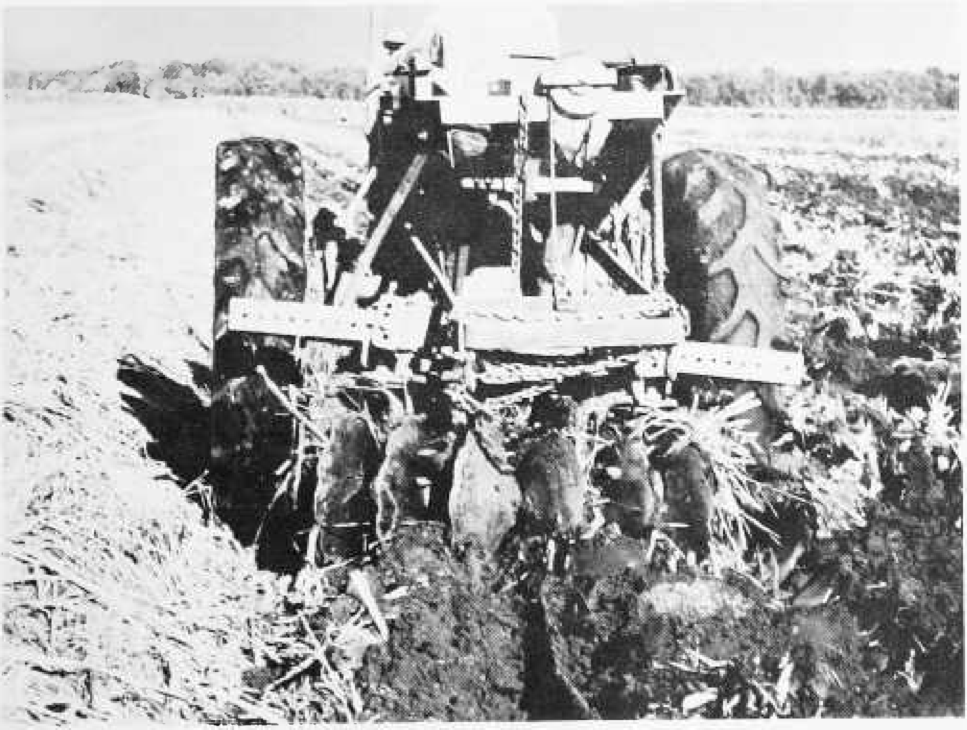


FIGURE 15.—First step in preparing seedbed is destroying old sugarcane stubble.

plowing under soybeans increase cane yields. Yields can also be maintained by adding nitrogen when it is impossible to grow soybeans and when fallow plowing is necessary to control weeds (*15*).

Turning under soybeans does not always increase the organic-matter content of the soil where sugarcane is grown in rotation. A good crop of sugarcane with large amounts of cane roots, tops, and leaves incorporated into the soil maintains the organic-matter content of the soil at a level equal to that obtained from a crop of soybeans.

Planting

The planting season is from August 1 to October 15. Sometimes it may be extended to November or early December, but such late planting has the disadvantages of requiring labor needed for harvesting and of frequent seasonal rains at that time, which make planting difficult (*3*).

Sugarcane planted in August usually has a higher yield than that planted in September or October (*3*, *7*). Stand failures from August planting have resulted in some years when the young plants are killed by a freeze before a good root system is established and after the seedcane has been depleted of its food reserves. Since the date of the first freeze cannot be predicted, it is recommended

FIGURE 16.—Field ready to plant. Note quarter drain (*A*) and ditch (*B*).

FIGURE 17.—Opening a furrow with a double moldboard plow prior to planting.

that part of the crop be planted in August so as to take advantage of the increased yield that ordinarily can be expected from such planting. Also in August, plantation labor can be more efficiently utilized because of the generally slack season at this time. Certain varieties, such as C.P. 48-103 and N. Co. 310, usually respond very well to summer planting.

Spring planting of seedcane kept in beds or banks during the winter is not recommended. The labor of banking or windrowing seedcane and then removing and planting it in the spring and the resultant loss

FIGURE 18.—Planting seedcane in an opened furrow.

