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By E. W. BRANDES, *principal pathologist in charge*, S. F. SHERWOOD, *senior biochemist*, and B. A. BELCHER, *assistant agronomist, Division of Sugar Plant Investigations, Bureau of Plant Industry*[1]

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INTRODUCTION

The northern limit of the range for growing sugarcane commercially for sirup is where the cane remains immature, imparting an obnoxious green taste to the sirup or gives a prohibitively small yield due to the short season. With present varieties of cane this restricts the profitable production of sugarcane sirup in the United States to the Southern States, mainly those bordering the Gulf of Mexico. The requirements for growing sugarcane for the manufacture of sugar are even more exacting than for sirup, and in only a portion of this area, chiefly southern Louisiana and parts of Florida and Texas, can sugar be made in ordinary times at a profit. In great contrast to the extensive sugar plantations with large, expensive sugar mills, the sirup industry is dependent almost exclusively on small farm enterprise, and thousands of farmers are engaged in the production of sirup for the market or for home use. Notwithstanding the relatively small units, ranging from a fraction of an acre to 10 or 20 acres, the aggregate of land devoted to the culture of sugarcane for sirup is roughly equal to that used for sugar production.

[1] This circular replaces Farmers' Bulletin 1034, Growing Sugarcane for Sirup, by P. A. Yoder, parts of which have been extensively revised and incorporated herein.

Table 1 indicates the extent of the cane-sirup industry in terms of gallons produced, by States.

TABLE 1.—*Sugarcane sirup production by States*[1] *for certain years from 1899 to 1938*

State	1899	1909	1919	1929	1930	1937	1938[2]
	Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*
Georgia	3, 226, 367	5, 533, 520	10, 640, 000	4, 785, 000	3, 640, 000	5, 425, 000	4, 389, 000
Louisiana	1, 552, 641	4, 125, 083	3, 672, 000	5, 773, 000	6, 208, 000	8, 210, 000	7, 395, 000
Alabama	2, 672, 438	3, 078, 531	8, 480, 000	2, 106, 000	2, 160, 000	3, 770, 000	2, 500, 000
Mississippi	1, 413, 219	2, 920, 519	6, 675, 000	3, 247, 000	1, 800, 000	4, 495, 000	4, 482, 000
Florida	1, 687, 452	2, 533, 096	4, 590, 000	1, 860, 000	1, 530, 000	1, 872, 000	2, 090, 000
Texas	888, 637	2, 246, 774	2, 421, 000	868, 000	852, 000	768, 000	875, 000
South Carolina	805, 064	881, 558	1, 369, 000	590, 000	590, 000	420, 000	380, 000
Arkansas	44, 819	286, 637	336, 000	106, 000	54, 000	175, 000	110, 000
North Carolina	1, 957	21, 677	(3)	(3)	(3)	(3)	(3)
Arizona	438	1, 040	(3)	(3)	(3)	(3)	(3)
New Mexico	(3)	5, 038	(3)	(3)	(3)	(3)	(3)
Oklahoma	(3)	56	(3)	(3)	(3)	(3)	(3)
Total	12, 293, 032	21, 633, 529	38, 183, 000	19, 335, 000	16, 834, 000	25, 135, 000	22, 221, 000

[1] The figures for 1899 and 1909 are from the Bureau of the Census, U.S. Department of Commerce; those for all other years are from the Bureau of Agricultural Economics, U.S. Department of Agriculture. The latter figures are more comprehensive in that they include reports from the small sirup makers.
[2] 1938 figures are preliminary and subject to revision.
[3] Figures not available.

Sirups are produced in considerable quantities from the saps of sorgo (sweet sorghum) and maple trees and from cornstarch by a chemical process. In addition, sugarcane molasses, which is a by-product in the manufacture of sugar, is used for similar sweetening purposes and in cooking. Comparison of the quantity of cane sirup produced in 1931 with that of other sirups and molasses used as human food in the United States is shown in the following tabulation:

	Gallons
Cane sirup[2]	14, 359, 000
Sorgo sirup[2]	17, 818, 000
Corn sirup and mixtures of corn and other sirup[3]	81, 686, 000
Maple sirup[2]	2, 186, 000
Maple sugar as sirup[2]	202, 000
Cane molasses (consumed as food)[2]	5, 168, 000
Total	121, 419, 000

The most direct competitors of sugarcane sirup are corn sirup, made by acid hydrolysis of cornstarch, and sorgo sirup, prepared by concentrating the crushed-out juices of stalks of sorgo in essentially the same manner as cane sirup is made from the juices of sugarcane stalks.

Sorgo is not sugarcane, yet the two names have often been confused. This confusion has arisen through the loose use of the term "cane" or even the term "sugarcane" to designate varieties of sorgo used in making sirup. Sorgo is raised from seed, while sugarcane, a distinctly different though closely related plant, is propagated commercially by means of "seed cane" or sections of the stalk. In the Tropics and even in southern Florida sugarcane occasionally produces seedstalks bearing true seeds. The seeds, however, are not suitable for use in growing ordinary commercial crops of cane. They are exceedingly small and germinate very poorly. The seedlings require a much longer time to develop into full-grown plants than do

[2] Reported by Bureau of Agricultural Economics, U.S. Department of Agriculture.
[3] Computed from preliminary figures reported by the Bureau of the Census, U.S. Department of Commerce.

the sprouts from "eyes" or buds on the seed cane. Moreover, the plants raised from true seeds do not come true to type and are usually inferior to the parent plant. However, the occasional production of seeds is useful to the plant breeder. It offers him the opportunity of selecting new types of sugarcane and has proved valuable in the United States in permitting the development of sugarcane varieties that resist diseases.

Within the last two decades an accidentally imported disease of sugarcane known as mosaic caused damage to the sugarcane industry estimated at over $100,000,000 before it was brought under control by substituting resistant varieties introduced or bred by the Bureau of Plant Industry of the United States Department of Agriculture. Complete reconstitution of the sugar industry has resulted from the use of the resistant varieties, with yields restored to normal. The new varieties occupied practically all of the 294,000 acres of land used for sugar production in 1938, and a rapid shift to the new varieties had taken place in the sirup belt extending from Florida to Texas.

VARIETIES OF SUGARCANE

Sugarcane varieties propagated vegetatively, that is, from seed cane or portions of the stalk, do not tend to run out or degenerate from planting in that fashion over long periods of time. It is a fact, however, that the popular old varieties are gradually disappearing from culture. The explanation lies in the prevalence of diseases of the sugarcane plant, particularly mosaic, to which these varieties are specially susceptible, so that with the spread of the diseases the old varieties give way to more resistant ones. Within the past decade the varieties that were the backbone of the industry have been almost completely supplanted over wide areas in the South. In isolated places, however, these old varieties continue to maintain favor with cane planters, mainly because the diseases have not penetrated to the localities where they are still grown.

For sirup making in the Southern States sugarcane should possess the following qualities: (1) Early maturity; (2) a large yield of stalks; (3) a high percentage yield of juice; (4) juice having a large proportion of solids, mostly sugar; (5) light-colored stalks (green or yellow) which do not impart a dark color to the sirup; (6) resistance to disease, both during growth and while in winter storage for spring planting; (7) good germinating and stooling qualities; (8) good ratooning qualities, that is, coming up freely from the stubble after the first year; (9) strong, erect habit of growth, not readily lodging in storms; and (10) a fairly soft stalk, relatively low in fiber. In addition, it is desirable for the sugarcane to have a measure of resistance to cold, so that it is not necessary to harvest and windrow all the cane immediately after the first moderate freeze in early winter.

Viewing the requirements as a whole, it is readily seen that a difficult task confronts the plant breeder in attempting to combine these desirable qualities in one plant. Such attempts have been made by the Department of Agriculture, however, with enough success to point the way to eventual development of varieties better suited to conditions in the present sirup area.

As already indicated, new varieties arise from sprouting the true seed of the cane tassel, and where tasseling occurs, as in southern Florida, an opportunity is provided for cross-pollinating and combining in the new seedlings the desirable qualities of different parental varieties. To incorporate resistance to disease (fig. 1), special adaptability to particular climatic and soil conditions, and other essential qualities, re-crossing is often necessary, and many thousands of seedlings must be produced and tested, requiring years of patient labor to find one that will outstandingly improve production. For

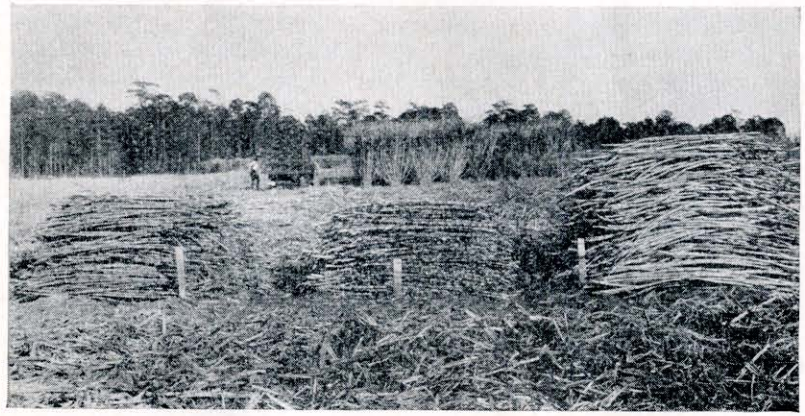

FIGURE 1.—A result of breeding for resistance to mosaic. At the center is the susceptible Louisiana Purple; on the left is P.O.J. 213, a hybrid resulting from crossing Louisiana Purple with Chunnee, a variety which resists or tolerates mosaic without evidence of great injury; on the right is C.P. 807, a descendent of P.O.J. 213, which is apparently immune to mosaic. The piles were harvested from plant-cane plots of equivalent size and treatment at Cairo, Ga., under conditions of severe mosaic prevalence.

this purpose the principal commercial and wild sugarcane types of the world have been assembled at the United States Sugar Plant Field Station at Canal Point, Fla.

Annually hundreds of new seedlings are sent for testing to the Department's sirup cane field station near Cairo, Ga. (representing the conditions of the eastern Gulf States), and to Houma, La. (typical of the Mississippi Delta and adjacent areas). If after several years of comparative testing, usually in cooperation with experiment stations of the various States and with farmers, a new variety is found to be definitely superior, planting material is increased cooperatively for distribution and rapid extension of the variety. Cayana and P.O.J. 213,[4] two foreign varieties, were distributed in 1915 and 1919, respectively, while C.P. 807, distributed in 1931, came from the Canal Point (Fla.) station. As shown later, these new varieties have materially increased the acre yields in the eastern Gulf States.

GROUPING OF VARIETIES

Particular varieties will be grouped in accordance with botanical relationship for the purpose of this discussion. The observant cane planter familiar with many varieties will readily perceive that some have points of similarity and fall naturally into groups. These groups are known to the botanist as species. It is desirable for the cane planter to be able to distinguish between these groups or species, because in general the varieties within a species have characteristics in common that are of practical importance in commercial cane growing. Such characteristics may be hardness of stalks, tendency of leaves to adhere to the stalks as dry fodder, resistance to certain diseases, prolific tillering or production of a large number of stalks per stool, etc. Examples of such characteristics or qualities possessed by the members of one species but not possessed by members of other species are numerous, and, as frequently they are significant in field operations, it is worth while for the farmer to be sufficiently well informed about them to enable him to judge whether a variety of a particular group or species will fit his requirement.

There are five species of sugarcane of economic importance in the sugar and sirup industries and each species is divided into numerous varieties. The common names of these species groups are (1) noble canes, (2) Chinese canes, (3) canes of northern India, (4) small wild canes, and (5) large wild canes. The names suggest some peculiarity of the varieties in the species or the supposed geographic origin. "Noble", for example, refers to the large size and aristocratic appearance of the varieties in the first group, while canes of northern India indicate that these particular varieties are presumed to be indigenous to the northern Provinces of British India. Crossing of varieties belonging to different species is possible, and the resulting hybrids for convenient reference may be designated "interspecific hybrids."[5]

NOBLE CANES

Varieties of the noble canes of the species (*Saccharum officinarum* L.) are distinguished mainly by relatively thick stalks and broad leaves, the latter separating freely from the stalk in cane approaching full size so that the stalk is exposed. Internodes are relatively short and frequently barrel-shaped. Usually the stalk is highly colored. A wide range of color, extending from dark purple, almost black, to light cream color, and including brilliant shades of red, yellow, and green, and striped combinations of these colors, is found among the hundreds of varieties of this species. Typically the canes in this group are soft, having a lower percentage of fiber than varieties in the other species. The varieties of this group that deserve mention because of popularity for sirup production in the past or because they are still grown for that purpose in isolated places are the following:

LOUISIANA PURPLE

Louisiana purple (also called Home Purple or Red) has been heretofore the most extensively grown variety of *Saccharum officinarum* in the principal sirup sections of this country. It is a purplish-red variety with somewhat barrel-shaped internodes, and owes its popularity primarily to the fact that it matures early and yields a sirup of excellent quality. Because of its early maturity the percentage of sugar (sucrose) in the juice is relatively high and that of the invert sugar is relatively low. Consequently sugar tends to crystallize from sirup which is boiled thick. The flavor of sirup from Louisiana Purple cane is

[4] Many varieties of sugarcane are commonly designated by letters or other abbreviations indicating the origin of the seedling cane. The meaning of such designations of the varieties mentioned throughout this circular are as follows: C.P.=Canal Point (Fla.) where seedlings are bred by the U.S. Department of Agriculture; P.O.J.=Proefstation Oost Java seedlings; P.O.J. 36-M=Mingka selection of P.O.J. 36; D.=Demerara; Co=Coimbatore (India).

[5] The popular classification of sugarcane varieties herein is based on work not yet completed by the Division of Sugar Plant Investigations, Bureau of Plant Industry, and is purely tentative. Recent work by investigators in Java indicates that further subdivision of species may be necessary.

milder than that from many other varieties. The sirup has a tendency to be dark red, partly because of the coloring matter in the cane rind. Stubbling qualities are fair, and in the absence of disease the yields are good. Unfortunately, this variety is subject to great injury by mosaic, a recently introduced virus disease, and yields of cane have fallen off greatly in recent years because of its susceptibility to this disease. Louisiana Purple is not recommended for planting, and except in isolated places where the disease has not yet penetrated, farmers are strongly urged to replace it with disease-resistant varieties. In the centers of sirup-cane production, where sirup is made for the market, Louisiana Purple is almost certain to produce disastrously low yields.

LOUISIANA STRIPED

Louisiana Striped (also called Red Ribbon or Ribbon cane) is a purple and green striped variety which was almost as extensively grown as Louisiana Purple in some important centers of production. In central and southern Florida the Ribbon cane found more favor than Louisiana Purple. Because of the lighter color of the rind the sirup from this variety is a shade lighter than that from Louisiana Purple. Almost everything that has been said respecting Louisiana Purple applies equally to Ribbon, and because of its susceptibility to mosaic and other diseases extension of plantings anywhere is not recommended. (See table 2.)

CRYSTALINA

Crystalina (known also as White or White Transparent) is closely related to Ribbon, being a sport or color mutation of that variety. It makes a sirup decidedly lighter in color. The stalk is light green or yellow, sometimes flamed with pink. This variety is just as susceptible to mosaic as Ribbon and it is not recommended for planting.

