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GROWING SUGAR CANE *for* SIRUP

SUGAR CANE requires a warm climate and long season, so its culture in the United States is limited to a region 200 to 300 miles wide along the extreme South Atlantic coast and the Gulf coast and to some low-lying valleys under irrigation in southwestern Arizona and southern California.

It is also a gross feeder and requires heavy fertilizing and strong soils peculiarly adapted for and susceptible of good cultivation.

Sugar cane rarely matures seed in the continental United States, but is propagated from cuttings from the stalks, even in tropical countries. A crop is usually grown the second season, sometimes the third, from the rootstocks which are left in the ground.

There are few varieties in the United States, but some promising new sorts have been introduced recently.

An abundance of humus is necessary in the soil, which may be supplied by barnyard manure and by green-manure crops. Proper rotation of crops is extremely helpful.

This bulletin aims to give directions for growing and harvesting sugar cane in those regions where sirup is produced and where it is essentially a small-farm business.

Those wishing a more detailed discussion of this subject are referred to Department Bulletin No. 486, U. S. Department of Agriculture, "Sugar-Cane Culture for Sirup Production in the United States," which may be obtained for 10 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

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GROWING SUGAR CANE FOR SIRUP

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SUGAR-CANE growing for sirup at present is essentially a small-farm enterprise, in marked contrast to the sugar-cane industry in those parts of the United States and foreign countries where sugar is the main product from cane.

METHODS OF PROPAGATION

Sugar cane, though belonging to the family of grasses, is not, like most of the other cultivated grasses, propagated commercially from seed but by planting cuttings made from the stalk of the old plant or the whole stalk. Both the top and the underground parts of the stalks are used for this purpose. New stalks sprout from the eyes that have developed at the nodes of the stalks, and roots push out around the old stalks immediately below the eyes at the nodes. On the underground part of the stalk (the so-called "root," properly called rootstock) these nodes and the eyes are especially close together. If these rootstocks of cane are not dug up, the small feeding roots connected with them die, but the rootstocks themselves remain alive and may send forth sprouts, called ratoons, from their eyes the following season; they thus develop a new root system and produce another crop of cane, a so-called stubble or ratoon crop. However, as many of these rootstocks do not survive, because of diseases or decay, mutilation at harvesting, freezing during the winter, or other causes, or because the soil is not in a favorable condition, the ratoon crop is rarely as good as the first or plant-cane crop. The second stubble or ratoon crop, if the stubble is left to grow another year, is usually still smaller. It is rare that more than three crops—the plant-cane crop and two ratoon or stubble crops—are taken from one planting, and usually it is not profitable to take more than two crops before replanting.

In the climate of the Southern States sugar cane rarely goes to seed, for 14 to 18 months of growing weather are required to mature seed (fig. 1). The seeds are very small, and many of them are either infertile or germinate very poorly. For these reasons and because seedling canes are usually of a quality very inferior to the cultivated varieties it is not practicable to propagate sugar cane commercially from seed.

Sugar cane is not sorghum.—Confusion in names exists through a loose use of the term "cane" or even the term "sugar cane" to designate the sorgos used in making sirup. Some sorgo-seed and sorgo-sirup producers give their crops names suggesting sugar cane. Thus a sorgo variety is sometimes advertised as "seeded Ribbon cane," the Louisiana Ribbon cane being one of the best-known varieties of sugar cane, and so named because of the striped color of the stalk. Another sorgo variety is listed in some seed catalogues as "Japanese honey cane." There is a Japanese cane which, like ordinary sugar cane, does not produce seed in the climate of our Southern States but is used to some extent for sirup production, yielding a product practically the same as that from the ordinary cane.

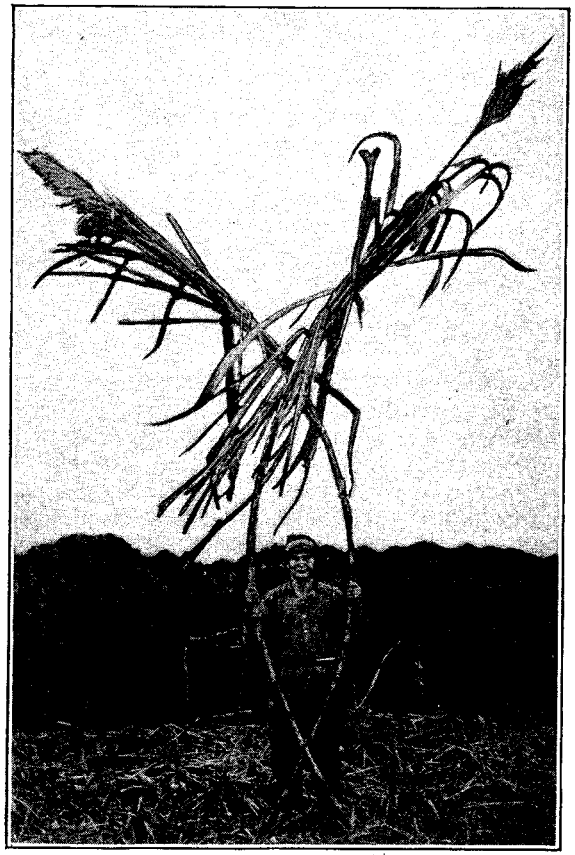

FIG. 1.—Sugar cane gone to seed. The seed rarely matures in the United States. It is of no value for field planting when it does, as seedling canes usually are inferior to the cultivated varieties

The use of such confusing terms as names for sorgo varieties should be discontinued, and those varieties which are ordinarily propagated from seed should be called sorgos and not sugar cane or cane. Only the cane propagated by stalk planting should be called sugar cane. The term Ribbon cane should not be applied indiscriminately to all varieties of sugar cane, but should be limited to the striped variety.