FIGURE 19.—Covering seedcane.

in germination of the seed material are important arguments against spring planting, even if yields are not reduced. Yields of spring-planted cane are considerably less than those of summer- or fall-planted cane.

Seedbed preparation consists in building ridges approximately 12 inches high and spaced 6 feet apart (fig. 16). Furrows are opened in these ridges to a depth of 4 to 10 inches (fig. 17). This means that the cane will be planted from 2 to 8 inches above the water furrow between the ridges. The greater depth is preferable, especially for cane planted in August, provided it is not covered too deeply (*19*).

Whole stalks, referred to as seedcane, are usually cut by machine and dropped by hand from tractor-drawn carts into the furrows (fig. 18). These stalks with adhering leaves or trash are usually then segmented into two pieces to improve germination and to fit any crooked stalks in the furrow. Each segmented piece will have from five to six buds, as whole stalks generally have 10 to 12 nodes at planting time. The five-bud seed piece is the optimum size to plant (*10*). Although shorter lengths may result in more rapid germination, the longer lengths give higher yields. The seedcane is then covered (fig. 19) and the land is cultipacked (fig. 20).

FIGURE 20.—Cultipacking land after covering seedcane.

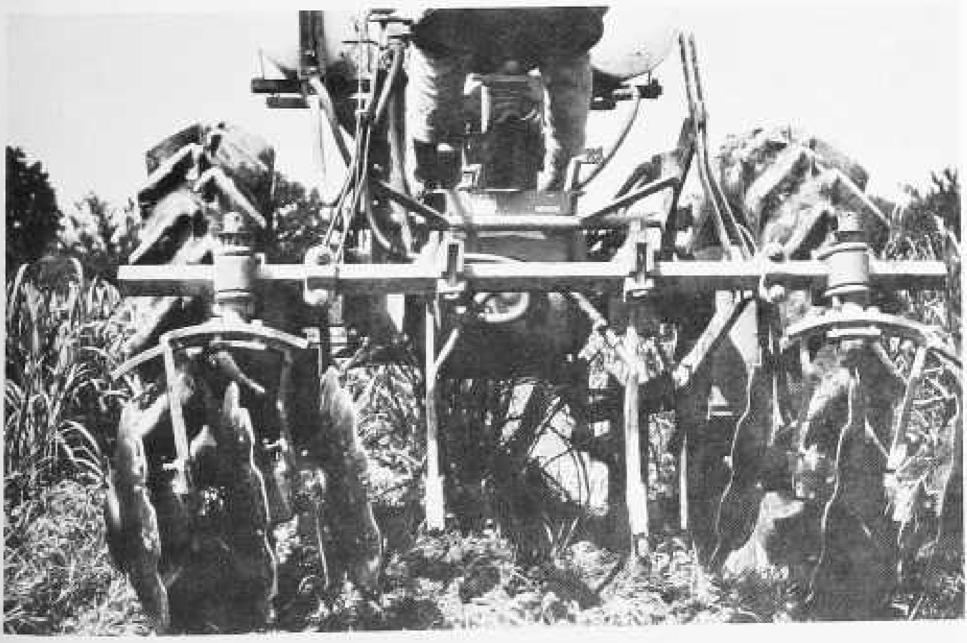


FIGURE 21.—Applying nitrogen in the form of anhydrous ammonia to sugarcane.

Fertilization

Nitrogen is the most important fertilizer element for increasing sugarcane yields. Until the early 1940's no fertilizer was used when plant cane followed legumes, and only small quantities were used for the first- and second-stubble crops. Much higher rates are used now. Recommended rates of applications per acre are as follows: For plant cane, 40 to 60 pounds of nitrogen on light- or medium-textured soils and 60 to 80 pounds on heavy soils; for stubble crops, 80 to 100 pounds. However, higher rates are sometimes used (*8*).

Anhydrous and aqua ammonia are the major sources for the commercial nitrogen fertilizers now used for sugarcane (fig. 21). Urea and Uramon [5] are equally effective in supplying nitrogen and are used to some extent.