D-74

D-74 (Demerara 74) is a seedling of Crystalina, that is, it arose from a true seed of the foregoing variety, and not from an "eye" or bud of the stalk. The stalk color is green, changing to yellowish green. As it grows in the United States, it is distinguished from all varieties of *Saccharum officinarum* by its exceedingly erect habit of growth, both stalk and leaves being typically upright. This variety resists being blown down by the wind more than other varieties of the group. D-74 has been popular in the sirup-making sections of Louisiana, giving higher yields than Louisiana Purple or Ribbon. In addition, its juice contains higher percentages of sugar than most other varieties and the yield of sirup is correspondingly greater. It meets the requirement of early maturity but unfortunately is susceptible to mosaic and is greatly injured by that disease and by root rot. For that reason planting of D-74 is hazardous and extension of its culture is not recommended.

HOME GREEN

Home Green (commonly called Green in Georgia and Florida, Caña Blanca, Otaheite, and Bourbon in the Tropics) is grown extensively for sirup in central and southern Florida. The large thick stalk is light green in color and very soft. Because of softness of the stalk it is used to some extent for chewing or eating in Georgia, and many people plant a few rows of it in gardens for this purpose. It makes a pretty, bright sirup of fine flavor. This variety is notorious for inability to withstand adverse conditions, and ratoons poorly except in rich or virgin soil. Drought affects it greatly, and it is the most susceptible to mosaic, root rot, and red rot of all varieties mentioned.

GREEN RIBBON

Green Ribbon (commonly known as "Simpson" in Florida) has a yellow and green striped stalk, but is identical in all other respects with Home Green, which is a sport or color variant of Green Ribbon. When first grown in virgin soil the cane is very impressive, and, because of its attractive appearance, there is a tendency to plant it. However, because of its susceptibility to disease, it is economically unsound to do so, especially in the established centers of commercial sirup production where cane diseases have accumulated.

CHINESE CANES

All varieties of Chinese canes (*Saccharum sinense* Roxb.) are easily distinguished from varieties of the foregoing group belonging to the species of *S. officinarum*. They are tall growing, but the stalk is not so thick and is less colorful, all varieties in this country being of a dull-green color. The stalks are harder on the average, having a higher percentage of fiber, and typically the joints are enlarged or swollen so that the portion of the stalk between joints is spindle-shaped. The leaves are more narrow and the leaf sheaths adhere to the stalks for a longer period, so that the stalk does not become exposed naturally, as is the case with varieties of *S. officinarum*. They ratoon especially well and it is possible to grow a longer succession of crops without replanting. In general, this group of varieties is much more resistant to diseases than the preceding group. Under present conditions they are more important than the varieties of *S. officinarum* for the sirup industry, and several varieties, which because of superiority or usage in the sirup areas are noteworthy, will be described briefly.

JAPANESE

Japanese (Zwinga, Japanese Fodder cane) is the name by which a representative of the Chinese cane group, long known in this country, has been designated. It is very slender, hard, and green colored, hardy and prolific, and stools abundantly, thus giving a good stand even with thin planting. It ratoons especially well, and for that reason many crops can be cut over a period of years without replanting. The leaves, which are very narrow, clasp the stalk tenaciously, which adds greatly to the expense of preparing the cane for the mill. The hard, almost woody character of stalks increases the cost of milling by requiring stronger mills and more power. In addition, there is a low yield of juice per ton of cane, and the juice is deficient in sugar and total solids. It is highly resistant, possibly immune, to mosaic. In spite of disease resistance, low cost of planting, good ratooning qualities, and large yield of cane per acre even under adverse conditions, the good qualities of this variety do not compensate for its disadvantages when better disease-resistant varieties are available.

CAYANA

Cayana (Cayana 10) (pl. 1) is larger than Japanese, with greater diameter of stalk, but otherwise resembles it rather strikingly. The black blotches shown in the illustration are caused by a superficial "sooty mould" associated with many varieties of sugarcane. Cayana germinates well and less planting material (seed cane) is required per acre than for the varieties of the species *Saccharum officinarum*. The chances for 3 or 4 successful ratoon crops are considered to be about as good as those for 2 ratoon crops of such varieties as Louisiana Purple when no disease is present and immeasurably better under the conditions of disease prevalence in the sirup sections today. At present Cayana far surpasses such varieties as Louisiana Purple, Ribbon, and Home Green in yield, due to its great resistance to mosaic, root rot, and other diseases. (See table 2.) The juice contains a relatively high proportion of invert sugar, yielding a sirup with less tendency to crystallize when boiled to high density. The green color of stalk makes the sirup lighter than that from a deeper-colored cane, such as Louisiana Purple. Although Cayana has the defects enumerated for Japanese, they are less pronounced. Its good qualities make up for the undesirable ones. Where it is expedient to economize on cost of production at a slight sacrifice of quality of product, or necessary to utilize lands somewhat deficient in fertility, the prospects of realizing something on the crop is better with Cayana than with almost any other available variety. The labor of stripping and topping Cayana is about double that for the "self-cleaning" varieties of the species *S. officinarum*. However, economies in planting, which comprise (1) a more modest requirement in amount of seed cane, and (2) less frequent demand for replanting, together with less cultivation cost due to earlier closing of the rows, more than make up for increased harvesting costs.

UBA

Uba is almost identical with Cayana. Only the most precise, comparative tests in replicated experiments reveal any differences whatever. Statistical studies show a slight advantage in favor of Cayana. It is noteworthy that many varieties of *Saccharum sinense* that have been imported and studied by the Bureau of Plant Industry resemble each other so closely that it is impossible for the layman to tell them apart, and even the expert botanist must be assisted by cultural studies of performance in distinguishing them.

CANES OF NORTHERN INDIA

The third group of sugarcane varieties, clearly distinguished in botanical characteristics from the two groups already discussed, is included in the species *Saccharum barberi* Jeswiet, the canes of northern India. These varieties, as such, are not used for sirup production in the United States, but because they have been used in breeding and enter into the make-up of hybrid varieties now important in North America (which will be described under Interspecific Hybrids) a brief summary of their history and characteristics is inserted.

All varieties of *S. barberi* so far as is known originated in northern India. Although as a group they are easy to distinguish from the two species already described, they are not homogeneous, and botanically it may later be necessary further to subdivide *S. barberi* into two or more species. Roughly they are more slender canes than those of *S. sinense* and enlarged joints are not so prominent in them. The internode, or portion of the stem between joints, is very long and cylindrical, not spindle shaped, as in *S. sinense*. Mostly the stalk color is white, ivory, or grayish green, frequently flamed with reddish or pinkish tints. Parallel, pencil lines of corky texture are often found extending longitudinally on the stalk. Leaves are more narrow and shorter than in varieties of *S. sinense*, and do not cling to the stalk as dead fodder to the same extent in plants approaching full growth. Practically all of the crude sugar produced in India is made from these varieties, which may number up to 100 separate kinds. Only one variety, Chunnee, will be listed here because of its significance in the local sirup industry.

CHUNNEE

Chunnee is a thin cane, with long cylindrical internodes and joints not enlarged. It is green, covered with bluish-white bloom or wax, later becoming flamed with red or reddish brown. It is susceptible to mosaic, but in contrast to most varieties of *Saccharum officinarum*, Chunnee is not greatly injured when infected with that disease. It is that fact coupled with somewhat greater tolerance of low temperatures that makes the variety important in connection with the sirup industry. Chunnee is one of the parents of a group of interspecific hybrids, several of which are valuable as sirup canes in the United States.

SMALL WILD CANES

The fourth species, *Saccharum spontaneum* L., which comprises the small wild canes, will be described even more briefly than the others, as it is of importance in the United States only in attempting to improve sugarcane by breeding. All varieties of this species are wild plants found in northern Africa, anterior, central, and southeastern Asia and adjacent islands. The stalk, in most cases, is about lead-pencil size, green in color, with long, straight-sided internodes and small buds at the joints. They cross freely with cultivated sugarcane. Observations and experiments indicate that some are entirely immune to mosaic. Some are resistant to cold and grow rapidly at low temperatures. Many hybrid varieties resulting from crossing these wild forms with *S. officinarum* have become immensely important in the sugar industry because of disease and cold resistance, and a number of such hybrids produced by the Bureau of Plant Industry are under test for sirup qualities.

LARGE WILD CANES

For the sake of completeness mention will be made of another wild species, *Saccharum robustum* Jeswiet, which includes the large wild canes recently discovered in Papua and the New Hebrides by explorers from the Bureau of Plant Industry. It is of interest because of the great size and vigor of all varieties found thus far. These plants reach a height of 30 feet when growing naturally along watercourses, with fairly thick, strong, woody stalks, green, yellow, or red in color, and long underground stems or rhizomes. They are deficient in sugar and high in fiber, but it has been found possible to cross them with varieties of *S. officinarum*, and, like varieties of *S. spontaneum*, they are being used at the cane-breeding station of the Bureau of Plant Industry in attempts to improve our sugar and sirup canes.

MISCELLANEOUS HYBRIDS (INTERSPECIFIC HYBRIDS)

Some of the most important canes now available for sirup production in the United States have resulted from crossing varieties of one species with those of another species. Thousands of varieties have been produced in that way. Exacting tests in comparison with standard varieties are necessary to determine whether they are superior. The varieties described here are those which have been sufficiently tested and proved of value for sirup.

CO. 290

Co. 290 (pl. 1) is a green cane with a blush of reddish purple. From a distance it appears blue because of the wax layer. The habit of growth is erect with usually straight stalks, which are generally longer and larger in diameter than those of Cayana, P.O.J. 213, or C.P. 807. It is relatively late maturing and somewhat susceptible to drought and freezing injury. The lower portions of the stalk have a relatively high concentration of sugar. The fiber content is low and the ratooning qualities will almost equal those of C.P. 29/116. This cane strips easily.

C.P. 29/116

C.P. 29/116 (pl. 1) has an erect habit of growth and generally straight stalks, which are about as long and large in diameter as those of Co. 290 and are green to greenish yellow, taking on a darker yellow where exposed to the sun. Like Co. 290, this variety has a low fiber content and good ratooning qualities. The leaves strip readily.

P.O.J. 213

P.O.J. 213 (pl. 1), a cross between Louisiana Purple (*Saccharum officinarum*) and Chunnee (*S. barberi*), is a red or purplish-red variety with canes of medium thickness, characterized by good stooling qualities, rapid growth, early maturity, and fancy quality of sirup. The internodes are long and have straight parallel sides. It is resistant to mosaic or, more properly, tolerant of mosaic, as it takes the disease readily but is not severely injured when infected. Yields of cane and sirup from plant-cane crops of P.O.J. 213 about parallel those from Cayana, but yields from ratoon crops are slightly inferior. (See table 2.) The

250707°—40——2

ratoon crops are, however, fairly good, and as many as three profitable crops may be expected normally from one planting of P.O.J. 213 on fertile soils. It is well adapted to culture on the light soils of southern Georgia and northern Florida and is already well established there and in Louisiana. The stalks are soft and can be milled with ease in the small mills in common use. There is a somewhat higher percentage of sucrose in the juice than in the corresponding juice of Cayana, and the purple rind imparts a darker color to the sirup. The good flavor fully compensates for the somewhat darker color of the product. P.O.J. 213 is subject to considerable lodging in storms, and brittleness of the upper joints results in frequent breaking off and losing part of the cane in the field or in transporting it to the mill. When lodging occurs from storms or overfertilization the upper part of the stalk is frequently crooked in characteristic fashion, bending at each successive joint in about the same degree, so that the whole becomes as the arc of a circle. The buds of banked seed cane are easily injured, and in spring-planting operations the seed cane must be handled carefully. Germination of seed cane in low wet lands tends to be slow and faulty, usually resulting in poor stands in these spots. This is sometimes due to red rot beginning in the banks. It is a variety that requires attention to good, careful practices, but when such attention is given excellent results are attainable.

P.O.J. 36-M

P.O.J. 36-M (36-M) (pl. 1), a cross between Ribbon cane (*Saccharum officinarum*) and Chunnee (*S. barberi*), has a gray-green base color overlaid or flamed with rose or purple, sometimes with faint longitudinal stripes of lighter color. It is readily distinguished from P.O.J. 213 by the straighter stalks of slightly greater diameter and more erect habit of growth, and from Louisiana Purple by the straight-sided internodes, relatively longer and thinner with no tendency to be barrel-shaped. Characters further distinguishing P.O.J. 36-M from P.O.J. 213 are the less pronounced groove above the eye and the lighter green color of the leaves. In the alluvial soils of Louisiana P.O.J. 36-M makes an excellent sirup of lighter color than the other mosaic-resistant varieties thus far released. The cane is relatively soft and is easily milled. Better results are obtained on the light soils of Louisiana than on the so-called "black lands," which tend to produce darker sirup. A point in favor of P.O.J. 36-M (true also of P.O.J. 213 and Cayana) is that when cut and left in the field for some time in warm, dry weather inversion of sucrose is initiated in the cane which tends to prevent crystallization of sugar in sirup made from it, while on the other hand Louisiana Purple, Ribbon, and D-74 can hardly develop any invertase at all under the same conditions.

C.P. 807

C.P. 807 (pl. 1) is of parentages similar to the preceding variety but selected from the second generation of seedlings after the original cross. It is a green cane with stalks of medium thickness and somewhat spreading habit of growth. It stools prolifically. Yields of plant cane and sirup over a period of several years average 10 to 15 percent higher than Cayana or P.O.J. 213. C.P. 807 is very resistant to mosaic and may be immune, as no authentic cases of the disease have been recorded for the variety. Germination of seed cane is unusually good and ratoon crops show up well. The tough fibrous nature of the rind gives a somewhat deceptive impression of hardness, and although the percentage of fiber is relatively high, the stalks of C.P. 807 can be milled without difficulty in the small mills. The spreading growth and ease of stripping the loose trash or leaves from the stalk are advantages in the harvesting operations. As in the case of P.O.J. 213, this variety is subject to severe lodging when strong windstorms occur, and during rainy harvest seasons the upper joints tend to become brittle and break off in handling. Juices have a high average sucrose content and high percentage of purity. The sirup produced is of good flavor and intermediate in color between Cayana and P.O.J. 213. In spite of a few faults C.P. 807 gives promise of becoming a leading variety in the sirup industry.

OTHER VARIETIES

In addition to the sugarcane varieties briefly described herein the Bureau of Plant Industry has imported or produced by crossing a large number of varieties of potential value to the sirup farmers of the South. Because of the difficulty that would be experienced by

the average planter in distinguishing between such closely related plants and the danger of confusion, it is the policy of the Bureau to limit numbers by releasing for commercial planting only those varieties that have been proved by exacting tests to be superior to varieties already grown in the South. Experience has shown that premature release of inadequately tested varieties is costly to the industry. It is characteristic of many newly imported varieties or newly produced seedlings that they make a better appearance at first than subsequently. This is partly due to the fact that they are free of the local pests and diseases in the beginning and exposure to these enemies requires a fairly long period of years. This is especially true of diseases that are intermittent in intensity or make their appearance at irregular periods in the form of epidemics. A fair comparison of varieties can therefore be made only after a reasonably long and intensive period of experimental testing, and the policy of precaution in releasing varieties is justified.