VARIETIES OF SUGAR CANE

For sirup making in the Southern States, sugar cane 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) ratooning well, i. e., coming up freely from the stubble after the first year; (9) erect habits of growth, not readily lodging in storms; and (10) softness of stalk, making grinding easy, a property which unfortunately is usually accompanied by a lack of resistance to disease.

In general, these are the qualities desired by the sugar planter also, except that the sugar manufacturer desires in the solids of the juice a high proportion of ordinary sugar (sucrose), while the sirup maker prefers a considerable percentage of solids not sucrose, provided they do not injure the flavor, for with such a mixture he can cook his sirup thicker without its granulating or crystallizing upon standing after cooling.

POPULAR OLD VARIETIES

A purplish red variety, the Louisiana Purple cane (also called Home Purple or Red) and a purple-and-green striped variety, the Louisiana Ribbon cane (also called Ribbon, Red Ribbon, Louisiana Striped, or Home Striped), have hitherto been the most popular varieties in the principal sirup sections of this country. In southern Georgia and northern Florida the Louisiana Purple (Red) cane is planted more than any other. In central and southern Florida the Louisiana Ribbon cane finds more favor.

Two other varieties whose growth in this country is of long standing are a green variety, generally called simply Green or Home Green cane, and a yellow-and-green variety, the Green Ribbon or Simpson cane. Both are soft, therefore much liked for chewing, being planted in small patches for that purpose. In early maturity, in disease resistance, and in yield where cane diseases prevail they are decidedly inferior to the Louisiana Purple and the Louisiana Ribbon canes. They ratoon poorly, resulting in very poor stands in stubble crops. A further disadvantage of the Green and the Green Ribbon varieties is the presence of stiff prickles that develop under the base of the leaves and on the leaf sheaths, which are very annoying to persons handling the unstripped cane with bare hands.

JAPANESE

A representative of the Chinese group of cane varieties long known in this country as Japanese cane is very slender, hard, and green colored, hardy and prolific, and stools abundantly, thus giving a good stand even with thin planting. Poor soil conditions do not affect it so seriously as the large varieties. It ratoons especially well, and for that reason can be continued on the same ground for more years without replanting. It is extensively grown as a forage crop, but to some extent it is also used for sirup making.

Its disadvantages as a sirup cane are threefold: (1) The small size of the stalks and the firm adherence of the leaf sheaths to the stalks, increasing greatly the expense of stripping; (2) the hard, fibrous character of the stalks, increasing the expense of milling by requiring a stronger mill and more power; (3) the low percentage yield of juice and of sugar and total solids in the juice, resulting in a small yield of sirup per ton of cane.

The low cost of Japanese cane for planting, its disease resistance, its good ratooning qualities, and its large yields of stalks are ad-

vantages which on ordinary soils very nearly compensate for the disadvantages of this variety, and on light soils they may more than compensate for them.

NEW SEEDLING VARIETIES

In recent years many agricultural experiment stations in this and other countries have been engaged in the production and testing of seedlings from sugar cane. The seedlings are usually very inferior to the parent plants, but by testing large numbers these experimenters have now and then found one that actually possesses superior qualities. Usually numbers are assigned to these seedlings by their originators, and to this number is prefixed an initial denoting the country or place where the station is located.

Thus, the variety D–74 was originated in Demerara, in South America, from seed. While this variety never found much favor in tropical countries like Demerara, it proved to be very well adapted to the conditions in Louisiana, where it was introduced in 1873. On sugar plantations it now has displaced largely the old varieties. Like the Louisiana Purple and Louisiana Ribbon canes, it matures sufficiently early for that climate, and on rich land it yields more

FIG. 2.—Two varieties of sugar cane of equal growth, after a severe storm. At the left is a seedling variety, the D–74, and at the right the Louisiana Purple, an old variety. The D–74 has more rigid stalks, stands up better, and yields a heavier weight of cane, having more juice, which also is richer in sugar

cane, the cane yields a higher percentage of juice, and the juice is richer in sugar. Another important advantage is that the stalks are more rigid, withstanding ordinary storms without lodging, thus lessening the expense of harvesting (fig. 2). Being a green-colored cane, it yields a sirup of lighter color than that from the Louisiana Purple and the Louisiana Ribbon canes. It seems less well adapted for light soils, and probably for that reason it has not found much favor in the sirup sections east of Louisiana. The D–74 cane grows very erect, with leaves more nearly upright than those of the old home varieties, a characteristic by which the plants are distinguished readily in the field.

Another seedling variety introduced into Louisiana at the same time is the D–95. This is a purple-red cane, strongly resembling in color and habits of growth the Louisiana Purple cane. It is also a fairly good yielder on rich soil, but it has not been adopted so extensively as the D–74.

NEW VARIETIES OF THE SLENDER HARDY (CHINESE) TYPE

In recent years several varieties of sugar cane of the slender, fibrous, hardy (Chinese) type, somewhat larger than the old small

Japanese cane but otherwise resembling it, have been imported and planted at Cairo, Ga., by the United States Department of Agriculture. Among these are the Cayana from Brazil, originally called Cayana–10 to distinguish it from other Cayana varieties that have since been discarded; Uba from Natal; Kavangire from Argentina; Yontanzan, Tekcha, and several others from Japan; and Khera from India. Of these the Cayana seems the most promising and has been given wide distribution. It is now the principal variety grown in the vicinity of Cairo, having especially come into favor since the mosaic disease, to which it is immune, became prevalent in the old varieties. It possesses all the other good qualities of the Japanese cane, that is, good stooling, prolific growth, large yields, good ratooning for stubble crops, and green-colored stalks which yield a light-colored sirup. It also has most of the disadvantages of the Japanese cane, but not in such a high degree. Besides being larger in size the leaves on the mature cane strip off more easily, it is not so hard to grind, and the juice is decidedly richer, equal in this respect to the Louisiana Purple or the Louisiana Ribbon cane. For sugar manufacture the Cayana, along with the other varieties of the types above mentioned, has the additional disadvantage of a somewhat low sucrose content and low purity of sucrose in the juice, occasioning difficulties in crystallizing the sucrose. This, however, is an advantage for sirup making.