Fertilizers are usually applied during March or April, depending on the season and on the condition of the crop. When nitrogen is used at the recommended rates, all of it is applied at one time, but when high rates of 140 to 200 pounds are used, half of it should be applied early in the spring and the other half later in the spring.

Anhydrous or aqua ammonia is generally applied after the ridge has been built. If solid fertilizer is used, the prevailing practice is to off-bar, or remove the excess soil on each side of the row of cane, to a width of 12 to 16 inches and to apply fertilizer before rebuilding the ridge. Use of ammonia, which requires thorough preparation of the ridge for its application, is of great value to the sugar industry. Since loss of nitrogen follows application of anhydrous ammonia in poorly prepared land, farmers spend more time and effort in preparing the land and hence derive greater benefits not only from the applied fertilizers but also from plant-food elements and moisture in the soil itself.

Usually phosphorus and potassium are not recommended for use on the Recent alluvial soils. However, both mineral elements should be applied for stubble crops grown on the light Pleistocene terrace soils in the area west of the Atchafalaya River (*8*).

Cultivation

In a perennial crop, such as sugarcane, the row of planted cane remains in the same location throughout the crop cycle of plant-cane and stubble crops. This varies from 2 to 3 years in Louisiana. During that time perennial weeds multiply, weed seeds accumulate, and the soil becomes compacted. Cultivation of the sugarcane field is necessary. It includes (1) shaving to remove the long pieces of stubble that sometimes remain on the row after harvest or to remove excess soil on plant cane (fig. 22); (2) off-barring, or removing the excess soil on each side of the row of cane, to a width of 12 to 16 inches (fig. 23); and (3) fertilization and rebuilding the row with disk cultivators, or choppers (fig. 24). All subsequent operations, including cultivating the sides of the row with disk cultivators, or choppers, are to control weeds.

[5] The mention of a trade product does not imply its endorsement by the U.S. Department of Agriculture over similar products not named.

FIGURE 22.—Shaving sugarcane.

FIGURE 23.—Off-barring sugarcane.

FIGURE 24.—Disk cultivators: *A*, Single-row; *B*, two-row.

Shaving of stubble is the first cultural operation in the spring. It is done with a sharp horizontally revolving disk mounted either directly on the tractor or on two wheels separate from the tractor. Maintaining a sharp edge on the blade minimizes the damage to the cane stubble.

Although shaving of stubble cane is practiced to some extent over most of the sugarcane area, it has some disadvantages. In some years a loss in yield of both cane and sugar may result from shaving. After a mild winter when stubble or summer plant cane is in an advanced stage of growth, shaving in the spring would be expected to reduce yields. Summer annual weeds sometimes increase after spring shaving destroys winter annuals, because the crop was retarded long enough to permit summer weeds to germinate and get established before the cane could effectively shade the row. Another objection to shaving, especially early in the spring, is that the emerging, rapidly growing young cane shoots are more susceptible to cold injury. Stand failures have resulted from early shaving (*18*).

In order to control johnsongrass, shaving is sometimes helpful in removing all surface