VARIETIES RECOMMENDED FOR SIRUP PRODUCTION

Summarizing the discussion of varieties now grown or obtainable for sirup production, all of those listed under Noble Canes are of doubtful value because of the prevalence of mosaic and red rot, to which they are extremely susceptible. Only under special conditions of remoteness from the established sirup centers where the disease has not yet penetrated can they be grown profitably. In the eastern Gulf States they have been superseded by C.P. 29/116, Co. 290, P.O.J. 213, C.P. 807, and Cayana. The variety C.P. 31/511, recently released for commercial cultivation, has found acceptance for chewing. P.O.J. 36-M has proved most satisfactory as a sirup cane on the light, sandy soils of the Mississippi Delta and adjacent areas, and is recommended for planting in Louisiana on soils of that type.

Table 2 gives the average performance of the varieties recommended for the eastern area in contrast with two of the best of the old varieties, Louisiana Striped and Louisiana Purple, and may be taken as a guide to results that may be expected under present conditions.

TABLE 2.—*Yields of five varieties representing the average of tests at Cairo, Ga.*

Test and variety	Yield of cane per acre	Yield of sirup per acre	Sirup per ton of cane
	Tons	*Gallons*	*Gallons*
Plant-cane tests in 1938:			
C.P. 29/116	28.82	639.6	22.2
Co. 290	27.54	604.7	22.0
P.O.J. 213	17.78	374.8	21.1
Plant-cane tests in 1937:			
C.P. 29/116	30.88	574.1	18.6
Co. 290	27.59	530.6	19.2
P.O.J. 213	21.43	369.0	17.2
First stubble-cane tests in 1937:			
C.P. 29/116	27.11	549.7	20.3
Co. 290	20.16	406.6	20.2
P.O.J. 213	13.00	237.4	18.3
Tests during previous years: [1]			
Plant cane, Louisiana Striped	12.55	259.1	20.6
Plant cane, Louisiana Purple	14.60	292.3	20.0
First-stubble, Louisiana Striped	7.14	129.9	18.2
First-stubble, Louisiana Purple	8.54	162.3	19.0

[1] Tests discontinued.

The Department of Agriculture has no seed cane of any of the varieties for free distribution. However, seed cane of all of these

varieties is available from the usual commercial sources. C.P. 29/116, Co. 290, C.P. 31/511, Cayana, P.O.J. 213, C.P. 807, and P.O.J. 36-M are in commercial production and can be obtained from farmers in practically every sirup-producing center of importance.

SELECTION OF SUGARCANE LAND

As sugarcane is a tropical plant, grown in the United States somewhat beyond its natural climatic zone, it is more sensitive to climatic conditions here than in the Tropics. The crop requires a uniformly high temperature, ample sunshine, and a large and constant supply of moisture to keep the plants growing rapidly during the crop season, which should extend for a period of 8 months or more. These requirements restrict profitable culture of sugarcane to a definitely limited area (fig. 2). Within this area sugarcane is grown on a variety of soils, but because it is a gross feeding crop, making heavy

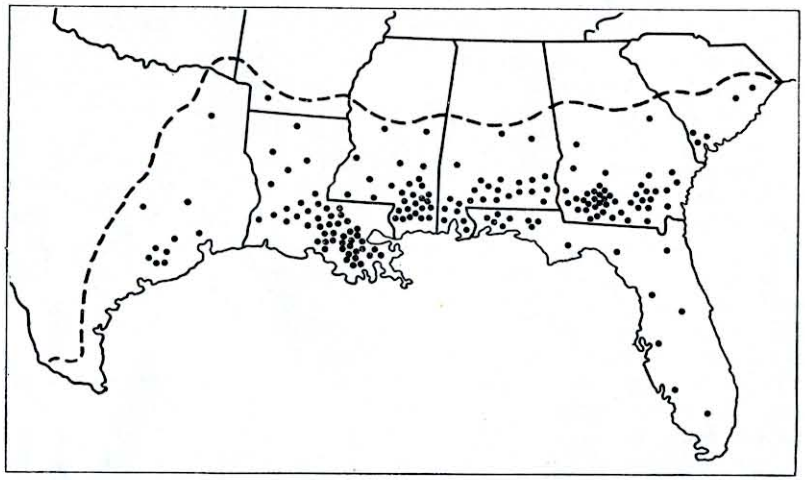

FIGURE 2.—Successful sugarcane culture for sirup production is restricted to the area below the broken line shown in the map. The geographic concentration of the industry within this area is indicated by dots, each of which represents 100,000 gallons of sirup produced in 1932.

demands upon the soil for moisture and plant food, the soils must possess definite characteristics for successful cane culture. Only the best soils in the area indicated can be used to advantage. They must be well supplied with mineral and other required plant food and humus. They must retain moisture well, but it is imperative that they be naturally well drained or drained by means of inexpensive systems of ditches. It is important that the texture of the soil permit rapid prolific root growth and allow thorough cultivation. In the eastern part of the area alluvial soils along streams, depressed areas where the soils are dark, and the more fertile uplands are used successfully for cane. It is generally known that a lighter-colored and better-quality sirup is produced from cane grown on light-textured, well-drained, sandy loam and fine sandy loam. In Louisiana Sharkey clay in its better-drained phases is extensively used for sugarcane growing, but for sirup production silt loam, silty clay loam, and fine sandy loam are preferable.

LIGHT SANDY LANDS AND HEAVY CLAY LANDS

The expense of keeping up the fertility on light sandy lands is prohibitive and, in the absence of frequent and adequate rainfall, the crop suffers quickly and seriously from drought. On the other hand, heavy clay lands do not warm up early enough in the spring, do not drain properly, and cannot be kept in a state of cultivation necessary for best results.

The prospective sugarcane planter in the eastern Gulf States where sand predominates in the soils must seek a soil with a relatively high percentage of silt and clay or, in their stead, a liberal supply of humus to enable it to retain moisture and plant food and to produce good crops. In these sections, where very sandy soils predominate, the rolling clay hills or the so-called "hammocks" are sought, or, where such lands are not available, the drained bayheads and shallow ponds are utilized. It is doubtful, however, whether the humus-sand soils which lack silt and clay completely will continue productive through a long series of years under ordinary farm methods, which tend to deplete the humus supply. With such soils expensive means of replenishing the humus must be employed, and only under exceptional circumstances will the value of the cane crop justify the cost.

The flat piny-woods sand areas with neither clay nor silt and with only very small quantities of humus which occur so extensively near the southern Atlantic and eastern Gulf coasts are unsuitable for the culture of sugarcane. Such land, when plentifully supplied with water, frequently produces fairly good crops for a few years while it is new and contains a good supply of humus, but satisfactory yields are rarely secured throughout any long period of years. Land of this kind can be made to produce further crops of sugarcane by treatment to restore the humus and plant food, but the continuous need for such treatment involves too great expense to make it profitable.

Where clay predominates in the soil, as in the alluvial bottoms along the lower Mississippi River, lands containing a relatively high percentage of silt and sand are found more suitable for sugarcane culture. These are usually found adjacent to the river and to the numerous bayous. Clay soils lying farther back from these streams, and frequently adjoining swamps, are less suitable, as they are generally too stiff to permit being kept in the most favorable state of cultivation and usually do not warm up early enough in the spring for early growth of the cane. Such soils are more suitable when they contain considerable humus or vegetable matter, but in general heavy, impervious clay soils are unsuitable for satisfactory culture of sugarcane.

PEAT SOILS

Peat soils, provided they have a high percentage of mineral matter and are well drained, will produce large yields of cane, and with a long, favorable season, as in southern Florida, the cane will contain satisfactory percentages of sugar. It is questionable whether peat soils that contain a very low percentage of mineral matter, and that are, therefore, deficient in natural plant food, can be used successfully for sugarcane culture even if well drained. One disadvantage of any peat land is that it affords such poor anchorage for the roots

that the cane lodges easily and gives a tangled mass of stalks instead of erect rows. Compared with other soils, heat radiation from the black peat is rapid, and during cold, clear nights in winter this results in lower temperatures and greater injury to the cane. In Georgia it is commonly reported that rich, dark soils along the edges of swamps, while producing high yields of cane, exert a deleterious effect upon the color, clearness, and flavor of sirup made therefrom. Such soils are not generally used, the growers preferring the lighter-colored loamy upland soils.

DRAINAGE

In low, flat areas where natural drainage does not keep the ground-water level 3 feet or more below the surface, it is essential that artificial drainage be provided. Under such conditions, drainage is ordinarily accomplished by means of systems of ditches, the depth of which is sufficient to maintain the ground-water level at least 3 feet below the surface and the width and distribution of which is sufficient to permit prompt run-off of excessive rainfall. In the case of some peat soils the growth of the cane appears to be favored by maintaining the ground-water level at less than 3 feet below the surface, especially during periods of insufficient rainfall, and in some instances drainage ditches are laid out in such manner as to permit raising the water level by flooding them. The low, flat character of lands in Louisiana and southern Florida and the frequently excessive rainfall which occurs in these areas necessitate extensive systems of drainage ditches of ample capacity. The character and the elevation of the lands used throughout the greater part of the areas in which sugarcane is grown for the production of sirup only does not necessitate artificial drainage, though in many instances, such as lands adjacent to the coast and low-lying, poorly drained lands elsewhere, drainage must be provided either by systems of ditches or by tiling.

Irrigation of sugarcane is rarely practiced in the United States, as the amount and distribution of rainfall in the States in which sugarcane is grown is usually sufficient for reasonably satisfactory growth of the crop. However, serious droughts occur from time to time, the effect of which is very harmful upon the growth and yield of the crop. The application of irrigation water would undoubtedly prove profitable in areas of frequent droughts, provided adequate supplies of water were readily available and the cost of applying water would not greatly increase the per-acre cost of producing the crop. Application of irrigation water would be necessary, of course, in connection with any attempts to grow cane in regions with scanty rainfall, such as southern Arizona and California.

MANURIAL REQUIREMENTS

COMMERCIAL FERTILIZERS

The use of commercial fertilizers in sugarcane growing is almost universal in the United States and in other cane-growing countries, but local practices differ widely as to the particular fertilizer elements used and the forms and proportions in which they are applied.

Some form of nitrogenous fertilizer can be applied with profit or is absolutely essential in practically all localities. The quantity of

nitrogen that is applied on the best-managed farms of the South usually ranges from 20 to 50 pounds per acre.

The soils of nearly all sugarcane localities respond to the application of phosphoric acid, but the quantity required varies considerably. From 40 to 80 pounds per acre of soluble phosphoric acid in a complete mixture are usually recommended in Louisiana. To the lighter soils of Georgia and Florida it is not unusual to apply considerably more, even up to 120 pounds per acre.

Applications of potash give little or no response in most of the rich alluvial sugarcane soils of the Mississippi Delta. In the States east of Louisiana, however, potash is applied, usually at the rate of 30 to 50 pounds per acre.

It is a common practice to buy fertilizers ready mixed, though in the interests of economy many farmers do their own mixing. In the trade the mixed fertilizers are commonly described by three figures in regular sequence referring to the percentages of plant food which they contain, and the order, nitrogen-phosphoric acid-potash, is standard practice. However, in the Southern States the order phosphoric acid-nitrogen-potash is commonly used.

The mixtures most popular in southern Georgia and northern Florida for spring and early summer application usually do not vary far from the 4–8–4 formula, i.e., 4 percent of nitrogen, 8 percent of phosphoric acid, and 4 percent of potash. The total quantity of fertilizer applied varies from 500 to 1,500 pounds per acre, depending upon its composition, the fertility of the soil, and the character of the crop preceding the cane. Under some conditions the application of from 500 to 800 pounds proves sufficient, though under most conditions and for most soils more satisfactory growth and yields result from the application of from 1,000 to 1,500 pounds. These quantities are mentioned as an example of common practice in southern Georgia and northern Florida and not as a recommendation for any wide range of localities or soils. Where the soil has been restored to high fertility by turning under a crop of legumes, application to the plant-cane crop of commercial fertilizers, especially nitrogenous ones, may be decreased greatly or even omitted, although in the case of soils deficient in phosphoric acid and potash moderate quantities of these plant foods should be applied. Succeeding ratoon crops should be given sufficient fertilizer to insure rapid and satisfactory growth.

APPLICATION OF FERTILIZERS

In spring planting it is customary to scatter a rather liberal application of mixed fertilizer in the furrows in which the cane is to be dropped. Some implement is run through the furrow to mix this fertilizer with the soil. For cane planted in the fall or early winter, fertilizer is used very sparingly, if at all, at the time of planting, most of it being applied in the spring when the crop starts to grow.

In case of either spring or fall planting, another application is frequently made near the middle of May, designated as a side application, because it is distributed along the sides of the rows and cultivated into the soil. Some growers favor the application of a top dressing of readily available nitrogen at the time of laying-by the crop, July 15 to August 1, but the once common practice of late

summer application of nitrogenous fertilizer has been practically discontinued among farmers who grow cane for sirup, as it is well known that it is very liable to exert a harmful effect upon the quality of the sirup.

In the absence of trustworthy information concerning the fertilizer requirements of soil on which sugarcane is to be grown, the grower should not blindly follow any special fertilizer formulas or rates of application that may have been found suitable for some other type of soil or some other crop, but preferably should carry on experimental trials with several fertilizer combinations which he has reason to believe may prove most suitable. Commercial mixtures carrying varying proportions of fertilizer ingredients or home-mixed fertilizer made from suitable proportions of nitrogen from such sources as ammonium sulphate, calcium nitrate, cyanamid, nitrate of soda and calurea, and sulphate of potash, superphosphate, or other compounds may be used. Materials such as cottonseed meal, tankage, and fish scrap, the decomposition of which tends to increase the humus content of the soil, may also be used for supplying a portion of the nitrogen requirements, though under ordinary conditions these materials are not suitable for furnishing the entire nitrogen requirement, as sugarcane needs considerable quantities of nitrogen in more quickly available form. Cottonseed meal, which is said to exert a favorable influence upon the quality of the sirup, is favored by many sugarcane growers. It may be obtained with a total nitrogen content equivalent to 7 or 8 percent ammonia (NH_3) and is commonly applied at the rate of from 250 to 500 pounds per acre.

ORGANIC MANURES

The value of green-manure crops for restoring or improving the fertility of soil has been amply demonstrated, and the cane grower should utilize them whenever it is possible to do so without interfering too seriously with the crop rotation. Practically all soils in the sugarcane-growing areas, both the heavy clay soils similar to those occurring extensively in Louisiana and the lighter ones occurring in the States farther east, are very responsive to improvements resulting from plowing under such crops.

Plowing under legume crops, such as cowpeas, soybeans, Austrian winter peas, vetches, sour clover, and Crotalarias, early enough to permit the green material to become well rotted before sugarcane is planted usually results in a profitable increase in yield of cane. Crops of this kind, which increase the nitrogen content of the soil, restore vegetable matter and humus, and aid cultivation by improving the texture of the soil, are beneficial even when harvested for hay, but maximum results are obtained when the entire crop is turned under. The cane grower should, of course, utilize legume crops that are most suitable for culture in his own locality. Such plants when grown as winter cover crops conserve soil moisture and retard or prevent erosion or washing. Legume crops are frequently grown between the rows of stubble cane; when this practice is followed the cover crop should be disked in or plowed under early in the spring before the cane has made much growth.