SELECTION OF SUGAR-CANE LAND

Sugar cane requires eight months or more of warm growing weather with plenty of moisture to mature. It can, therefore, be grown only in the warmer parts of the United States, including the extreme southern portion of South Carolina, all of Florida, the southern third of the States of Georgia, Alabama, and Mississippi, the southern half of Louisiana, and the low Coastal Plains of Texas. Apparently the lower lying valleys of southwestern Arizona and southern California are adapted to the culture of cane under irrigation, though the crop has not been tested extensively in these regions.

The total areas of sugar-cane growth, total cane produced, and total gallons of sirup made in the several States in 1919, according to the reports of the Fourteenth Census, were as shown in Table 1.

The major portion of the crop in Louisiana was manufactured into sugar. In the other States practically all the cane not reserved for planting was made into sirup, the amount reserved ranging from 5 to 25 per cent of the total acreage.

TABLE 1.—*Cane grown and sirup produced therefrom in the United States in 1919*

Geographic area	Acres	Cane grown (tons)	Sirup produced (gallons)
United States	[1] 372,938	[1] 3,544,679	21,240,960
Georgia	41,558	365,603	7,052,984
Florida	20,413	179,573	3,675,249
Alabama	25,302	208,342	3,235,231
Mississippi	25,256	186,283	3,015,956
Louisiana	[1] 234,049	[1] 2,435,683	1,899,423
Texas	18,407	124,493	1,631,459
South Carolina	5,537	34,947	563,953
Arkansas	2,406	9,695	165,947
Arizona	10	60	758

[1] These figures include also the cane grown in Louisiana for manufacture into sugar.

The crop makes heavy demands upon the soil for moisture and plant food, and for that reason only the best of the soils in the localities mentioned can be used successfully for sugar cane—those that retain moisture and plant food well and admit of thorough cultivation.

LIGHT SANDS AND HEAVY CLAYS NOT DESIRABLE

On light sandy lands the expense of keeping up the fertility is prohibitive, and the crops suffer quickly and seriously from drought. On the other hand, heavy clay lands do not dry out and warm up early enough in the spring, and they can not be kept in such good tilth as the cane crop requires.

The prospective cane planter in the eastern Gulf States where sand predominates in the soils, therefore, 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 produce good crops. In these regions 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 humus, which occur so extensively near the southern Atlantic and eastern Gulf coasts, must be avoided. Frequently such land produces fairly good crops for a few years, while it is new and contains an abundance of humus. These soils can also, of course, at any time be made to produce big crops of sugar cane by suitable treatment, but this can not be done continuously without involving too much expense to make it profitable.

On the other hand, where clay predominates in the soil, as in the alluvial bottoms along the lower Mississippi River, the cane planter seeks the lands with a relatively high content of silts and sand. These are usually found immediately adjacent to the river and the various bayous. The clay lands of the swamps lying farther back from these streams are generally too stiff to secure good tilth and to warm up as early in the spring as is required by the sugar cane. The conditions are vastly better if this clay has considerable vegetable mold or humus in it.

HUMUS AND DRAINAGE ESSENTIAL

The muck soils, provided they have a high mineral content and are well drained, will produce big yields of cane and under favorable seasonal conditions may have satisfactory sugar content. It is doubtful whether peat land or muck land that is very low in mineral content can be used successfully for sugar-cane production even if drained. A disadvantage with any muck land is that it affords such poor anchorage for the roots that the cane lodges easily, and this gives a tangled mat of stalks instead of erect rows. In Georgia it is commonly reported that the 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 the sirup made therefrom. The farmers there, in consideration of the quality of the sirup, prefer the lighter colored loamy upland soils, suitably enriched with commercial manures, especially cottonseed meal.

In the 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. A depth to ground water greater than 3 feet should be obtained if possible.

MANURIAL REQUIREMENTS

COMMERCIAL FERTILIZERS

The use of commercial fertilizers in sugar-cane growing is almost universal in the United States and other cane-growing countries, but local practices differ widely as to the particular fertilizer elements required 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 sugar-cane localities respond well to the application of phosphoric acid, but the quantity to be applied most advantageously varies considerably. From 40 to 80 pounds per acre of soluble phosphoric acid are applied usually in Louisiana. To the lighter soils of Georgia and Florida it is not unusual to add considerably more, even up to 120 pounds per acre.

Applications of potash give little or no response in most of the rich alluvial sugar-cane 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.

In these States it is a common practice to buy the fertilizers ready mixed, though many farmers do their own mixing in the interests of economy. In the trade the mixed fertilizers are commonly described by three figures, referring in their order to the percentages of available prosphoric acid, ammonia, and potash which they contain.