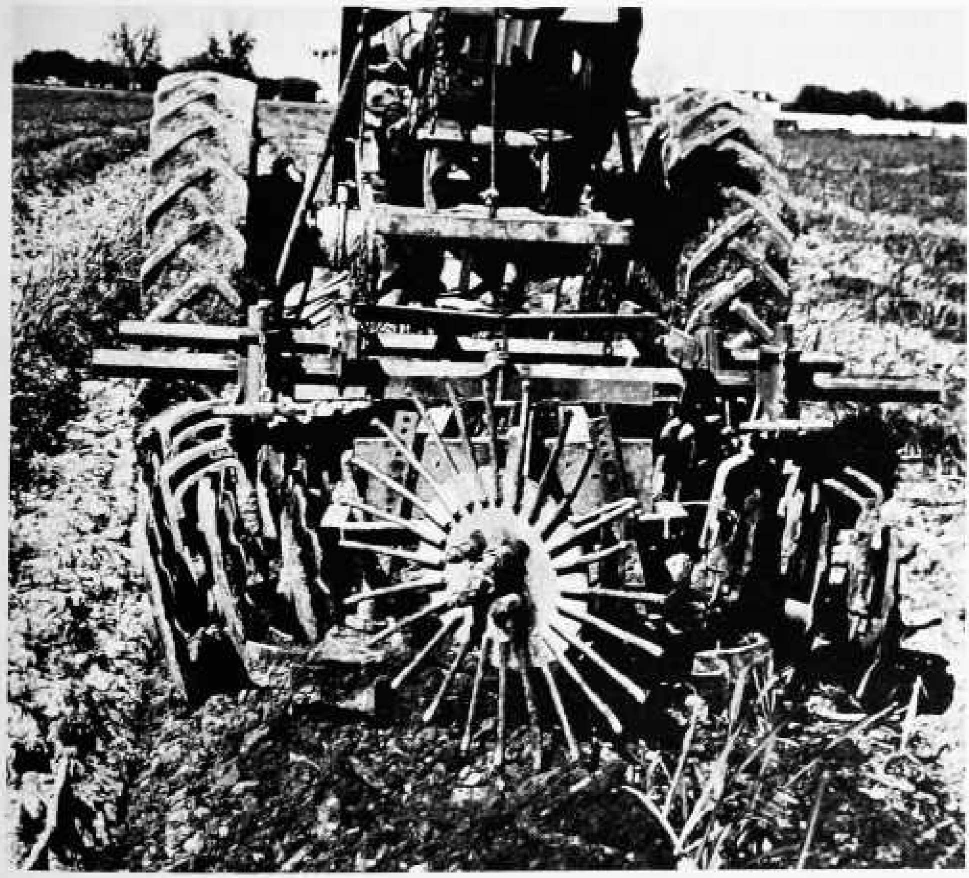


FIGURE 25.—Rotary hoe.

growth so that preemergence chemicals can be placed on the surface of the row before the weeds emerge. Also, contact herbicides can be applied more effectively as postemergence treatments to the young weed growth. Shaving to remove excess dirt to permit germination of young cane shoots is sometimes necessary. This can be done by shaving the surface of the row to the required depth. The excess dirt can also be removed with rotary hoes (fig. 25) or stubble diggers.

All machinery designed for use in growing sugarcane in Louisiana is standardized to operate on rows spaced 6 feet apart. This spacing is used exclusively with this crop and is probably the widest of any in the sugarcane world. It seems like a waste of land to most visitors from other countries where cane is grown with narrower row spacings. However, experiments conducted at various times have proved that from the standpoint of efficiency of labor and economy of seed material the 6-foot spacing is optimum. Based on the results of several experiments, there are essentially no differences in yield between the 6-foot spacing and narrower spacings, as shown in table 3.

TABLE 3.—*Average yield of plant cane and stubble in row-spacing experiment with an erect (C.P. 36–105) and a recumbent variety (C.P. 44–155), 1954–55*

Row spacing (inches apart) and variety	Yield per acre of—		
	Plant cane	1st stubble	Average
42:	*Tons*	*Tons*	*Tons*
C.P. 36–105	34.55	25.96	30.25
C.P. 44–155	36.88	24.93	30.90
Average	35.71	25.44	30.57
57:			
C.P. 36–105	30.90	25.14	28.02
C.P. 44–155	34.33	24.62	29.47
Average	32.61	24.88	28.74
72:			
C.P. 36–105	30.14	28.29	29.21
C.P. 44–155	34.81	27.22	31.01
Average	32.47	27.75	30.11

Weed Control

Weed control entails a twofold attack—frequent cultivation to smother or uproot unwanted plants and use of herbicides (fig. 26).

Fallow plowing is effective against johnsongrass. Six to eight plowings during the summer usually destroy johnsongrass plants and rhizomes in the field, but many viable seeds remain and will germinate when conditions are favorable. Cultivation of the cane crop will destroy many of the weed seedlings the following year, but others will escape to reinfest the fields.

FIGURE 26.—Applying herbicides to sugarcane in the spring.