It is the common experience of cane-sirup makers that applications of barnyard manure, especially horse manure, to the cane crop injure

the quality of the resulting sirup, making it darker in color and imparting a strong salty flavor. It is therefore advisable to make the applications to the cane crop sparingly if the cane is to be used for sirup production, or else, if such manures are available, to make heavy applications to the crop preceding the sugarcane in the rotation. The use of liberal quantities of sugarcane bagasse—frequently called "pomace" in Georgia and other States—as litter in the stables and corrals tends to increase the quantity of manure available through preventing waste of animal manure. When bagasse is used in this manner the manure should be protected from the weather and permitted to rot thoroughly before it is applied.

The trash remaining after the cane is harvested is usually burned, but turning it under returns nitrogen, vegetable matter, and humus to the soil and improves its texture and moisture-retaining capacity. Results are inferior to the effect of turning under a green-manure crop, but in light soils especially it is advantageous to utilize trash when feasible to do so without interfering with proper treatment of the ratoons. The total nitrogen in the trash from 1 acre of cane varies from about 10 to about 20 pounds; this is lost when the trash is burned, but, when it is turned under, most of the nitrogen becomes available after the trash decomposes. The slow rate at which trash usually decomposes may exert a temporary deleterious effect upon the growth of the stubble crops, but decomposition may be hastened and the deleterious effect avoided by dusting it with nitrogenous fertilizer, at the rate of 10 to 20 pounds of nitrogen per acre, when it is plowed under. Burning the trash is not only valueless in reducing injury from insect pests, but, as will be described later, results in destruction of certain beneficial insects.

Many who apply barnyard manure prefer to put it into the furrows in moderate quantity in well-rotted condition at the time of planting the cane. It is usually more convenient, however, to distribute it broadcast either before or after breaking the land; in the latter case it is disked in before opening the furrows to plant the cane. The application of 5 to 10 tons per acre, which is the quantity ordinarily applied, permits of a reduction of one half or more in the quantities of commercial fertilizer needed for the crop.

CROP ROTATION

Fertilizer requirements for the sugarcane crop depend to a considerable extent upon the crops preceding cane, and land upon which cane has been grown should preferably be planted for several seasons with other crops before it is again returned to cane. Lands on large plantations in Louisiana are frequently planted to cane again after a single intervening crop of legumes has been plowed under and permitted to rot thoroughly, but in general, and especially throughout the areas in which cane is grown for sirup production, it is a better practice to grow several intervening crops.

Rotation crops may include corn, oats, peanuts, potatoes, cotton, or other crops commonly grown in the Southern States, but it is better to include at least one legume crop such as those mentioned on page 16. The legume should preferably be grown during the season immediately preceding the cane crop and, when feasible, the entire

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crop should be plowed under and permitted to rot before the cane is planted. This practice not only favors the growth and yield of cane, but ordinarily permits of a reduction in the quantities of fertilizer, in particular nitrogen fertilizers, needed for satisfactory growth of the cane.

The universal use of corn for forage and for food in the Southern States renders it almost unavoidable in the rotation program. However, its culture on sugarcane plantations has been questioned because of its susceptibility to attack by mosaic of sugarcane, and because it affords a favorite breeding place for the sugarcane moth stalk borer. (See p. 40.) There appears to be no reason why corn should not be grown in areas in which varieties of sugarcane resistant to mosaic are grown, and in which the sugarcane borer is not prevalent.

FIGURE 3.—A well-cultivated field of young sugarcane in Georgia. In this instance the cane rows have been spaced somewhat wider apart than usual and potatoes, which will be ready to harvest by the time the cane shades the ground, have been planted in the middles.

Farmers who grow only small patches of cane can usually select land that is especially fertile or that has had especially favorable treatment. For small patches it is a favorite practice to shift the cow-pen area from time to time and to use the old area for the production of cane. Good results are also obtained by heavily manuring fields on which sweetpotatoes are to be grown and planting the field to cane the succeeding year.

In some instances the cane rows are spaced relatively wide apart, and an early-maturing crop, such as potatoes, that will mature before the cane shades the rows, is planted in the middles (fig. 3). When this practice is followed, additional fertilizer should be applied in sufficient quantities to take care of the needs of the extra crop.

PREPARATION OF THE LAND

Preparation of cane land varies considerably in different localities depending upon the character of the soil and corresponds in general to the practices followed with other crops. It is desirable to

plow the land considerably in advance of planting time and then to cultivate it thoroughly before planting by means of disks or other suitable implements. Where a green-manure crop has been plowed under the vegetable matter should be permitted to rot completely before the land is plowed and cultivated. When cane is grown on clay soil with a compact subsoil, it is especially responsive to deep plowing, which brings a considerable depth of soil into cultivation and opens the land for the storage of moisture. A reasonable depth to plow is 8 or 10 inches, with a subsoiler run through the furrow to a depth of another 6 or 8 inches. Deep cultivation is especially advantageous in clay-soil areas in which periods of drought are liable to occur. However, deep plowing may prove disadvantageous in the case of cane land underlain by clay or sandy subsoil that is deficient in humus or vegetable matter, and it is not advisable to turn up more than an inch of such raw soil at one plowing. It is preferable to attain the desired greater depth of cultivated soil gradually

FIGURE 4.—Sugarcane field in which the rows follow the contour of the hillsides. When rows are laid out in this manner washing away of fertile topsoil by heavy rains is greatly reduced.

through a series of years, giving opportunity meanwhile for the subsoil that is turned up to become converted into productive loam through mixture with surface soil and vegetable matter.

TERRACING

On the rolling uplands of southern Georgia and adjacent States special precautions against soil erosion are needed. Besides terracing the land on the hill slopes, the rows are usually run on contour lines or so as to give them a fall of only 4 to 6 inches per 100 feet (fig. 4). If the field is terraced, these terraces afford the necessary guide lines. If it is not terraced, it is most advantageous to run guide lines every 3 to 5 feet of vertical rise in advance of laying off the rows. This is done most conveniently and satisfactorily by means of a small farm level and leveling pole, locating points along the hillside nearly on a level, allowing for the required fall, and then, by the use of a 1-horse marker, connecting these points with a light furrow.

FURROWING

After determining the correct course and spacing for the rows, the furrows are opened with a 2-horse middle breaker or other plow. On light, well-drained lands in Georgia and other States flat furrowing is the usual practice, but on heavy poorly drained lands, such as those occurring in southern Louisiana, the furrows in which the cane is planted are ordinarily made in ridges that are elevated slightly above the surface of the field. Ridging is done for the purpose of securing better drainage, the elevation of the ridges depending upon the location and character of the land and the experience of the grower.

The space between the rows varies from about 4 to 6 feet. In the rich soils of Louisiana the usual spacing is 5½ to 6 feet. In southern Georgia 4½ feet is most common. The more rapidly the cane grows and the longer the growing season, the wider may be the spacing. It is desired that by midsummer, at laying-by time, the crop shall shade the ground well.

Commercial fertilizer, and sometimes also barnyard manure, that is applied at the time of planting is distributed in the furrow and mixed with the soil by cultivating with a suitable implement. Seed cane is then distributed in the furrow and lightly covered with soil (fig. 5).

PLANTING

Throughout the States in which sugarcane is grown for sirup production planting has customarily been done in the spring—February or March—but varieties, such as C.P. 29/116, Co. 290, and C.P. 807, have given satisfactory results when planted in the fall. Except in the more northern limits of the cane-growing sections, the practice of planting in the fall appears to be increasing among farmers who have abandoned the culture of the varieties that were formerly grown. In those sections of Louisiana in which cane is grown for the production of sugar the greater part of the crop is now planted in the fall—October and November—though spring planting is still followed to some extent. Elsewhere in the State planting is done either in the fall or in the spring, with an increasing tendency toward fall-planting practice. In extreme southern Florida it is customarily planted in the late fall or early winter, though it is frequently planted in the spring and even during the winter. Different varieties respond differently to fall planting, depending on vigor and rate

FIGURE 5.—Planting sugarcane in Georgia. The cane has been stripped and cut into 2- or 3-foot lengths and is being placed in the furrows so as to form a continuous line of sound cane. The quantity of seed cane placed in the furrows varies, depending upon variety and condition. With varieties recommended in this circular considerably less seed cane is required than with the old varieties.

FIGURE 6.—Stripping the cane for spring planting. In the fall the cane for planting is banked and covered with earth. In the spring it is "stripped" and cut into proper lengths for planting. Spoiled stalks and portions of stalks infected with red rot should be discarded.

of development, and the exact date should vary accordingly, but, in general, the cane should be planted far enough in advance of frost to permit the establishing of roots and some growth before the young cane is killed back by cold weather. The grower who contemplates fall planting should determine by experimental trials the most favorable date at which the cane should be planted in his locality. The advantage of fall planting is that in those areas in which the practice is feasible the cane starts to grow at an earlier date in the spring, and, in the absence of late killing frosts, is more mature by harvesting time.

The depth to which the seed cane is covered with soil is an important factor in connection with germination, early growth, and stand of cane, and, in general, it should be covered only deep enough to conserve soil moisture and prevent injury from freezing temperatures. Seed cane which is covered too deep—5 to 8 inches—fre-

quently fails to germinate, and the seed pieces may even rot, and such cane as germinates and grows ordinarily affords a poor and irregular stand. In most sections a covering of 1 to 3 inches of soil is ample for spring-planted sugarcane and 2 to 4 inches for fall-planted, but in sandy soils in the sirup-producing States 3 to 4 inches is preferable for fall-planted as a precaution against the seed cane drying out during the winter months. Upon the advent of warm weather in the spring any excess soil should be scraped off, leaving a depth of 1 to 2 inches over the cane.

Frequently the seed cane stored in windrows or banks for use in spring planting is damaged by red rot or from other causes. On the basis of ordinary field sanitation it is advisable to trim off the diseased portions and to plant only sound cane, the eyes of which are in good condition.

FIGURE 7.—Fall planting sugarcane in Louisiana. From one to two continuous lines of seed cane are ordinarily placed in the furrows. Where the borer is present in large numbers, as in Louisiana, an increased quantity of planting material is demanded to secure full stands in the resulting crop because of the large percentage of injured buds in the seed cane.

In Georgia and other sirup-producing States seed cane is customarily stripped and cut into pieces varying from about 18 inches to about 3 feet in length for placing in the furrow (fig. 6). In Louisiana whole stalks are usually used (fig. 7), and if the cane is too crooked to lie in the furrow it is cut after placement by "whacking" with a cane knife.

QUANTITY TO PLANT

As a factor contributing to maximum yields of cane the importance of a complete stand of plants in the row cannot be overemphasized. Even short gaps in the stand may reduce the yield by several tons per acre and longer gaps at frequent intervals of space are ruinous (fig. 8). The rate of planting in the row, considering sound, viable buds as the basis of rate, is primarily the thing that governs the resulting stand. Hazards, such as drought or other detrimental

weather conditions or invasion of the planted cane by disease organisms, may occasionally impair the stand arising from the most carefully planned seeding, but nothing can remedy an initially faulty seeding. It is within the power of an experienced planter to provide the requisite seed for a full stand however powerless he may be to escape the risk of subsequent hazards.

In the United States there are two ways to express the total amount of seed cane used to plant an acre. It is customary to state the requirement in tons in Louisiana and southern Florida, but in most other places the planting material is expressed in actual numbers of stalks, with some definite length of stalks stated or implied. Because of variation in distance between rows in different fields, it is readily seen that the same quantity of seed cane evenly distributed in the row would plant more or less acreage, or, stated in another way, the same quantity of seed cane would have to be distributed at a greater or lesser rate in the row to plant an acre. This has led to the

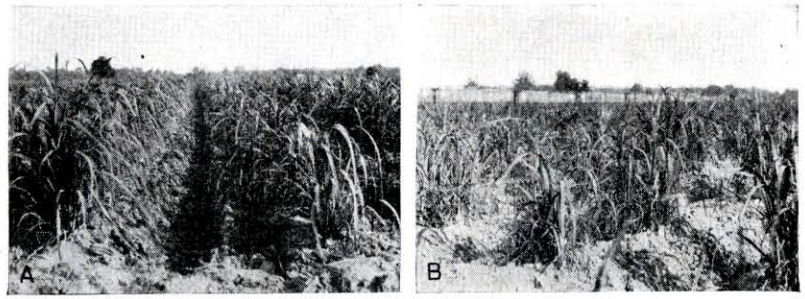

FIGURE 8.—Two views of the same field, illustrating loss due to gappy stand: A, Field viewed from the headland. No great loss is apparent looking down the rows. B, Field viewed across the rows showing gaps due to faulty planting. The main drainage ditch shown in A is typical of sugarcane fields in Louisiana.

use of another term to designate seed-cane requirements, namely, the number of continuous lines of cane stalks laid in the planting furrow. A fraction of a line, due to overlapping of the stalks, is referred to as a "lap" and in general the lap amounts to half of a continuous line.

None of the expressions in common usage state accurately the real requirement for a perfect stand, the basis of which, as already mentioned, is the rate of occurrence in the furrow of sound, viable buds, but they are terms of convenience, and experience has shown that for a given locality there is a fairly definite relationship between lines of seed cane in the furrow and number and distribution of sound eyes in the furrow. This relationship is due to the fact that, under normal conditions in a particular place, the percentage of buds that will germinate is about constant for a given variety of cane. Fluctuation in percentage of viable buds is mostly due to injury and disease of the seed cane, and even this can be taken into account by careful inspection of the seed cane at planting time.

One of the striking advantages of the varieties recommended in this circular is that there is great economy in the seed-cane requirement as compared with Louisiana Purple, Louisiana Striped, D-74, and other varieties formerly grown. The economy is due (1) to disease resistance and consequent higher percentage of sound buds,

and (2) to slenderness of stalk so that the number of buds per weight of cane is greater. Moreover, because these canes ratoon for a longer period of years it follows that replanting is less frequent and additional economy in seed cane is effected. A conservative estimate of the seed-cane saving throughout the country since adoption of the new varieties is 50 percent. The seed cane thus conserved goes into making sugar and sirup, and, as the former seed-cane requirement for the United States was a half million tons or more annually, the total saving is impressive.

The actual amount of seed cane that should be planted varies, depending upon distance between rows, time of planting (fall or spring), size and soundness of the stalks, and other factors, but with the above considerations as a guide the grower should plant sufficient seed to obtain a complete stand. In Georgia and northern Florida, where the rows are commonly spaced 4½ feet apart, the practice is to plant one continuous line of sound seed cane in the spring. Because weather favorable for germination is uncertain, it is good insurance to plant 1½ lines or "one line and a lap." An acre of rows spaced 4½ feet apart represents 9,680 feet of planting furrow and requires one thousand nine hundred and thirty-six 5-foot stalks planted in one continuous line. The requirement for stalks of other length or for 1½ lines, 2 lines, etc., can be calculated easily from this. In Louisiana, expressed in terms of weight, the requirement for fall planting rows 5½ feet apart is 1 to 2 tons per acre. With the old varieties the requirement is double that amount. Spring planting is still practiced to some extent, and because of the gradual deterioration of the windrowed seed cane during the winter a somewhat larger quantity is required for planting in the spring.