The mixtures most popular in southern Georgia and northern Florida for spring and early-summer applications usually do not vary far from the 8–2–3 formula—i. e., 8 per cent of soluble phosphoric acid, 1.65 per cent of nitrogen (equivalent to 2 per cent of ammonia), and 3 per cent of potash. This is supplied in one or two applications in quantities totaling 800 to 1,600 pounds per acre, often followed in late summer with a top-dressing of readily available nitrogen, such as nitrate of soda. These quantities are here mentioned as an example of common practice in one locality and not as a guide or recommendation for any wide range of soils or localities. The popular source of nitrogen in the past has largely been cottonseed meal, or even cottonseed, tankage, dried blood, fish scrap, etc., and small quantities of nitrate of soda. Because of the favorable influence of cottonseed meal on the quality of the sirup, it especially is a favorite among the sirup producers. It seems wasteful, however, to use for fertilizer products having such high food value. With the rapid advance in the prices of most of

these organic-nitrogen fertilizers and with the increasing availability of artificial ammoniates, due to improvements in nitrogen-fixation methods and the development of hydroelectric power, it is probable that these artificial nitrogen compounds, especially ammonium sulphate, will largely displace the organic ammoniates in the fertilizer mixtures. Phosphoric acid is almost universally applied as acid phosphate. Formerly the potash was largely in the form of crude products, such as kainit, but with the higher transportation charges now prevailing the more concentrated forms are more economical; namely, the muriate or the sulphate of potash. With the neutral potassium phosphate now becoming more available, this concentrated form for these two plant-food constituents deserves careful trial. Using these and other concentrated artificial fertilizer materials it is possible to prepare more concentrated mixtures than the 8–2–3 formula above mentioned (for example, a 10–4–6 formula) and thus reduce the quantity required per acre and the labor of applying it.

It can not be too strongly urged that the farmer, in the absence of trustworthy and conclusive experience with his particular type of soil, should not blindly follow any special fertilizer formulas that may have been found suitable for some other type of soil, but rather that he should experiment on his own farm on small plats with several of the combinations that he has reason to suppose will most probably fit his needs.

GREEN MANURES

Natural manures, such as green crops plowed under and barnyard manure, are highly beneficial in increasing the yield of cane, much more so than the plant-food elements therein contained would indicate. Practically all soils in the sugar-cane localities, both the heavy soils, like those in Louisiana, and the lighter ones of the States farther east, are very responsive to increases in the humus content.

The farmer should, therefore, plow under vegetable matter whenever it is possible without interfering too seriously with cultivation. The tops and leaves from the cane at harvesting were in the past usually burned to make the field cleaner for the cultivation of the stubble crop of cane the next season, and in the hope of thereby destroying insect pests.

Since the entomologists of the United States Department of Agriculture have collected evidence which tends to show that the damage from insect pests is not reduced by burning the trash, many planters have adopted the plan of working it into the soil.

It is the common experience of cane-sirup makers that applications of barnyard manure, especially of horse-stable 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 such applications to the cane crop sparingly where the cane is to be used for sirup production. In such cases it is good practice, if such manures are available, to make heavy applications to the crop preceding the sugar cane in the rotation.

APPLICATION OF FERTILIZERS

In spring planting it is customary to scatter in the furrows in which the cane is to be dropped a rather liberal application of mixed

fertilizer. Some implement is run through the furrow to mix this fertilizer with the soil. For cane planted in the fall or early winter, the fertilizer is used very sparingly, if at all, at the time of planting, but most of it is applied in the spring when the crop starts to grow.

In case of either spring or fall planting, another application is 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. Many farmers favor giving a top-dressing of readily available nitrogen, e. g., nitrate of soda, at the time of laying by the crop, July 15 to August 1.

Many who apply barnyard manure also 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.

FIG. 3.—The sugar-cane rows are wide spaced and potatoes are planted between. The potatoes receive additional applications of fertilizer and are ready to harvest by the time the cane shades the ground

CROP ROTATION

The fertilizer requirements depend very largely upon the crop preceding the cane. A very good practice is to precede the cane during one or two years with crops that include legumes, e. g., cowpeas, velvetbeans, or soybeans.

Owing to the demonstrated serious damage to the corn crop by the widespread sugar-cane mosaic[1] and also because the corn crop affords a favorite breeding place for the cane moth borer, it is questionable whether corn is a suitable crop to rotate with cane.

In the principal sirup-producing localities, unlike the sugar plantations, the farmer can usually select for his cane patch a location that had a specially favorable treatment. Thus, for small

[1] Brandes, E. W. Mosaic disease of corn. *In* Jour. Agr. Research, vol. 19, pp. 517–522, illus. 1920.
——— and Klaphaak, P. J. Cultivated and wild hosts of sugar-cane or grass mosaic. *In* Jour. Agr. Research, vol. 24, pp. 247–262, illus. 1923.

patches a favorite practice is to shift the cowpen area from year to year and plow up the old area to plant in sugar cane. Very good results are obtained by manuring very heavily a field to put into sweet potatoes, then in the succeeding year planting it in cane. To obtain the requisite manure the cane bagasse (also called pomace or mash) is put in liberal quantities as litter into the stables or corrals, and then, after it has had about a year to rot, it is applied to the sweet-potato ground.

In some localities it is found advantageous to give the cane rows relatively wide spacing and to plant in the middles a quick-maturing crop like potatoes, giving this crop a moderate additional application of fertilizer (fig. 3). In recent years in Louisiana sour clover has proved very beneficial as a winter green-manure crop. In the fall it is sown on cane-stubble land, on fall-planted land, or on land to be planted in the spring, and it is then turned under in the spring.

PREPARATION OF THE LAND

With regard to preparing the land, not much need be said that might not be said with equal propriety with reference to other crops. It is desirable to plow considerably in advance of the planting time, especially for spring planting, and then to cultivate well before planting. Grown on a clay soil with compact subsoil, cane is especially responsive to deep plowing, bringing into effective tilth a considerable depth of soil and opening 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. This deep cultivation is especially advantageous during seasons with periods of drought.

Where the subsoil is very sandy, lacking humus, deep plowing may be disadvantageous. With a clay subsoil which always has been plowed shallow, it is not advisable to turn up more than an inch of the subsoil at one plowing. It is better to attain the desired greater depth of plowing gradually through a series of years, giving opportunity meanwhile for the inert subsoil that is turned up to become converted into a productive loam through mixture with surface soil and vegetable mold.