Ditches 12 to 15 feet wide spaced every 100 to 150 feet in the fields are a source of infestation for many weed pests, including johnsongrass, bermudagrass (*Cynodon dactylon* (L.) Persoon), and alligatorweed (*Alternanthera philoxeroides* (Martius) Grisebach) (*4*). It is less difficult to control weeds when V-shaped ditches have been made rather than square-cut ditches.

Although it is possible to control some of the weeds by cultivation, many of them escape and must be destroyed in other ways. Until World War II, hand hoes were used for that purpose. During and following the war, flame cultivators were used to control weeds in canefields and on ditch banks, but they are seldom used now.

Herbicides are used to control weeds in sugarcane. Where it once was virtually impossible to grow sugarcane because of severe alligatorweed infestation, it is now easy to control this weed pest with 2,4-D. Tie vines (*Ipomoea* sp.) are also easily controlled with 2,4-D. It can be applied at relatively low cost by airplane after the cane is too tall for most spraying machines (*13*). Johnsongrass is still a serious pest, but it is possible to grow a crop of cane if the fields are fallow plowed at 7- to 10-day intervals and herbicides are used to control seedlings and surviving plants originating from rhizomes. Many chemicals other than 2,4-D are used to control weeds in sugarcane, and new ones are constantly being developed and tested (*23*). Among those used extensively in canefields are TCA, sodium chlorate, diuron, 2,4,5-T, silvex, and dalapon. The new chemicals fenac and simazine show promise (*22*).[6]

Continuing research programs are directed toward testing many new chemicals in canefields, as well as determining the proper time and rate of application. The reaction of different sugarcane varieties to certain chemicals is being studied, because some commercial varieties are damaged more than others.

HARVESTING

The sugarcane grower in Louisiana is confronted with the problem either of harvesting an immature crop, which is increasing in value every day, or of harvesting later with the risk of losing much more because the crop is subject to freezes, which can be expected any time after the middle of November (*16*). An important objective of the breeding program is to produce varieties that mature early so that the growers can start early in the season to harvest those varieties with relatively high sucrose content.

Differences in relative maturity among certain varieties are of economic importance to sugarcane growers. For example, two varieties approximately equal in sugar content in the average of analyses made over the entire season may show differences at the beginning and at the end of the harvest season. Although one may be higher at the beginning of the season, the other may surpass it at the end of the season. All new varieties are evaluated for their relative maturing qualities before being released for commercial use (*16*).

Accurate sampling of sugarcane for sucrose content of the juice is difficult in Louisiana because of the different ages of the stalks. Differences in the date of tillering, or suckering, together with the relatively short growing season, produce stalks of variable ages that are unlike in juice quality. In sucrose content, not only the stalks differ but the internodes of a stalk vary; the lower ones are higher in sucrose than the upper or middle ones. Therefore a representative number of stalks should be sampled for an accurate appraisal of the entire population; likewise, a representative internode or internodes should be sampled when only a part of the stalk is appraised (*11*).

Careful planning of the harvest operations is essential. The stubble crops are usually more mature and should be harvested first. It is also preferable to delay harvesting the plant cane until later in the season because of possible detriment to the following year's crop from too early cutting. The earlier maturing varieties should be harvested first in order to realize the most benefit from the crop. It is also advisable to cut only that cane which can be hauled to the factory within a day or two because of the inversion of sucrose to simple sugars in most varieties. The danger of freeze injury is always present. The harvest

[6] Diuron is used in the spring only, fenac in the fall or spring, and simazine in the fall or spring or both.