The heavier requirement for Louisiana is explained in part by the presence of the borer and greater injury by red rot; also, inspection and culling of seed cane is not done in Louisiana to the extent that it is in the eastern area, where, because of smaller units and less congestion of work, this commendable practice may be followed.

In southern Florida, with weather conditions approaching those of the Tropics, the requirement is less than in the Georgia-northern Florida area, and one 3-eye cutting for every 18 inches of planting furrow is usually sufficient in the relatively warm, fertile soils. Because of the longer season in southern Florida it is also possible to replace seed that does not germinate, in order to fill up gaps in the stand. In the areas to the north such replacement of seed is not practicable because the resulting plants would not mature during the limited growing season. Top cuttings, such as are used in the Tropics, may also be used to advantage in southern Florida instead of the whole stalk. They are softer and less stable than the older portions of the stalk and require almost uninterrupted growing weather; that is, no dormant period during which it is necessary to store the seed cane.

The fundamentally different seed-cane requirements for the different sections are due primarily to differences in the relative lengths of growing and dormant seasons, resulting in greater or less loss of effective buds at the beginning of the growing season. This loss of effective buds ranges from less than 50 percent in the Tropics to more than 80 percent in Louisiana seed cane held over for spring planting.

Paintings by James F. Brewer.

Six sugarcane varieties now grown for sirup production. (All about four-fifths natural size.)

CULTIVATION

PLANT-CANE CROP

In the spring before the newly planted cane is up or while it is still small, it is advisable, if the ground becomes crusted over badly or weeds tend to get a start, to stir the soil lightly with a light spike-tooth harrow, or, still better, with a spring-tooth weeder, covering the field once or twice in a direction, either diagonal to or up and down the rows.

FIGURE 9.—Off-barring sugarcane in Georgia.

After the cane is up and during its early growth it is usually necessary to give it from 1 to 3 hand hoeings in the rows to clean out the weeds. The cultivation of the space between the rows after the cane is up is much like that of other crops, a matter of killing the weeds and keeping the ground in good tilth. The early cultivation, before the root systems have developed much, should be relatively deep, but later in the season the cultivation must be shallow to avoid injuring the fine feeding roots that spread out from the cane near the surface.

Suckering of the cane can be controlled to some extent by cultivation. Leaving the bases of the plants exposed favors suckering, and therefore the soil is withheld from the rows as far as feasible during the early stages of cultivation to secure the best possible stands of cane. Later, when the season is too far advanced to permit new suckers reaching a suitable state of growth by harvest time, the soil is more liberally thrown against the rows to discourage the growth of suckers. This operation results in ridging the rows to some extent, but throughout the eastern Gulf States subsequent rains and light cultivations leave them but slightly above the level of the middles after lay-by time. Where natural drainage is poor, as in most of the Louisiana cane belt, the cane is planted in rows which are ridged up, sometimes to a height of 6 inches, above the level of the

middles. Cultivation is ordinarily carried on in such manner that the rows remain elevated above the middles, the latter serving as drainage furrows to quickly carry off surplus rainfall. Elevation of the rows depends largely upon the location and character of the land and the experience of the grower regarding the best conditions for securing adequate drainage.

The only difference in the cultivation of fall-planted cane, the rows of which should be covered late in the fall with a few inches of soil as a protection against cold, is that the rows are barred-off as early in the spring as the weather and the condition of the cane will permit and the soil scraped off of the top of the row (fig. 9). To off-bar means to plow a furrow away from each side of the cane, usually with a turnplow, leaving a ridge about a foot wide. This ridge is then scraped off with hoes or with a suitable implement, leaving 1 to 2 inches of soil over the cane.

RATOON-CANE CROP

Profitable sugarcane production depends to a large extent upon the yields obtained from ratoon (stubble) crops, and it is important that the stubbles be given timely and careful treatment. The customary practice is to burn the trash shortly after the cane has been harvested and then to "wrap" the stubble rows by throwing a furrow to them from each side by means of a turnplow. At the same time the remainder of the space between the rows is plowed with the turnplow. The crop is left in this condition through the winter. From the standpoint of improving the physical condition and fertility of the soil, especially of the lighter types of soil, turning the trash under appears preferable to burning it where it is feasible to do so without interfering with proper protection of the stubble rows. In lieu of "wrapping" some growers prefer to protect the stubbles through the winter by leaving the trash in the fields. This practice serves the purpose, especially if the trash is heaped directly upon the rows.

Treatment in the spring is about the same as that for fall-planted cane; that is, excess soil is removed, the rows are off-barred, and weeding and cultivation begun. Early cultivation should be relatively deep, but later in the season it must be shallow, in order to avoid injuring the roots which spread out near the surface. Practice followed in the application of fertilizer varies; in some instances the total quantity to be applied is distributed early in the season either in the off-bar furrow or as a side dressing, and in others the major part is applied in this manner and the remainder as a side application about the middle of May. The total quantity applied varies, depending upon local conditions and practices, but it is important that sufficient fertilizer be applied to insure rapid and satisfactory growth.

In the sirup sections of the eastern Gulf States, most of the cultivating and planting operations are done with 1-mule implements. This practice is in part justifiable because of the small patches prevailing, and also, in the rolling sections, because of many short rows resulting from laying off the rows on contour lines along the hill sides. In fields in which long rows prevail, however, there is undoubtedly room for improvement in the efficient utilization of a laborer's time by using 2-mule implements.

Cultivation generally ceases and the crop is laid by about the middle of July or the first of August. By this time the crop shades the ground and the rows have spread out until it is impracticable to get through with single-mule implements.

HARVESTING

With the coming of cool nights and moderately cool days in the fall, usually in October, the cane begins to mature[6] and rapidly stores up sugar in the stalks. With suitably cool weather it may be in condition to permit the beginning of harvesting and grinding by the latter part of October, though throughout most of the areas in which it is grown for sirup the growers with small crops to dispose of prefer to wait until the middle of November. In southern Florida, where early winter frosts rarely occur, the beginning of the harvest may be delayed until December.

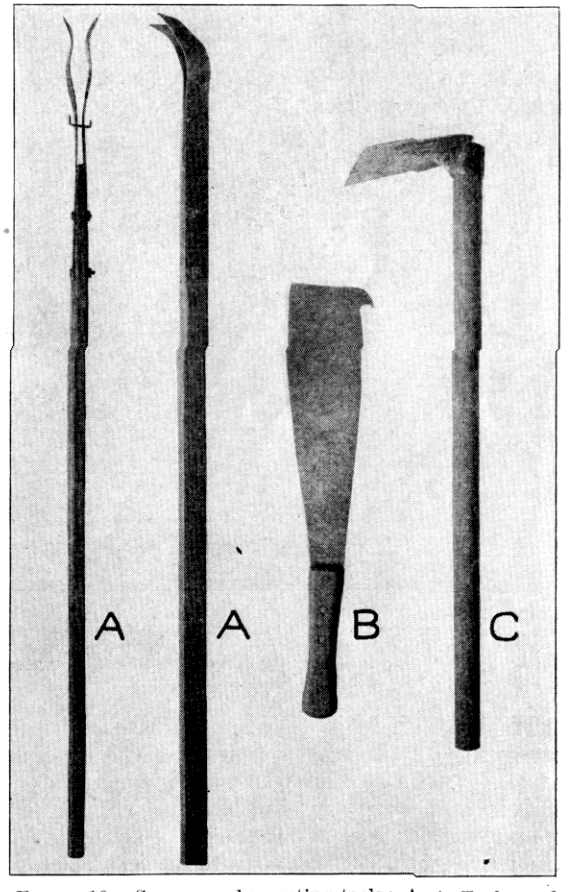

FIGURE 10.—Sugarcane harvesting tools: A, A, Tools used in Georgia and adjoining States for stripping the leaves from the standing cane; B, a type of cane knife commonly used for cutting the stalks; C, hoe of a type used when the stalks are cut below the level of the soil.

The cane continues to mature until its growth is stopped by frost, and the later in the fall or winter that harvest can be delayed the greater the yield of cane and sirup. However, frosted cane is liable to deteriorate rapidly and, therefore, harvesting should be begun enough in advance of the earliest probable frost to permit the major part of the crop to be harvested before the cane is seriously injured by cold. Slightly immature cane is not only less objectionable for sirup than it is for sugar manufacture but is usually even advantageous in that

[6] The term "mature" as used here means that the cane has reached a stage of development suitable for making sirup. In the United States sugarcane never matures in the sense of developing flowers and true seeds except in southern Florida.

the sirup made from it is less likely to crystallize. The reason for this is that the immature cane, while containing less sucrose (common sugar), contains more reducing sugars, the presence of which in the sirup lessens its tendency to crystallize when boiled to the usual density. Sugars of this kind do not affect the flavor, taste, or food value of the sirup, but cane should not be harvested when too immature, as sirup produced from such cane cannot be made clear and light colored and usually possesses an objectionably strong and sometimes even a bitter taste.

FIGURE 11.—Harvesting sugarcane in Louisiana. The stalks are cut at the ground level, the leaves stripped off with the back of the cane knife, and the tops cut off. The stalks are then thrown into piles, the yield from four rows usually forming the "heap-row" or "middle" which is kept free from trash to facilitate loading on wagons. The variety represented is P.O.J. 213.

Harvesting, which is almost universally done by hand, consists of stripping off the leaves, removing the tops, and cutting off the stalks at the bottom. The tools used consist of specially designed cane knives and stripping implements (fig. 10). In Louisiana the customary practice is to cut the stalk at the level of the ground, strip off the leaves with the back of the knife, and cut off the top (fig. 11). In the eastern Gulf States the customary practice is to strip off the leaves with a stripping tool, cut off the top, and then cut the stalk at the bottom (fig. 12). In most instances sharp hoes, instead of cane knives, are used for cutting the stalks at the bottom. In either case, the stalks are thrown into piles for convenience in loading and hauling. The lower part of the stalk is more mature, and therefore contains more sugar, and the grower should save as much of it as

possible by cutting it at the level of the ground. Cutting at a higher point is wasteful, leaving stubble several inches in length and resulting in a loss of a ton or more of cane per acre. The upper part of the stalk is least mature, and the topmost joints are of little or no value for the manufacture of sirup or sugar. Therefore, depending upon the maturity of the cane and whether it has been injured by frost, two or more of the topmost exposed joints should be discarded when the top is cut off.

In some instances, especially where it has been windrowed to save it after it has been exposed to severe frost, the growers are inclined to mill the cane without removing the leaves. This practice should not be followed, as the leaves not only decrease the quantity of extracted juice but tend to result in the production of cloudy, dark-colored, and generally inferior sirup.

FIGURE 12.—Harvesting sugarcane in Georgia. The leaves are beaten off with the back of the knife or removed with a special stripping tool, the tops are cut off, and the stalks cut off at the bottom and laid in piles for loading on wagons. The varieties represented are: Left, C.P. 807; center, P.O.J. 213; extreme right, Cayana.

YIELDS

PLANT-CANE CROP

The yield of sugarcane and sirup is so dependent upon soil, fertilizer, climate, weather conditions, and varieties of cane grown as to preclude exact statements regarding probable yields. On good sugarcane land in the principal sirup sections of Georgia, northern Florida, and other States, under good treatment as regards fertilizer application and cultivation, and in a year with favorable weather conditions, a yield of 20 to 25 tons per acre of cane, stripped and topped, may reasonably be expected from varieties such as C.P. 29/116, Co. 290, and P.O.J. 213. On good soils in southern Louisiana and Florida, and under favorable conditions elsewhere, yields of 30 to

35 tons of cane per acre are frequently obtained. Even greater yields are sometimes obtained under exceptionally favorable conditions. These estimates are for the plant-cane crop; that is, the first crop from a planting.

RATOON-CANE CROP

Yields from ratoon (stubble) crops in any locality are generally more subject to variation than those from plant cane, depending to a considerable extent upon the varieties of cane grown and the cultivation and care of the crop. Occasionally ratoon crops yield better than plant cane, but for an average it may be assumed that the first ratoon crop will yield about two thirds as much as the plant cane and the second ratoon crop somewhat less than the first. Subsequent ratoon crops usually yield less. It is uncommon for more than three crops, a plant cane and two ratoon crops, to be harvested from one planting, and in numerous instances the yield from the second ratoon crop is unprofitable. However, under favorable conditions and with good cultivation, some of the new varieties, such as, for instance, Cayana and C.P. 807, have produced from 3 to 5 profitable stubble crops.

SIRUP

Cane is not ordinarily weighed by the average grower engaged in the manufacture of sirup, the yield of sirup commonly being estimated upon the total number of gallons produced per acre rather than upon the number of gallons produced per ton of cane. Under good management of small-scale farm outfits for making sirup a yield of from 20 to 22 gallons of sirup per ton may be expected or, upon a basis of yields of 20 to 25 tons of cane per acre, a yield of from 400 to 550 gallons per acre. However, yields within this range may be expected only when good varieties of cane are grown, when the crop is properly fertilized and cultivated, when the cane is harvested at a reasonably advanced state of maturity, and where the cane is milled and the sirup manufactured in an efficient manner.

Data on production of cane sirup given in Yearbook of Agriculture 1932 shows that the average number of gallons produced per acre for all States in which cane is grown for sirup was 185.5 in 1928, 185.9 in 1929, 161.9 in 1930, and 142.9 in 1931. These figures clearly show that numerous growers secure yields far below those that can be obtained under good conditions and with good practice. It is probable that continued planting in the sirup sections of varieties susceptible to injury by mosaic and other diseases contributes largely to the low average. Most of the cane used for sirup is milled on small 3-roll mills, many of which are operated by animal power, and it is probable that the use of inadequate milling equipment, or even of worn-out mills, is an important factor contributing to low production of sirup. Thus, it is doubtful that the average farm mill extracts more than 50 to 55 percent of juice on the weight of the cane milled, whereas on a small but powerful mill driven by a gas engine upwards of 65 percent may be extracted. The quantity of juice represented by the difference between 50 and 65 percent extraction represents from 3½ to 5 gallons of sirup per ton of cane, depending upon its maturity and the quantity of sugar in it, or, on a basis of a yield of 20 tons of cane per acre, from 75 to 100 gallons of sirup per acre which may be lost as the result of inefficient milling equipment. More careful attention to these and to the factors mentioned above should enable the grower to increase his yields and to produce cane and sirup upon a more profitable basis.

STORING CANE FOR PLANTING

If the new plantings are not made in the fall, some means must be employed for storing the cane in localities subject to winter frosts until it is time to plant it, which is usually in the spring. Two methods of storing are in common use—windrowing and banking. The methods of harvesting cane intended for seed also differ, many growers digging up the stalks with the rootstock left attached and others merely cutting them at about the ground level. The former method permits use of the short rootstocks, which bear a large number of buds or eyes. However, if a crop is to be grown from the stubble, digging into it for the purpose of removing the rootstock has a harmful effect upon the growth of and yield from the succeeding crop.