PLANTING

On well-drained land in Louisiana and in parts of Florida it is deemed desirable to plant the cane in the fall, as late as is safe and yet avoid frosts. However, for economic reasons, the fall planting is done somewhat earlier, because after the harvesting for the mill commences the available labor and teams are fully occupied at that work. The fall planting therefore usually stops in the latter part of October, and planting unfinished at that time is left to be done in the spring as soon as the soil is in suitable condition to work and the weather is such as to occasion no fear of freezing the cane. In Louisiana this is usually in February or early March. Occasionally there is suitable planting weather in January.

In Georgia and northern Florida the planting is almost always done in the spring. The impression prevails that fall planting leads to an imperfect stand through the spoilage of cane during the winter. In the spring the cane may be selected so as to avoid using

the spoiled stalks or portions of stalks (fig. 4). The availability of labor at this time also favors spring planting.

In parts of southern Florida where frosts are rare it is the practice to plant at any convenient time in late fall or in winter. An advantage in fall or winter planting is that the cane gets an earlier start in the spring, resulting in more mature and therefore richer cane at the time of harvesting and a slightly larger yield.

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.

FIG. 4.—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 are thrown out

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. 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 (fig. 5).

FURROWING

After determining the right course for the rows, with suitable provision for securing the right spacing between them, the furrows are

opened deep with a 2-horse middle breaker or other plow. In flat, poorly drained land, like that in southern Louisiana, the furrows are opened shallower than on well-drained land. In the irrigated sections of Texas and Arizona the planting is extra deep, to permit the crop to be irrigated through the furrows.

The commercial fertilizer that is to be applied at the time of planting, and sometimes also the barnyard manure, is distributed in the furrows and mixed with the soil by again driving through with a suitable implement. The cane is then distributed (fig. 6) and covered to a depth of 1 or 2 inches in the case of spring planting, or about 4 to 6 inches in fall planting, by throwing light furrows on from both sides. In the latter case the covering is again raked off in the spring, leaving only 1 or 2 inches over the cane.

Frequently the cane in the windrows or banks is more or less damaged by red-rot or some other disease. Practice varies with reference to cutting away the diseased parts before planting. On the basis of ordinary field sanitation, it seems advisable to trim off

FIG. 5.—On a hillside the rows must run with the slope. They are laid out with a farm level and leveling pole, and the furrows are made with a plow

the diseased parts and to plant only sound stalks. However, until it is determined whether the diseases in question are transmitted to any great extent through the plant material, there is some doubt as to the advantage of trimming.

QUANTITY TO PLANT

The rate of planting in the row varies with the time of planting, the width of row, and the size and soundness of the cane. Ordinarily, with rows 4½ feet apart in Georgia and Florida, in spring planting the aim is to get as much as one continuous line of sound cane. If the cane is partly diseased, it is lapped or doubled to make the line of sound cane complete. With good sound cane, less than a complete line, as low as two-thirds or three-fourths of a complete line will ordinarily give a satisfactory stand in 4½-foot rows. In Louisiana, with 5½ to 6 foot rows and with the cane usually damaged both by diseases and by borers in the stalks, the practice in fall planting is to put into the furrow about two lines (fig. 7) or "two lines and a lap," and in spring planting somewhat more, even up to three or four lines if the cane is in bad condition.

In tropical countries, where the new growing season follows immediately upon the harvesting and planting time and the cane consequently need not lie dormant in the furrow or in storage through the winter, subjected to disease, it is common practice to plant only the tops of the stalks, which are less valuable for sugar manufacture, yet are quicker to start growth than the older, more mature parts of the stalks. It is still an open question whether some system similar to this can be used to advantage in our own sugar-cane localities.

FIG. 6.—Planting sugar cane in Georgia. The cane has been stripped and cut into 2 or 3 foot lengths. These are generally dropped so as to form a continuous line of sound cane

About 3 to 4 tons of cane are usually stated as the requirement to plant an acre in Louisiana, where the whole stalks without rootstocks are used.

In the States farther east, with a smaller acreage, it is customary to quote plant cane in actual numbers of stalks, with some definite length stated or implied as the average length, and upon the basis of such counts commercial transactions with seed cane are made. Prices are then quoted per 1,000 stalks.

To plant an acre in 4½-foot rows, with a single complete line of stalks, 9,680 linear feet of plant material are required, or 2,420 stalks averaging 4 feet in length; and this may be taken as an average quantity of moderately good cane. Such stalks, including the rootstocks, may be expected to weigh about 3 pounds each; hence, the weight of plant cane required is 7,260 pounds, or 3⅔ tons. Stalks without rootstocks of this quantity of cane if harvested for the mill

would weigh about 3 tons. Thus, at best, the seed-cane requirement in the sugar-cane industry is a very heavy drain upon the net proceeds from the crop.

With the slender hardy variety of the Chinese type, such as the Cayana, the Uba, and various Japanese varieties, this drain is far less (1) because these varieties ratoon well, giving good yields for three to six years from one planting, and (2) because the stalks are so slender and stool out so well that a single ton will plant from three-fourths to 1 acre.

CULTIVATING THE CROP

If in the spring, before the newly planted cane is up or while it is still small, the ground becomes crusted over badly or weeds tend to get a start, it is advisable 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 diagonal to the rows.

FIG. 7.—Planting sugar cane in Louisiana. Because of the tendency to damage by disease and borers, more cane is planted, two or three, and sometimes even four, lines of entire canes in a furrow

After the cane is up and during its early growth, it is usually necessary to give it from one to three 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, with the end in view of killing the weeds and keeping the ground in good tilth. The early cultivations, 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.