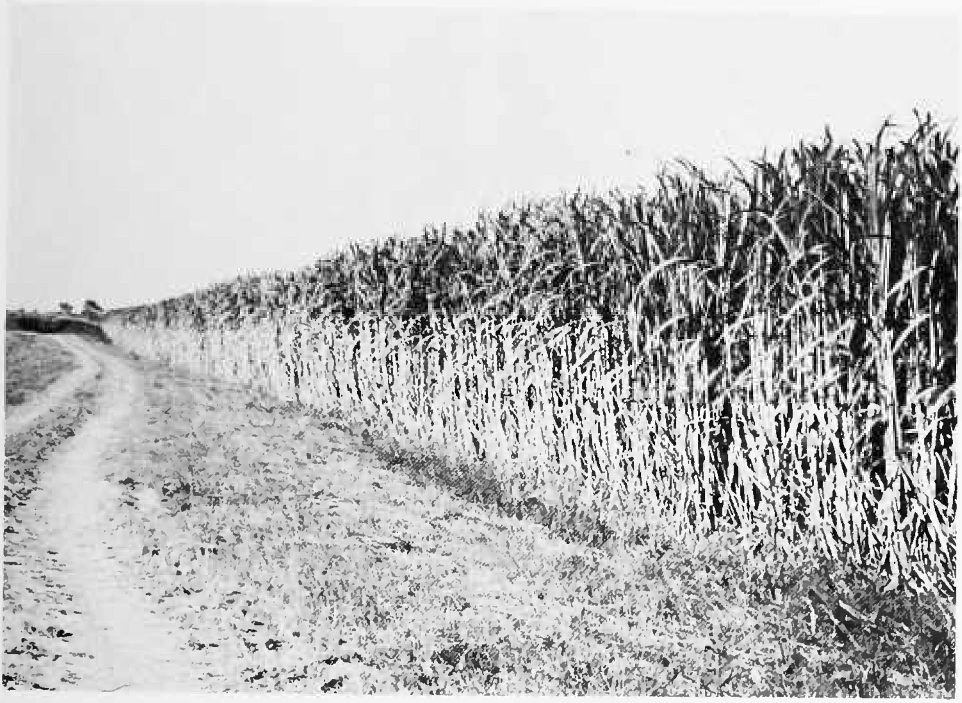


FIGURE 27.—Field of sugarcane ready to be harvested.

FIGURE 28.—Sugarcane harvester, illustrating pickup attachment (A) for harvesting lodged sugarcane.

FIGURE 29.—Burning leaves and other trash from sugarcane piled in heap rows.

program should be planned to remove the more susceptible varieties before freezes occur, and if that is impossible, these varieties should be harvested as soon as possible after the freeze.

The harvest season is from the middle of October until the first or fifteenth of January. Since cane is often just emerging on April 1, the early cane—usually the first or second stubble—is only 6½ months old and the last cane is only 9 months old when they are ready to be harvested (fig. 27).

Harvesting is done almost entirely by machine (fig. 28). Plantations that formerly employed a hundred or more laborers with cane knives to cut and clean the cane crop now use machines that cut it at the bottom and at a single level at the top and pile three rows on one "heap" row. The leaves and other trash are burned in the heap row after drying for a short time (fig. 29). The cane is hauled directly to the factory in tractor-drawn carts or to loading derricks in the field for transfer to trailer trucks or railroad cars for transporting to the mills (fig. 30).

The Hurry-Cane harvester, manufactured by the Thomson Machinery Company, Inc., of Thibodaux, La., and the J & L machine manufactured by the J & L Engineering Company, Inc., of Jeanerette, La., are used to harvest practically the entire Louisiana crop.[7] These ma-

[7] The manufacturer's name is given for information purposes only and does not imply that the U.S. Department of Agriculture endorses the machine as to performance.

FIGURE 30.—Loading and hauling sugarcane.

chines do not clean or strip the cane.

Two experimental machines—the Cary harvester, developed by the Cary Iron Works of Opelousas, La., and the U.S. Department of Agriculture machine developed at Houma, La.—are both complete harvesters in that they cut, clean, and load the cane directly into the wagons. The Cary machine segments the stalks into 18-inch lengths and removes the leaves and the leaf sheaths with a blast of air before loading. The U.S. Department of Agriculture unit strips the stalks of leaves by means of rubber, metal, or fiber appendages attached to a rotating cylinder. It conveys the cut and cleaned stalks directly into the cart by means of carrier chains. Both machines have the advantage of direct loading of cane into carts so that fresh cane can be supplied to the factory. As a result, higher sugar yields are obtained and there is a saving in total labor requirements. If these machines were put into commercial use, the existing loading and handling equipment in the field and at the factory would have to be changed.