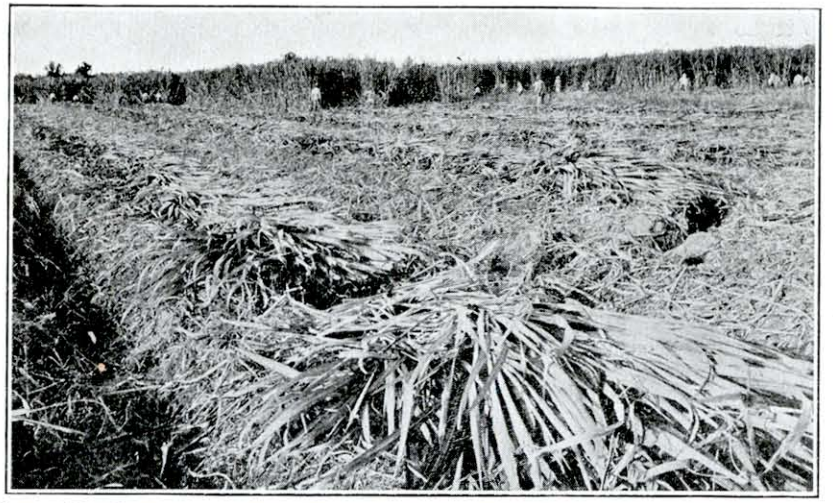

FIGURE 13.—Sugarcane in windrows ready for covering in Louisiana. The cane from 2 or 3 rows is laid in one of the deep middles formed by cultivation, the tops overlapping, and then covered with earth. The soil is thrown on the cane by means of a turnplow and the covering is completed by hand with shovels.

STORING CANE IN WINDROWS

Windrowing (fig. 13) is generally practiced on the large cane plantations, like those in Louisiana, where large quantities of cane must be stored in a relatively short time. The ridge method of cultivation results in deep furrows being formed in the middles between rows during the cultivation. The cane from 2 or 3 rows, cut off at the ground and without removing the foliage, is laid into one of the middles, overlapping in such manner that the tops always

cover the stalks previously laid down. The windrow thus formed is covered with soil by the use of large plows, throwing about two furrows from each side over it. If the soil is cloddy or wet, a disk cultivator is sometimes driven over the windrows to smooth out the soil that the plows have thrown up, and finally shovels or hand hoes are employed to fill in such gaps as the plows and cultivator may have left. At planting time the cane is pulled out of these windrows by a mule dragging a specially constructed implement with prongs or hooks crosswise of the rows.

STORING CANE BY BANKING

The storage of cane by banking is similar to windrowing in principle, but the layer of cane is usually deeper and the space covered wider. The depth of the cane in the bank before covering is from 18 to 30 inches and the width from about 5 to 10 feet. The length

FIGURE 14.—Banking sugarcane for spring planting. The layer of cane is deeper and wider than that in a windrow, and it must be covered mostly by hand.

of these banks is governed by convenience. Only the edges can be covered with plows, and the center strip of the bank must be covered by hand with shovels (fig. 14). Usually it is all covered by hand. About 1 to 2 inches of soil is put on the bank. At planting time the soil is shoveled off these banks and the cane pulled out by hand and stripped of leaves and topped. It is thus seen that banking the cane, while possibly somewhat more economical of planting material, requires proportionately much more hand labor, and can therefore be practiced only where the cane areas are small and the labor available is abundant.

WHEN TO STORE

Whether the cane is to be banked or windrowed, it is necessary to take every precaution to see that it is well matured and that it is kept as cool as possible in storage without, however, exposing it to injury from freezing temperature. The nonavailability of labor while harvesting for the mill and the danger from frosts lead the

planters usually to store the seed cane before beginning to harvest for the mill. This involves some sacrifice in the maturity of the cane. Cool, wet days are chosen, if possible, for the work of storing. If the ground is warm and dry, it is advisable to scrape away the surface soil immediately before putting down the cane. If it must be banked during warm weather, it is also desirable, conditions permitting, to bank only in the cool of the morning, or even during the night, covering the cane before it warms up in the midday heat. These precautions are necessary to guard against serious losses by red rot during storage.

DISEASES OF SUGARCANE

Numerous references have been made to diseases of sugarcane in preceding sections of this publication. The subjects of cane varieties, field practices in handling the crop, and diseases of the cane are so interrelated that it is impossible to discuss them independently. In comparatively recent years cane diseases have profoundly influenced the methods of cane culture in the United States by reason of the adoption of varieties differing in essential qualities from those previously grown. The change in varieties was a necessary consequence of the accidental introduction of a foreign disease. To be specific, mosaic, an introduced virus disease, became widespread about 20 years ago and resulted in the failure of the varieties Louisiana Purple, Ribbon, and D-74, which collectively occupied practically the entire acreage devoted to cane in this country. By the efforts of the Department of Agriculture varieties were found or developed which resisted this disease. These varieties—Cayana, P.O.J. 36, P.O.J. 213, P.O.J. 234, P.O.J. 36-M, Co. 281, C.P. 807, and, more recently, Co. 290 and C.P. 29/116—were distributed and rapidly gained favor with sugar and sirup planters because in the presence of mosaic the resistant varieties proved definitely superior.

More than 400,000 acres of land are now occupied by new varieties, and the old varieties have been discarded to the degree that they are nonexistent on sugar plantations and exist to only a limited extent in the centers of sirup production. Their complete elimination is now recommended because they are a source of mosaic infection and are no longer needed for chewing purposes, since the recent release of the superior variety C.P. 31/511. The characteristics of the new varieties are so essentially different from the old that their adoption has brought about significant changes in field practices, such as the amount of planting material required, which is much less; the period of ratooning or stubbling, which is longer by 1 or 2 years; and changes in rotation and fertilizer practice and other details of the industry extending to the harvesting and the fabrication of the crop in the mill. The importance of precise knowledge of cane diseases and their potential destructive or revolutionary effects cannot, therefore, be overemphasized, and sufficient familiarity with the common diseases to enable recognition by the grower will be definitely to his advantage.

It is deemed fortunate that only four of the major cane diseases of the world have been reported as causing damage in the United States. Many times that number are in existence elsewhere and could logically be expected to gain a foothold in this country if permitted to enter. It is for that reason that entry of cuttings or other live parts of the sugarcane plant from abroad is prohibited under the

Plant Quarantine Act except by special permit, and an elaborate quarantine practice has been instituted to safeguard the industry if for valid reasons such permits are issued. Permits have been issued only to Government agencies, usually for importing breeding material, which is grown under observation of plant pathologists in special quarantine greenhouses in Washington.

For the most part indirect methods are employed to control diseases of the cane crop. These methods include the use of resistant varieties when available and field sanitation such as drainage, rotation with crops not subject to the disease or clean fallow temporarily, seed-cane selection, and ameliorative fertilizer practices that minimize damage by certain diseases. The more direct methods, such as spraying or dusting with fungicides, are not commonly used because of difficulty of application of such materials, which require moving heavy equipment through the fields.

In a measure, the fight against diseases of sugarcane is taken out of the hands of producers of the crop and really begins when the plant breeder makes his selection of parents in producing new seedling varieties. In cane-breeding work by the Department of Agriculture an attempt is made to employ for at least one parent of a given cross, a variety demonstrated to be resistant to local diseases. It is not always possible, however, to exclude parent varieties susceptible to the diseases that must be guarded against, as the susceptible ones may possess some outstanding desirable quality not possessed by available resistant parents. The hope in such a cross is that in the resulting progeny there will be combined in some individuals both resistance and the desired quality. The issue is uncertain, of course, and this uncertainty leads to the necessity of carefully testing all progenies for disease resistance as early as it is practicable to do so.

Since attention was more carefully directed toward disease problems as a result of the mosaic epidemic, a procedure has arisen in the development of varieties which seeks to anticipate by several years the acquiring of essential information on their disease resistance or susceptibility. Formerly this information was obtained by observation of infection by the organisms of disease as they occurred naturally in the field or test plots. As epidemics are often sporadic, however, it was frequently necessary to wait years for their occurrence and much valuable time was lost. The new procedure involves exposure of each lot of seedlings to artificial epidemics of certain important diseases under carefully controlled conditions. At present, because of a restricted budget, these methods are applied in the testing of three diseases only, but they are proving practicable and timesaving. The varieties that show little or no resistance to important diseases are immediately discarded no matter how promising they may be otherwise. This acid test, together with tests of the other qualities enumerated on page 3, results in the elimination of all but a few of the hundreds of varieties annually produced or imported.

RED ROT

Red rot, caused by the fungus *Colletotrichum falcatum* Went, is of primary importance in all sections where cane is produced for sirup making. The nature of the damage caused by red rot is essentially different in different localities, depending partly on whether the moth stalk borer, an insect pest of cane, is present or

absent, and partly on variations in field practices which are not uniform in all sections because of climatic differences. In the alluvial sections of Louisiana where the borer is present much harm is done to the standing cane as the fungus gains entrance to the stalk through the holes made by these insects. In northern Florida and in Georgia, on the other hand, red rot does not seriously damage standing cane because the borer is not in that section and does not provide the initial injury through which the fungus ordinarily penetrates the stalk. Great losses occur, however, in the banks or in windrows where seed cane is stored for spring planting. Both areas are subject to loss from gappy stands, owing to faulty germination of infected seed cane after the cold, wet winters. In southern Florida the borer is present and the greatest injury is to standing cane, but with climatic conditions more nearly approaching those of the Tropics, and little or no dormant period in winter, the damage to seed cane is not so great as in the other sections.

Red rot is easily recognized in the stalks of seed cane in the banks or planted in the field. By splitting the stalk with a knife a typical red discoloration of the internal tissues may be seen. In the early stages of the disease the discoloration is confined to the vascular tissue and appears as reddish threads running lengthwise of the stalk. The affected part has a slight acid odor. Later the pith is involved and uneven blotches of red are seen which may eventually involve the whole stalk except the rind. Darker red areas may alternate with lighter ones and frequently the elongated dark blotches may have white centers running crosswise. Finally the stalk may develop cavities running lengthwise filled with fluffy white mold, which is the fungus causing the disease.

In standing cane it is more difficult to recognize red rot until the leaves begin to wilt and the disease has progressed to a late stage. Wilting and dying of the leaves begins at the topmost youngest leaves or leaves approaching maturity, followed by dying of the older lower leaves. The tissues around borer holes, if dissected out with a knife, are almost invariably found discolored by red rot, and these insect injuries seem to be an important means of entry for the disease organism.

Rigid selection of seed cane should be practiced when the banks are opened in the spring and all affected cane should be discarded. No varieties at present grown for sirup are highly resistant to red rot. However C.P. 29/116 and Co. 290 suffer the least and P.O.J. 213 and Cayana the heaviest damage.

MOSAIC

Mosaic is a virus disease of sugarcane transmitted from diseased to healthy cane by the corn louse, *Aphis maidis* Fitch, and two other species of aphids in a manner similar to transmission of malaria or yellow fever by mosquitoes. The disease was introduced into the United States some 25 years ago and is now important in all sections where cane is grown. The disease is recognized by a paleness of the leaves, which is noticeable from a considerable distance if the affected plant is carefully scrutinized in comparison with adjacent healthy plants. Examination of a single leaf from a suspected plant will reveal longitudinal streaks, irregular in size, of a green color several shades lighter than the normal green color surrounding the streaks.

The streaks often coalesce or run together and in some cane varieties they may occupy more of the leaf area than the normal colored tissue. In extreme cases the normal color that remains may be restricted to isolated islands of dark green in the pale-green background. It is possible to confuse other injuries causing paleness, such as the roundish pale areas surrounding punctures by certain sucking insects or the early stages of some leaf-spotting diseases with the true symptoms of mosaic. Careful examination shows distinctive differences in pattern, though, and attention to the signs of mosaic as described here should enable a careful observer to distinguish between them with ease. If there is any doubt, the newest rolled leaves in the spindle should be unrolled and examined. The signs of mosaic will appear there if the plant is infected, but the insect punctures or incipient leaf spots of other diseases do not appear in leaves so young.

The principal damage by mosaic is a stunting of the plants. They are not killed outright, but stunting is severe in some varieties, particularly in those classed as noble canes, which have generally gone out of culture when this disease is present.

The easiest way to minimize damage by mosaic is to plant resistant varieties. However, resistance is a relative term, and among cane varieties there are many kinds and degrees of resistance. Some varieties, as, for example, Cayana, C.P. 807, and C.P. 29/116, rarely take the disease, whereas P.O.J. 213 and Co. 290 may become heavily infected but are not markedly reduced in yield as occurred with the very susceptible old varieties.

Control of mosaic is possible by seed selection and roguing out the affected plants from fields of young canes, but this method is troublesome and requires close attention. If utilized, the most efficient way to follow the principle of selection is to start with clean seed cane and plant it in a relatively isolated spot far removed from infected cane for use in establishing a supply of healthy seed cane. Constant vigilance is required to keep out infected plants from which the disease would spread.

CHLOROTIC STREAK

Chlorotic streak, the cause of which is as yet uncertain, was first recognized in the United States in 1937. Its present known distribution is limited to scattered fields in the sugar-producing section of Louisiana, where strenuous measures are being taken to prevent its spread and serious damage to nearly all of the commercial varieties. The disease is recognized on the leaves by yellowish to whitish (chlorotic) streaks with wavy irregular margins. One to several streaks one-eighth to three-eighths of an inch in width and extending almost the entire length of the leaf may occur on one or more leaves of the affected plant. On the older leaves the centers of the streaks are frequently dead and papery in appearance. The disease is perpetuated by planting cuttings from diseased plants, and may subsequently spread rapidly to healthy plants in the field, which suggests the activity of some insect vector.

The principal injury caused by the disease is in the reduction of germination and the stunting of affected plants. The damage varies greatly with varieties, and some may have the disease without being seriously affected. Of the sirup canes, Co. 290 and C.P. 29/116 have been rarely infected.

Chlorotic streak is cured in seed cuttings by submerging the cuttings for 20 minutes in hot water at 125° to 126° F., a rather precise and tedious operation, but sometimes indispensable for starting healthy seed plots.

Growers throughout the uninfected sirup-producing States have been warned by their local State departments of agriculture against careless and indiscriminate importations and transfers of seed cane which might spread this new disease. Any long-distance shipments should be undertaken only after certification of freedom from this and other serious diseases by qualified State or Federal agencies.

ROOT DISEASES

The root diseases cause immense damage to cane in some sections, particularly in Louisiana, and are present everywhere. The immediate causes of root troubles are fungi and nematodes, but there are many predisposing causes, such as cold, wet winters, poor drainage, inadequately worked stiff soils, lack of humus, and many others. The fungi involved are, in the order of importance, *Pythium* spp., *Rhizoctonia* spp., and *Marasmius* spp., and the nematode causing greatest damage is the root-knot nematode *Heterodera marioni* (Cornu) Goodey.