The suckering of the cane can be controlled to some extent by the cultivation. Throwing the soil toward the plants tends to restrain suckering. On the other hand, leaving the bases of the plants exposed favors suckering. Therefore, to get a good stand from the minimum of planted material the soil is withheld from the rows as far as feasible during the early stages of growth. Later, however,

when the season is too far advanced for new suckers to mature, it is desirable to prevent suckering, and the soil is therefore more liberally plowed against the rows.

Where the drainage is poor, as in most of the Louisiana cane belt, this ridging up of the rows is carried to an extreme, leaving deep drainage furrows between the rows to carry off the surplus rainfall quickly. In irrigated sections, on the other hand, the farmers strive to keep the cane row low as long as practicable, to enable them to run the irrigation streams through the rows, probably coming up to about flat cultivation by the end of the first year.

The only difference in the cultivation of the fall-planted cane is to bar off as early in the spring as the weather and the condition of the soil will permit and to rake off about the time growth starts. To bar off means to plow a furrow away from each side of the row, usually with a 1-mule turnplow, leaving a ridge about a foot wide at the row in which the cane lies planted under a covering of 4 to 6 inches of soil. This ridge is then raked off by hand with hoes or by cultivating crosswise with a harrow, leaving only 1 or 2 inches of soil over the cane.

THE RATOON CROP

If a stubble (ratoon) crop is to be taken, the stubbles receive some special attention. Shortly after harvesting, the trash is burned off (unless it is desired to incorporate it into the soil to increase the humus content), and the stubble row is "wrapped" by throwing a furrow toward it from each side with a 1-mule turnplow. The remainder of the space between the rows is plowed with a turnplow at the same time. In this condition it is left through the winter.

The treatment in the spring is to bar off and rake the stubble with a harrow, about as already described for fall-planted cane. Some farmers prefer to omit wrapping the stubble thus, but to let the trash lie until barring-off time in the spring and then burn it. Observations indicate that there is much in favor of this manner of protecting the stubble throughout the winter, especially if the trash is dropped mainly on the rows of stubble.

In the sirup sections of the eastern Gulf States, most of the cultivating as well as the planting operations is 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 hillsides. 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 the single-mule implements.

HARVESTING

With the coming of cool nights and moderately cool days, usually in October, the cane matures rapidly, i. e., stores up sugar in the stalk. With suitable cool weather, the cane may be in condition to commence grinding by the latter part of October. Farmers in the sirup regions with but small crops to dispose of prefer to wait until

nearly the middle of November. In southern Florida, where winter frosts are rare, they can afford to wait until December before commencing to grind.

The later in the fall or winter the cane is harvested, provided it is not damaged by frost, the bigger the yield of cane and the higher the sugar content; therefore, the better for the manufacture of either sugar or sirup. However, a slight degree of immaturity is not so objectionable for sirup making as for sugar manufacture. The immature cane, while containing less sucrose (common sugar), contains more of the reducing sugars, which lessen the tendency of sirup to granulate when boiled thick, a desirable property. It thus comes about that the sugar-cane industry for sirup making is carried on in somewhat higher latitudes, i. e., colder climates, than for sugar manufacture. If, however, the cane is too immature, the sirup

FIG. 8.—Harvesting sugar cane in Georgia. The leaves are beaten off with the back of the knife or removed with a special stripping tool. The tops are then cut off and the cane cut off at the bottom and laid in windrows or piles

can not be made sufficiently clear and light colored, and it has an objectionably strong, bitter flavor.

Harvesting (fig. 8) consists in stripping the leaves off the stalks, topping the canes, cutting them off at the bottom, dropping them in piles, loading, and hauling to the mill. The stripping, topping, and cutting of the cane are usually accomplished by hand with a cane knife, beating down or raking off the leaves with the back of the knife, then topping and cutting off at the bottom.

In most parts of the eastern Gulf States it is customary to do this in three stages, using three different tools (fig. 9): First, a special long-handled stripping tool to strip off the leaves, then a cane knife to top it, and finally a heavy hoe to cut it off at the bottom.

With Japanese cane the stripping operation is especially tedious, for the twofold reason that the stalks are slender and numerous and that the leaf sheaths adhere to the stalks very closely. This, in fact,

has made the stripping of this variety of cane and others of a similar type almost prohibitive, causing most farmers to abandon these varieties for sirup making, while others grind the cane without stripping, at much sacrifice both in yield and in quality of sirup.

The stripping of the cane becomes especially tedious with these varieties if the cane has to be windrowed unstripped so as to save it after having been severely frostbitten and until it can be ground. To strip such cane from the windrows, a device has been developed at the Sugar-Cane Experiment Farm of the United States Department of Agriculture, at Cairo, Ga. (fig. 10), consisting of a comb about 16 inches long with flat steel teeth one-sixteenth inch thick, set edgewise, about seven-eighths inch apart, projecting 3 inches. This comb is mounted on a suitable rack, and the cane, previously cut without topping and laid in windrows, is picked up by the tops, a handful at a time, and raked over this comb from top to bottom a few times, very effectively removing all the leaves and most of the leaf sheaths. In another operation the cane is then topped, also a handful at a time.[1]