MANUFACTURE OF SUGAR

Sugar is manufactured in large factories near the cane-fields (fig. 31). There were 46 factories operating in Louisiana during the 1960 season. Four of them produced refined as well as raw sugar and 42 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 many of them can process 100 tons of cane per hour. The average capacity of factories operating in 1960 ranged from 1,200 to 4,500 tons of cane for each 24-hour period. The refineries also vary in size. Their capacity in Louisiana ranges from 1 million to 3.5 million pounds of raw sugar per day.

Approximately 50 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. This latter group must sell 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 deductions for trash, such as cane tops, leaves, or sheaths, and (2) the juice quality. Provision is made for testing the extracted juice for percent sucrose and purity, but no consideration is given to the amount of fiber and, therefore, available juice in the cane.

Cane is transported to the raw-sugar factories by large trucks loaded with approximately 20 tons of cane or by railroad cars of 20- to 25-ton capacity. A small amount is transported by river barge. Upon arrival at the factory the sugarcane is either piled in the factory yard

FIGURE 31.—Louisiana sugar factory.

by means of huge derricks for milling during the next few hours or unloaded directly into the carrier for immediate milling. It is necessary to process sugarcane as soon as possible after cutting, because it loses sugar rapidly after being cut.

The sugarcane stalks are moved down a wide carrier to be washed and then cut into short pieces by revolving knives. The amount of water used varies from approximately 225 to 2,000 gallons per ton of cane. The conveyor deposits the washed and cut cane into a shredder in some factories or directly into the mill tandem.

The mill tandem has one or two 2-roller crushers and three to five 3-roller mills. The knives and shredders tear the cane into small pieces and prepare it for the mills but do not extract the juice. The crushers have two huge grooved rolls mounted horizontally one above the other. These rolls average 36 inches in diameter and 72 inches in length. Each mill has three grooved rolls, as large as the crusher rolls, which are mounted in a triangular fashion.

Hydraulic pressure at 25 to 60 tons per linear foot of surface is exerted on the top roll and 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. Most mills obtain values of 70 to 75 percent based on the net weight of the cane crushed.

One ton of cane yields 1,800 to 1,900 pounds of mixed juice, or 1,400 to 1,500 pounds of juice plus 400 pounds of maceration water. This juice must be clarified, the water in it evaporated, and the sugar converted into crystals of raw, or brown, sugar, which usually contains approximately 4 percent of water and impurities. The raw sugar is then refined into the white essentially pure sugar of commerce.

The extracted juice is acid with a pH of 5 to 5.5. It must be neutralized 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 consists in heating the limed juice to the boiling point and allowing the precipitates formed by this action to settle to the bottom of the tank, from which they are drawn and run through a filtering device to remove more juice. The clear juice is continuously drawn out or decanted from the top of the tank and sent to the evaporators (*21*).

The evaporator has three or more vacuum "bodies," or pans, connected and so arranged that each succeeding tank has a higher vacuum than the preceding one; therefore, the liquid boils at a lower temperature. By utilizing the steam from the preceding lower vacuum tank all bodies can be heated with the same steam. The units are known as "multiple effect" evaporators. The density of the juice entering the first body is 16 to 18 degrees Brix and that of the sirup drawn from the last body is from 55 to 75 degrees Brix (*21*).

The sirup goes to the "boiling pans," which are units heated under high vacuum of approximately 25 inches of mercury. When the sirup has been evaporated until saturated with sugar crystals or "grains," its density is approximately 90 degrees Brix and it is ready to be "dried." A centrifugal machine spins the thick sirup, or "massecuite," to remove some of the molasses. The remaining raw-sugar crystals, or brown sugar, are ready to be refined.

The refining process includes melting the brown sugar, decoloring the liquid by means of carbon filters, crystallizing it in the vacuum boiling pans, and drying it by centrifugal force. The centrifuged dried sugar is then ready for bagging and for the consumer.

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

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