The conspicuous signs of root diseases are gappy stands and stunted plants which do not tiller normally. In severe root disease the stool may have only 1 or 2 stalks instead of the large number found in vigorous, prolifically tillering healthy cane. Such diseased plants have practically no roots for anchorage and may be pushed over with little effort. When dug up the root system is found to be greatly reduced in size with only a few strands of white functioning roots. Injury to stubble cane evidenced by gappy stands is generally more severe than to plant cane, and in Louisiana the injury is much more pronounced in the heavy, black, poorly drained soils than in light, sandy soils.

Anything that can be done to promote rapid growth is beneficial. This includes adequate drainage and tillage, application of fertilizer, especially manure or organic fertilizers, and good cultural practices that will enable the roots to "grow away" from the disease. Varieties that are distinguished by prolific root development under good normal conditions are less injured than other varieties under root-rot conditions. C.P. 29/116 is a good illustration of a variety little injured by root diseases by reason of its vigorous, rapidly developing root system. Cayana and Co. 290 are other varieties which are outstanding in resistance to root diseases for the same reason.

Nematodes cause injury to sugarcane on light, sandy soils, especially when the cane is planted following a crop subject to the disease, such as tobacco. This is specially noticeable in western Florida. Stunting is the prominent symptom of nematode injury, as in the case of other root diseases. Examination of the roots reveals suppressed root development and the presence of small, elongated, bulblike processes at the ends of individual roots. The most effective way to avoid excessive injury by nematodes is to practice long rotations where this pest is prevalent. The crops intervening between plantings of sugarcane should be only those not supporting the root-knot organism, so that it will diminish or die out in the soil. The cane patch on most sirup farms can be moved every 2 or 3 years to

new locations and not returned to the original location for 7 or more years, and that is the best practice to follow from every point of view.

RED STRIPE

A disease of the leaves known as red stripe, caused by a bacterial organism (*Bacterium rubrilineans* (Lee, Purdy, Barnum, Martin) Elliott), has been noted in comparatively recent times in several localities where cane is grown for sirup, including Louisiana, Georgia, and Florida. It is known to be serious in some parts of the world, and while damage to varieties now grown commercially in the United States is not specially severe, it constitutes a threat and should be so recognized. The main sign of red stripe is the presence of long, narrow, maroon or deep wine-colored stripes lengthwise of the leaves. The narrow stripes originate midway between base and tip of the leaf as a rule and extend toward the tip. The first stripes tend to develop near the midrib, while the later ones arise farther away from the midrib but not at the extreme edges of the leaf. Occasionally the stripes run together, forming a broad band. Stripes are found on the lower side of the midrib itself but rarely on the upper side. The disease spreads in moist weather and has been observed in epidemic proportions in southern Georgia.

One of the most promising sirup seedlings ever produced at the Canal Point (Fla.) cane-breeding station (C.P. 155) had to be discarded because of special susceptibility to red stripe. The disease is of no special consequence in Cayana, P.O.J. 213, Co. 290, or C.P. 29/116.

BROWN STRIPE

Brown stripe, caused by the fungus *Helminthosporium stenospilum* Drechs., is widespread in the eastern Gulf States and at times causes damage there, but is infrequent in Louisiana. It causes very dark-brown to blackish pencil streaks one-fourth to one-half inch in length, each surrounded by a pale green "halo" on the older leaves. The early stages of this disease, before the streaks become brown, are sometimes confused with mosaic.

The stripes may become so numerous as to cause the leaves to shrivel and die during hot, dry weather. The advent of rain, or application of irrigation water, starts the plants growing again, and they resume the development of green, healthy leaves. The extent of damage is in direct proportion to duration of the drought. It is interesting to observe that red stripe spreads and damages the cane in wet weather, whereas brown stripe is held in check by the same agency.

POKKA BOENG

A disease known by the Malay term pokka boeng (damaged top), caused by a fungus, *Fusarium moniliforme* Sheld., sometimes makes its appearance in sirup areas on certain varieties. As long ago as 1919 whole fields of Louisiana Purple cane were observed to be affected by this disease in the vicinity of Cairo, Ga. In severe cases the whole top or growing point of the cane stalk becomes distorted, the emerging leaves being tangled and matted together. Accompanying this there may be a series of cavities, presenting a very characteristic ladderlike or chainlike appearance along the center of the stalk near the growing point. Sometimes the top rots cause destruction of the stalk, but usually the stalk recovers and resumes growth, leaving no trace except a series of shortened internodes where the injury occurred.

OTHER DISEASES

There is a long list of other local diseases of sugarcane, but, as most of them are not of regular occurrence or do not cause great damage when they do occur, they are not considered to be important factors in commercial cane production. Among these diseases are the common red rot of the leaf sheath, caused by *Sclerotium rolfsii* Sacc.; the eye spot of the leaf common in southern Florida, caused by *Helminthosporium sacchari* Butl.; rind disease, caused by *Melanconium sacchari* Mass.; black rot, caused by *Ceratostomella adiposum* (Butl.) Sartoris; pineapple disease, caused by *Ceratostomella paradoxa* (DeSeyn.) Dade; sheath rot, caused by *Cytospora sacchari* Butl.; and other diseases and injuries. Throughout the world nearly a hundred diseases and injuries of sugarcane have been described.

INSECT PESTS OF SUGARCANE

Many of the remarks in the introduction to the section on diseases would apply equally well to insect pests. Indirect methods of controlling pests are preferable for the same reasons, namely, the difficulty of moving heavy equipment through the fields for applying sprays or dusts. Airplane dusting has been attempted, but the economic soundness of such measures is not definitely proved. Biological control, including the artificial rearing and colonization of parasitic insects that destroy eggs and other forms of certain insect pests, has been tried with encouraging results, but this line of attack is still experimental.

The major pests of sugarcane in the United States are not present in all cane areas, and strenuous efforts should be made to prevent penetration of the uninfested areas by these pests. Establishing of a pest in areas not already occupied by it is often brought about by shipment or exchange of seed cane. This practice is engaged in by planters and others for the purpose of introducing new varieties for trial and has been responsible in a large degree for extending the areas occupied by pests. Such exchange of seed cane should be reduced to the minimum, and precautions should be taken to reduce the hazard of transporting insects with the seed cane. It has been found that hot-water treatment [7] of the seed cane or cuttings will kill all stages, including eggs, of the common pests that may lodge on or in the cane, without killing the buds, if the treatment is carefully controlled. The temperature of the water should be 122° to 126° F. and duration of treatment 30 minutes. This is an easy and practicable procedure for small lots of a dozen or less cuttings, the usual package for shipment, and requires no special equipment.

The practice of assembling cane varieties for trial or display, a tendency of some individuals with a bent for collecting, is dangerous for their neighbors who may also grow sugarcane, unless the dangers are recognized and guarded against. In general, it is well to leave this function to the State and Government experiment stations, whose experts are familiar with diseases and pests.

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[7] BRANDES, E. W., and KLAPHAAK, P. J. GROWTH STIMULATION AND PEST AND DISEASE CONTROL BY HOT-WATER TREATMENT OF SUGARCANE "SEED." La. Planter 71: 371–372, 392–394, 412, illus. 1923.

YODER, P. A., and INGRAM, J. W. HOT-WATER TREATMENT OF SUGAR CANE FOR INSECT PESTS.—A PRECAUTION. U.S. Dept. Agr. Dept. Circ. 303, 4 p. 1923.

SUGARCANE MOTH BORER

The most serious insect pest of sugarcane in the United States is the moth borer, *Diatraea saccharalis* Fab.[8] The borer is responsible for immense damage to sugarcane in Louisiana and is present also in southwestern Mississippi, southern Florida, and the Gulf section of Texas. This insect has not been found in Georgia, Alabama, or western Florida, and every reasonable effort to exclude it is justifiable. Injury to the cane by borers takes many forms, but is not specially noticeable in old cane except by close examination. If the leaves are pulled away, small holes may be observed in the rind, and the frass or sawdustlike material may be seen clinging to the stalk in the vicinity of holes. Upon splitting the stalk lengthwise tunnels are discovered through which the larva of the insect has eaten its way sometimes for several feet. The tunnels are about an eighth of an inch wide and meander lengthwise and crosswise through the interior of the stalk often joining but pursuing a course in general parallel with the main axis of the stalk, which is weakened to the extent that in some cases it is broken or blown down by the wind. Almost invariably the disease known as red rot becomes established in these injuries and finishes the work of destruction. Injury to young cane is more apparent in the field than injury to older cane. It takes the form of "dead heart" or death of the growing point and shriveling of the whorl of youngest leaves, and such affected stalks are conspicuous early in the season when the plants are 1 to 3 feet high.

Numerous ameliorative practices have been suggested to reduce damage by the borer. The practice of burning cane trash after the harvest should be discouraged as it results in destruction of the egg parasite *Trichogramma minutum* Riley, a beneficial insect that attacks borer eggs, as well as preventing the return of badly needed humus to the soil. Soaking the seed cane in water for several days is effective in killing many of the borer larvae and may be practicable where water is available. As the borer also attacks corn, the destruction of cornstalks near cane before the adult insects emerge from them would eliminate large numbers of borers. Direct attack on the borers by dusting the cane with sodium fluosilicate, either by airplane or hand dusters, has not given satisfactory results. The rearing of the egg parasites and scattering them through the fields is claimed to be effective and economically sound, but until more experience confirms this it must be considered to be only a suggestion worthy of serious trial.

THE MEALYBUG

The mealybug (*Pseudococcus boninsis* Kuwana) is a ubiquitous pest of cane in the United States, but it becomes important only when attended by ants, especially the Argentine ant. This peculiar relationship of the mealybug and ant is explained by the fact that the ants use for food the honeydew excreted by the mealybugs and solicitously care for them and protect them from their enemies. The white, woolly mealybugs feed by sucking sap from the tender stalk tissue at the growth ring and cluster around the eyes of cane

[8] HOLLOWAY, T. E., HALEY, W. E., LOFTIN, U. C., and HEINRICH, CARL. THE SUGAR-CANE MOTH BORER IN THE UNITED STATES. U.S. Dept. Agr. Tech. Bul. 41, 77 p., illus. 1928.

stalks in such numbers that often the eyes are killed. They can be discovered by pulling away the leaf sheaths of infested cane and are present in both standing cane and cane in the banks or planted. Reduction of ant populations by poisoning[9] automatically reduces damage by mealybugs and is effective in Louisiana where the Argentine ant is present. Planting uninfested seed cane at some distance from fields where the mealybug occurs, low cutting of the cane at harvest time, and destruction of cane scraps left in the fields and around mills are practices that tend to reduce mealybug damage. Hot-water treatment of cuttings or seed cane intended for shipment is recommended. Even where the insect is already present, it serves to retard development of the pest in the new plantings.

APHIS MAIDIS

Direct injury to cane by the corn leaf aphid, *Aphis maidis* Fitch, is insignificant, but this insect is the principal agent in transmitting mosaic to healthy plants during epidemics of this disease and, therefore, must be regarded as a pest of first importance. The corn leaf aphid is universally present in greater or lesser numbers in or near cane fields where it infests certain wild grasses and cultivated grass crops like corn. Abundance of the insect depends mainly on availability of food plants at the proper stage of succulent development, which in turn depends upon seasonal and weather conditions. Where varieties susceptible to injury by mosaic are planted (including those classed as tolerant) it is worth while to supplement seed-selection practices with measures tending to reduce infestation by *A. maidis*. These measures include eliminating from the near vicinity of seed-cane plots any plantings of corn or sorgo, which are favored food plants of the aphid and on which the insect breeds in enormous numbers. Sugarcane itself is not especially attractive for the aphid, but when the corn or sorgo becomes mature and less desirable as a source of food, they leave it and migrate to the cane. If any mosaic is present in the cane, it then serves as a source of the virus and is rapidly spread to other cane plants by the successive feedings of the insect.

SUGARCANE BEETLE

Injury by the sugarcane beetle, *Euetheola rugiceps* Leconte, is serious in some localities and in particular years, but it does not present a problem comparable with the insect problems already mentioned. The newly emerged adult beetle is black and shiny, about one half to five eighths of an inch long. Ragged holes gnawed in the shoots of cane just below the surface of the ground are responsible for the noticeable injury to cane. The inner leaves turn yellow, and the shoot usually dies. Damage to the field is apparent early in the season and is in proportion to the number of beetles present. Losses are ordinarily greater in plant than in stubble cane. The beetles breed heavily in sod lands and little or not at all in woodland. Where possible, sod and grass pastures in the vicinity of cane fields

[9] BARBER, E. R. THE ARGENTINE ANT: DISTRIBUTION AND CONTROL IN THE UNITED STATES. U.S. Dept. Agr. Bul. 377, 23 p., illus. 1916.
HOLLOWAY, T. E., and INGRAM, J. W. THE SUGAR CANE MEALYBUG IN GEORGIA. The Planter and Sugar Manufacturer. v. 77, no. 17, pp. 330–331. Oct. 23, 1926.

should be eliminated as a measure tending to reduce beetle population. In some sugarcane areas there is a gradual shift to early fall or summer planting, and because of the larger number of shoots the following spring from such plantings there is proportionately less beetle injury and better stands result.

SUPPLIES AND EQUIPMENT REQUIRED FOR GROWING CANE AND MAKING SIRUP

The implements required for field work are for the most part the same as those required for other field crops, with the addition of cane knives and stripping tools.

Certain supplies, some of which are peculiar to the production of cane and sirup, are also needed. The following represents an estimate of the requirements per acre for a plant-cane crop yielding 18 to 25 tons of cane, or 360 to 500 gallons of sirup, per acre, based upon experience in southern Georgia:

Seed cane; 1,500 to 3,000 stalks, depending upon average length of the stalks and rate of planting. (See p. 24.) Seed cane is usually grown on the same farm, the yield from one tenth of an acre ordinarily sufficing for planting 1 acre or more.

Commercial fertilizer; 1,000 to 1,500 pounds complete fertilizer mixture. (See p. 15.)

Barnyard manure; from none up to 10 tons. The application of barnyard manure permits of a corresponding reduction in the quantities of commercial fertilizer needed for the crop.

Fuel for operating the sirup evaporators; approximately 1 cord of wood for each 100 gallons of sirup made or 3 to 5 cords to make sirup from cane from 1 acre. This estimate should be increased by approximately one half cord where steam evaporators are used and the mill operated by steam power.

Fuel for a gasoline or kerosene engine for operating a mill; 20 to 30 gallons. A gasoline engine suitable for operating a mill with a capacity of 10 tons of cane per 10-hour day would consume approximately 12 gallons of gasoline per day, or approximately 24 gallons for a yield of 20 tons of cane per acre. In many instances small mills are operated by animal power.

Containers for the sirup; 11 to 15 barrels, with a capacity of 33 gallons each, or 8 to 10 barrels with a capacity of 50 gallons each. If the sirup is to be packed in cans, 70 to 95 cases, each case containing six 10-pound cans, twelve 5-pound cans, or twenty-four 2½-pound cans.

The cost of a sirup-making outfit, including cane mill, sirup evaporator, and suitable shelter varies from about $150 for the simplest small-scale type to several thousands of dollars for a large-scale type equipped with a large-capacity mill operated by means of a large gasoline, kerosene, or steam engine, multiple direct-fired, open-pan sirup evaporators or multiple open-pan steam evaporators, suitable piping and valves, large capacity juice and sirup tanks, and hoists for unloading and handling the cane.