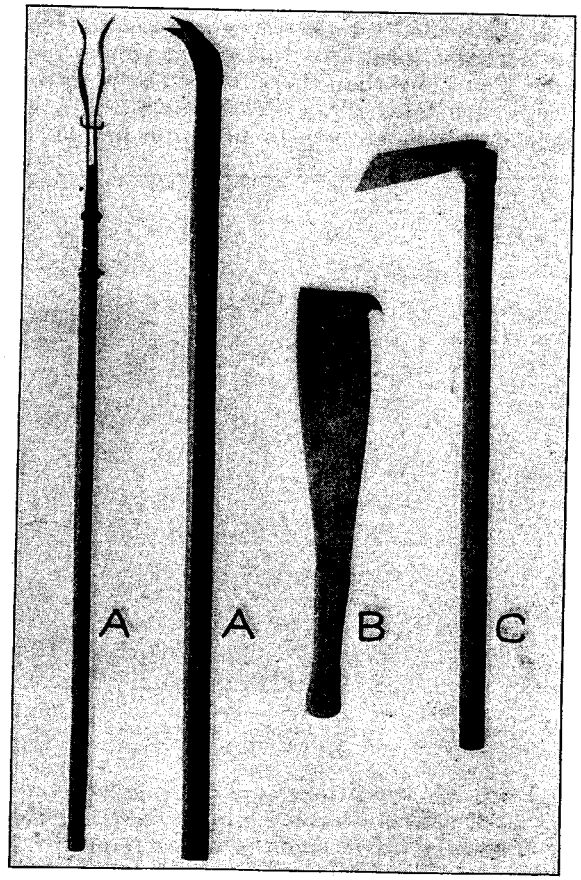

FIG. 9.—Sugar-cane harvesting tools used in Georgia and Florida. *A*, *A*, are tools used to strip the leaves from the stalks; *B* is a knife used to top the canes; *C* is a heavy hoe to cut off the canes at the bottom

YIELDS OF CANE

The yield of sugar cane and sirup is so dependent upon soil, fertilizer, climate, and weather conditions that statements as to yields must be read with much allowance. On good sugar-cane land in the principal sirup sections of southern Georgia and northern Florida, with good treatment as to fertilizer applications and cultivation and in a year with good weather conditions throughout, a yield of 20 to 25 tons per acre of cane, stripped and

[1] Yoder, P. A., and Longley, L. E. Cane-stripping comb. (U. S. Patent No. 1,322,990.) *In* U. S. Patent Office, Off. Gaz., vol. 268, pp. 661–662, illus. 1919.

topped, yielding 440 to 550 gallons of sirup may be expected reasonably. On the rich alluvial soils, like the best sugar-cane lands of the Mississippi River Delta in Louisiana, considerably higher yields are produced—30 to 35 tons per acre. This is the estimate for the plant-cane crop, i. e., the first crop from a planting.

Ratoon cane crops.—The ratoon crops are still more subject to variation. Occasionally a ratoon crop yields better than the plant-cane crop and occasionally not half so well. For an average it may be assumed that the first ratoon crop will yield about two-thirds and the second ratoon crop about one-half as much as the plant crop in the same locality. Subsequent ratoon crops yield still less. It is rare that more than three crops, the plant-cane crop and two ratoon crops, are taken from one planting, and very commonly even the second ratoon crop is found unprofitable.

FIG. 10.—Stripping Japanese cane with a cane-stripping comb. A handful of untopped cane is raked over the comb a few times and the cane is then topped. At the right a handful of cane is being stripped; at the left a handful of stripped cane is shown

With soil conditions equally as good as in the States just referred to, and with a warmer climate, so that the cane crop can be left to grow 11 or 12 months or even longer, the yields may be still higher. While yields like those mentioned may reasonably be expected under the favorable conditions set forth, the actual yields, as statistics show, are far less. Thus, the United States census report gives the average yield in 1919 at 8.8 tons per acre for both Georgia and Florida, 10.4 tons for Louisiana, and 9.5 tons for the whole United States, indicating that soil, climate, weather, fertilizing, cultivation, and management were far from ideal on most cane-producing farms.

SIRUP YIELDS

The estimates of sirup yields given above are based on well-managed farm outfits. In actual practice the mills in these farm outfits are very commonly not keyed up so close as to extract as much as 64 to 68 per cent of the weight of the cane in juice. The mills

possibly are not strong enough or the power provided (animal or engine) may not be sufficient. Very commonly only 50 to 55 per cent of extraction is accomplished where, with somewhat more power and if need be the substitution of a stronger mill, the extraction might readily be increased to 65 per cent. The sirup maker thus sacrifices 3½ to 5 gallons of sirup per ton of cane, or 70 to 125 gallons per acre. This loss is far from being offset by a reduction in the expense of providing a stronger mill and more power. It should be strongly urged, therefore, that in purchasing mills and engines the farmer select more powerful ones than are now commonly used.

Under good management of small farm outfits for sirup making, with the somewhat inefficient extraction of juice that such outfits permit even at their best, about 22 gallons of sirup may be expected from a ton of cane of a good variety and of average maturity. With the more nearly perfect extraction of juice (75 to 80 per cent of the weight of the cane) afforded by the big mills in the sugar factories, a yield of about 176 pounds of raw sugar, together with about 5.4 gallons of blackstrap molasses as a by-product, may be expected from the same ton of cane. From this it will be seen that the equivalent of 1 gallon of sirup is about 8 pounds of raw sugar and one-fourth gallon of blackstrap molasses.

STORING CANE FOR PLANTING

In localities subject to winter frosts, if the new plantings are not made in the fall, some means must be employed for storing the cane until it is time to plant it, which is usually in the spring. Two somewhat different methods of storing are in common use, windrowing and banking. Practice also varies, some preferring to dig up the cane and store it with the rootstocks left on, while others, to save labor, are content to cut the cane about even with the surface of the ground, thus sacrificing the short rootstocks, which bear a large number of eyes.

Storing cane in windrows.—Windrowing is generally practiced on the large sugar plantations, like those in Louisiana, where large quantities of cane are to be stored in a relatively short time. (Fig. 11.) The ridge method of cultivation results in deep furrows being formed in the middles between rows during the cultivation. The cane from two or three 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 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 of these banks is governed by con-

venience. Only the edges can be covered with plows, and the center strip of the bank must be covered by hand with shovels. Usually it is all covered by hand (fig. 12). About 1 to 2 inches of soil is put

FIG. 11.—Sugar cane in windrows ready for covering. The cane from two or three rows is laid in one of the deep middles formed by cultivation, the tops overlapping, and then covered with earth by a large plow to a depth of 1 or 2 inches

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

FIG. 12.—Banking sugar cane for spring planting. The layer of cane is deeper and wider than that in a windrow, and it must be covered mostly by hand

more hand labor, and it 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 kept as cool as possible in storage. 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, if conditions permit, 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 during storage by red-rot.