The sirup producer who grows from 1 to 3 acres of cane finds it economical to use a small animal-power cane mill with a capacity of 3 to 5 tons of cane per day and a 10-foot pan evaporator having a capacity of 75 to 100 gallons of sirup per day of 12 hours (fig. 15). A mill of this type is wasteful in that it does not afford a high extraction of juice from the cane, but the initial cost of such equipment is low and the cost of upkeep very little. The cost of an outfit of this type in 1932, including a simple shed for the evaporator, was around $150.

Sirup producers who grow from 5 to 10 acres of cane generally use a power-driven mill with a capacity of 10 or 12 tons of cane per day and a pan evaporator with a capacity of 200 or more gallons of sirup per day of 12 hours. The cost of an outfit of this capacity varies from one locality to another and from year to year, but the approximate cost in 1932 was about as follows:

3-roll cane mill of standard make	$250
Gasoline or kerosene engine of about 8 horsepower	200
Pan evaporator of galvanized iron, 15 feet long and about 42 inches wide, equipped with baffle plates and skimming troughs	21
Materials (approximately 2,500 bricks, 2 barrels of lime, sand, grate, juice tanks, juice pipe and valves, sirup-collecting tank, belt for cane mill, and miscellaneous small items) and labor for constructing the furnace and installing the evaporator	150
Material for shelter and cost of labor for construction	100
Total	721

FIGURE 15.—Sirup-making outfit of type widely used by farmers who grow from 1 to 3 acres of cane. An outfit of this type has a capacity of 75 to 100 gallons of sirup per day and costs $150 to $200. The cost of larger capacity outfits equipped with power-driven cane mills is proportionately greater.

LABOR AND WORK-ANIMAL REQUIREMENTS

The labor and work-animal requirements, together with supplies, fixed charges like taxes and interest, and depreciation of equipment go to make up the costs of production, which must be balanced against receipts to determine whether the operation has resulted in profit or loss.

Cost of producing the succession of plant and stubble crops from a single planting and the profits therefrom cannot well be considered separately by individual crop years. It is obvious that there would be no stubble crop without a preceding plant-cane crop and, therefore, the planting costs should really be distributed through the whole period instead of being charged to the plant-cane crop alone.

In working out a system of cropping to determine the number of stubble crops that may be profitably made, the grower needs to be on guard against drawing general conclusions from the operations for a single year, but should be guided by the average of results for all crops harvested from the initial planting. Nevertheless, his elements of cost and his crop receipts are figured each year to serve as the basis for calculating the average results.

Considering first the plant-cane crop, the record of labor and work-animal requirements in table 3 may be helpful to the inexperienced planter in arriving at an estimate of these requirements. It is based on field operations in southern Georgia by a farmer cultivating 35 to 50 acres of cane each year, and on sirup making by representative farmers with small power mills and continuous-stream evaporators with capacities of about 200 gallons per day of 12 hours.

TABLE 3.—*Labor and mule requirements, per acre of plant cane grown, in sugarcane growing and sirup making*

Operation	Labor		Mules
	Men	Women	
	Days	*Days*	*Days*
Breaking the land, 1 man and 3 mules with a disk plow breaking 2 acres a day	0.5		1.5
Harrowing	.2		.6
Laying off, marking, and opening the furrows	.5		.8
Planting the cane, with a force sufficient to plant 6 acres a day, including getting the cane out of the banks, stripping it, cutting it into short lengths, and trimming off diseased portions (2 men and 22 women); hauling the cane (4 men and 8 mules); hauling fertilizer (1 man and 2 mules); distributing the fertilizer and covering the cane (2 men and 2 mules); dropping the cane into the furrows (6 women); a total of 9 men, 28 women, and 12 mules to plant 6 acres per day, hence per acre	1.5	4.7	2.0
Hoeing twice by hand		2.0	
Cultivating 6 times (1 man and 1 mule covering 3 acres a day for each cultivation)	2.0		2.0
Second distribution of fertilizer	.3		.4
Harvesting, including stripping, topping, and cutting	6.0	12.0	
Hauling to mill, assuming a haul averaging three-fourths of a mile, 1 man and 2 mules hauling 8 loads (about 10 tons) a day, and a yield of about 22 tons per acre	2.2		4.4
Total days' work to produce the plant-cane crop, delivered at the mill	13.2	18.7	11.7
Grinding the cane and boiling the sirup (a crew of 4 men, including 1 expert sirup boiler, making about 200 gallons a day)	9.6		
Total days' work to produce the crop and make it into sirup	22.8	18.7	11.7

From this report it appears that about 13.2 days' work of men, 18.7 days' work of women, and 11.7 days' work of mules were required to produce 1 acre of plant-cane crop, and that it would require about 9.6 additional days' work of the men to make it into sirup on a small outfit. If mules are used in place of the engine to do the grinding, it would require at least two mules continually, or about 4.8 additional days' work of mules per acre of plant cane put through the mill. For the old varieties of cane, such as Louisiana Purple, Louisiana Striped, D-74, and Simpson, which were formerly grown for sirup production, and the C.P. 29/116, now popular, the harvesting requirements would be about one-half of those here stated, which are based upon the slender-stalk variety, Cayana, which is now widely grown throughout the sirup-producing States. Harvesting

requirements for the varieties Co. 290, C.P. 807, and P.O.J. 213, the culture of which has greatly increased subsequent to 1930, would be intermediate.

The foregoing report of labor which this farmer required for the field operations does not include the time of the overseers. He employed two overseers on the cane crop continuously during planting, and irregularly at other times.

A material saving in labor for grinding the cane and manufacturing the sirup can be effected when sirup manufacture is carried on upon a large scale, though in the case of large outfits necessitating the hauling of cane for longer distances, such saving may be offset to some extent by the increased cost of hauling.

In the case of stubble crops the expense of breaking land and preparing the seed bed and cost of seed cane and planting is omitted. The saving is offset to some extent by the small amount of work involved in wrapping the stubble for winter protection if the grower follows this practice, and in off-barring and removing excess soil in the spring. The cost of these operations is small compared with the cost of establishing a plant-cane crop. In addition, the actual outlay for harvesting, hauling, and sirup making on an acre basis is reduced in nearly the same proportion as the yield and, therefore, the investment during the stubble crop year is considerably less. It must be borne in mind that receipts will probably be less and such saving in per acre cost must be recognized as deceptive, especially if the yield has fallen off considerably. The lower the yield of cane the higher will be the cost per ton, and this principle, carefully applied, will determine whether an additional stubble crop should be grown or whether the investment in a new plant-cane crop is justified. The most carefully planned sirup farm operation is no less subject to risk than farm operations in general, due to weather hazards, fluctuation in the price of sirup, and other factors, and growers can only make judicious use of the facts brought out in records and apply them in making decisions as to continuation of stubble crops.

These considerations emphasize the advantage of growing varieties of cane that may be expected to give high returns because of high-yielding stubble crops, thus avoiding the great expense of frequent replanting. As already mentioned, Cayana, P.O.J. 213, C.P. 807, C.P. 29/116, and Co. 290, when grown under favorable conditions, with attention to the plant-food needs, will afford profitable first- and second-year stubble crops and frequently more, but under present conditions the varieties subject to great injury from the recently introduced diseases gives disastrously low yields even as first-year stubble.

MARKETING THE SIRUP

Considerable quantities of the cane sirup produced annually are packed in cans or bottles by the producers and sold direct for local consumption or to local dealers in food products, but the greater part is packed in barrels and sold to dealers, jobbers, or concerns engaged in the sirup-packing business. It is usually marketed within a few weeks to 2 months after having been produced and is sold at prevailing market prices which vary slightly, depending upon its density, color, flavor, and appearance, the best grades of sirup com-

manding the highest prevailing price. The price, which is governed largely by the prevailing market prices for sugar, varies greatly from year to year, depending upon the total production of sirup and upon the world supply of sugar and economic conditions. Thus, the market price of sirup in barrels at Cairo, Ga., ranged from 60 to 90 cents per gallon in 1925, from 40 to 60 cents in 1928, and from 20 to 35 cents in 1931–32. The very low prices for sugar in 1931–32 were largely responsible for the low prices of sirup in those years and an improvement in the price of sugar should result in an increase in the prices for sirup. When sirup is packed in cans the price is usually 10 to 15 cents a gallon more than when sold in barrels. In localities where the local demand exceeds the supply the sirup producer may usually get a higher price than the prevailing general open market prices, especially if he produces sirup of extra good quality.

Since the income from the cane-sirup industry is confined to the returns from the sale of sirup and cane—either seed cane or cane sold to operators of sirup mills—it is obvious that the cane grower's net profit may be greatly reduced during periods of low prices. Market prices for sirup and cane, which depend largely upon prevailing prices for sugar and supply of and demand for sirup, are governed by conditions beyond the control of the cane grower, but, under any given conditions, the relative return to the grower is governed largely by the efficiency with which he conducts his operations. Therefore, for most successful operation, it is of the greatest importance that the cane grower make every effort to produce maximum yields at minimum cost by growing suitable varieties of cane, by planting adequate quantities of seed cane, by properly fertilizing and cultivating the crop, by securing the greatest possible yield of sirup per ton of cane, and by conducting all operations at the lowest cost consistent with efficient operation.

UTILIZATION OF BY-PRODUCTS

There are three by-products from the cane-sirup industry—(1) the leaves and tops, (2) the bagasse ("pomace" or "mash"), and (3) the skimmings removed when the cane juice is boiled to sirup—all of which are almost completely wasted under present practices. Under present conditions these by-products have practically no sale value, but they are of sufficient value for certain purposes on the farm to justify their use in preference to the ordinary practice of destroying them.

LEAVES AND TOPS

The production of leaves and tops depends upon the varieties of cane grown and the yield of cane per acre. In fresh condition, as removed from the cane at harvesting, production varies from about 4 to 8 tons per acre throughout the areas in which cane is grown for sirup production. To a small extent stock is pastured upon this material, but it soon becomes weathered and unfit for feed and is usually permitted to remain in the field until early in the spring and then burned. In some instances it is placed upon the stubble rows for the purpose of protecting the cane stubble during the winter and is raked off in the spring and burned. The feeding value

of the tops and leaves, while apparently inferior to that of hay, corn fodder, and other winter forage, is sufficiently high to render the material suitable for winter forage provided that it is cured before it has been injured by frost, and that it is supplemented by other feeds. However, weather conditions during the cane-harvesting period are generally unfavorable for curing the tops. Attempts have been made to dry the tops and leaves artificially and to utilize the dried material either for feeding direct or as an ingredient in mixed stock feeds, but the practice has not been established to any important extent. Experiments carried on during 2 years at the United States Sugar Plant Field Laboratory at Cairo, Ga., indicated that the tops and leaves are suitable for making silage of satisfactory quality. Cattle ate the silage readily and thrived on it. Chemical analyses showed that its nutritive value was but little inferior to that of silage from corn. The results of these experiments have been substantiated by results of similar experiments carried on elsewhere, though some investigators have noted that the palatability of silage from cane tops and leaves is inferior to silage from corn, soybeans, and cowpeas. In making silage from tops and leaves it is important that the material be siloed before it has been injured by frost, and that it be thoroughly packed when the silo is filled. When the tops and leaves are not used for feed, plowing them into the soil appears preferably to the wasteful practice of burning them. (See p. 17.)

BAGASSE

Bagasse (or "pomace"), that portion of the cane remaining after the juice has been extracted, accumulates in great heaps at the sirup mills, and at the average small mill it is burned or hauled off to swamps or other waste land. A preferable practice is to permit it to rot for 1 or 2 years, and then spread it over the land and turn it under as a means of improving the humus content, moisture-holding capacity, and texture of the soil. Numerous cane growers use considerable quantities of bagasse as a litter in barnyards and corrals. When used in this manner, it absorbs much of the animal manure which would otherwise drain away and be lost. Where bagasse is used in this manner, the resulting manure should be rotted thoroughly before it is applied to the soil.

Bagasse produced at sugar factories and at large-scale sirup factories equipped with mills capable of obtaining a high extraction of juice has a high fuel value and is extensively used as fuel for the boilers, many sugar factories burning little else. Bagasse produced at small sirup mills is rarely used for fuel as it is ordinarily too wet to burn freely unless it is dried and for the further reason that the cost of the special type furnaces and stokers required for securing best results is usually too great to justify their installation.

Fresh bagasse from small mills may be used as rough forage, stock eating it readily, but it soon sours and becomes unfit for feed. Considerable quantities of the bagasse produced at sugar factories in Louisiana are used in the manufacture of fiber board, or lumber substitute, and small quantities are sometimes dried and sifted and the pith portion used as an ingredient in mixed feeds. It is not feasible to use bagasse from small sirup mills for such purposes, as the quantities produced are comparatively small and the cost of

assembling it at central locations would be prohibitive. The best method of utilizing bagasse from small-scale sirup mills appears to be as a litter in barnyards or by permitting the piles of bagasse to rot and then plowing it into the soil, especially on very sandy soils, on heavy soils, or on soils that are inclined to wash.

SKIMMINGS

The skimmings produced at most sirup mills are discarded. Some sirup makers collect this material in barrels or tanks provided with a tap hole or a faucet about 2 inches from the bottom, permit it to settle overnight or for half a day, draw off the juice between the sediment and the floating scum, and boil it back into the sirup. This practice is of doubtful value, as the quantity of juice recovered is small, and it is very liable to become sour before it is drawn off. The likelihood of its souring may be reduced by thoroughly cleaning the vessels each time they are used, preferably with live steam or boiling water, but even under such conditions it is liable to quickly sour or become slimy or "ropy." If juice in this condition is boiled back into the sirup, the flavor and quality of the sirup is injured.

Skimmings are suitable for feeding to hogs, some sirup makers using all of the fresh material in this manner. The material may also be boiled down to a very thick, semisolid mass, in which condition it will keep for a considerable length of time, and may be fed in small quantities to hogs or stock. It is relished by cattle and apparently has considerable food value. When fed it should preferably be spread over or mixed with other feed.

RECAPITULATION OF IMPORTANT POINTS

Adjustment of the sugarcane sirup industry to meet the emergency caused by the introduction and spread of mosaic, a virus disease of the sugarcane plant, has taken place during the two decades just past. This disease was responsible for losses to the sugar and sirup industries amounting to over $100,000,000. This circular describes mosaic-resistant varieties of sugarcane imported or bred by the Department of Agriculture, which have restored yields of sirup per acre to former levels or higher. These varieties have been adopted in commercial culture to the extent of approximately 90 percent in acreage of sugarcane grown for sirup production and 100 percent in the case of sugarcane grown for sugar production, representing in the latter case 294,000 acres in 1938. Because of desirable qualities other than resistance to disease and consequent larger yields, the new varieties have brought about additional economies in the production of sirup. The seed-cane requirement, which represents a large element in the cost of production, has been cut in half. Furthermore, the ratoon (stubble) crops do not fall off in yield as sharply as in the case of the susceptible varieties formerly grown, and therefore the expensive operation of replanting is required less frequently. Departures from previous practices with the old varieties in planting, culture, harvesting, and rotations with the resistant varieties are discussed.

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