INSECT PESTS AND DISEASES OF CANE

On the subjects of insects and cane diseases the reader is referred to other publications.[2]

INSECTS THAT DAMAGE CANE

A considerable number of insect pests have been known to do damage to sugar cane, yet only two have become a serious menace to this crop in the South, namely, the moth borer (*Diatraea saccharalis* Fab., var. *crambidoides* Grote) and the mealybug (*Pseudococcus calceolariae* Mask.). These two insects are widely prevalent in most tropical cane countries, and both of them infest the cane fields in Louisiana. The moth borer has become established also in the Rio Grande section of Texas and in portions of the central and the eastern coast of Florida, and the mealybug has recently appeared in southern Florida and southwestern Georgia.

No very effective way to combat these pests in the growing cane in the field has yet been worked out. For localities not now infested by them an ounce of prevention is worth many pounds of cure. In such localities it is very important that all planters avoid getting their seed cane from an infested area. This may work a hardship, especially on those who desire to accomplish quickly a great increase in their cane acreage, yet these same individuals should be most interested in keeping their neighborhood free from the pests. Fortunately, through a Federal law a quarantine is now established against the importation of seed cane from foreign countries, but for interstate or intrastate shipments the Federal law offers no efficient protection. Fortunately, a method has been worked out for freeing seed cane from both of these insect pests. It consists in heating the cane 20 minutes in water carefully kept at 50° C. (122° F.). The eyes in the dormant state are not killed by this treatment, but are actually stimulated to more rapid growth if planted immediately, the season and weather conditions permitting. If, however, the eyes have already sprouted, as is often the case when the cane is taken

[2] Barber, E. R. The sugar-cane mealybug and its control in Louisiana. Louisiana Agr. Exp. Sta. Bul. 185, 16 pp., illus. 1923.
Field, E. C. Fungous diseases liable to be disseminated in shipments of sugar cane. *In* U. S. Dept. Agr., Bur. Plant Indus. Circ. 126, pp. 3–13, illus. 1913.
Holloway, T. E. Insects liable to dissemination in shipments of sugar cane. U. S. Dept. Agr., Bur. Ent. Circ. 165, 8 pp. 1912.
——— and Loftin, U. C. The sugar-cane moth borer. U. S. Dept. Agr. Bul. 746, 74 pp., illus. 1919.
Yoder, P. A. Sugar-cane culture for sirup production in the United States. *In* U. S. Dept. Agr. Bul. 486, pp. 31–33. 1917.
——— and Ingram, J. W. Hot-water treatment of sugar cane for insect pests.—A precaution. U. S. Dept. Agr. Circ. 303, 4 pp. 1923.

out of the banks or windrows late in the spring to plant, most of the sprouted eyes are killed by this treatment. In that case less damage is done by treating the cane only 10 minutes at 50° C. (122° F.), this being preceded by a 20-minute preheating at 45° C. (113° F.).[3]

Termites, also called wood lice, do some damage to cane by boring up through the stalks, usually all stalks in a bunch, causing a hardening of the pith. They are most likely to be present where there is much coarse vegetable matter in the soil, as in new-land fields. They enter the growing stalks from the planted cane, causing hollows, which become surrounded with hardened tissue. If termites get started in a planted stalk, they usually enter all the young stalks sprouting from it. For this reason it is recommended in fields where they give trouble, to cut the stalks for planting into short lengths, 12 to 18 inches, and drop these pieces in the furrows somewhat diagonally or in such a way that the ends do not touch.

DISEASES OF CANE

Red-rot of cane.—Of sugar-cane diseases, one bringing about great damage in the United States is the red-rot, caused by a fungus (*Colletotrichum falcatum*). This disease is distributed throughout most of the regions where cane is grown extensively. The most serious damage from it has been reported from Louisiana and from the parts of southern Georgia and northern Florida where large areas are devoted to sugar cane. It does not damage seriously the growing cane or affect its sugar content, but it has caused great losses in the banks or windrows while cane is in storage for spring planting. In recent years on some farms it has frequently caused losses ranging from 25 to 75 per cent of the cane put away. Some precautions against damage by this disease have already been considered under "Planting" (p. 10) and under "Storing cane for planting" (p. 19).

Root-rot of cane.—Root-rot (*Marasmius plicatus*) is responsible in some localities for reduction in yields and some dying out of stubbles, resulting in a poor stand. In the growing cane that is diseased, it is recognized in the earlier stages and in wet weather as a slimy growth between the stalk and the leaf sheaths near the ground and later by a whitish mold that cements the lower leaf sheaths to the stalks. In putting away seed cane, such stalks, or at least the affected lower ends of them, should be rejected. Some recent investigations of very serious root troubles in sugar cane have revealed the fact that a species of parasitic snail (*Zonitoides arboreus* Say) is probably the primary cause of or at least a major predisposing and contributing factor in the dying of the cane from root troubles and of the frequent and almost complete failures of ratoon crops in Louisiana.[4]

Mosaic disease of sugar cane.—The mosaic is also known in Porto Rico as the mottling disease and in Java and Hawaii as the yellow-stripe disease. It had been observed for years in some of the tropical cane countries and in the summer of 1919 was discovered by employees of the United States Department of Agriculture to have gained a foothold also in several places in the United States. At the time of the discovery of its occurrence here it had already spread widely in Louisiana and had a start in a few very limited areas in the eastern Gulf States, notably at Cairo, Ga., and in at least a dozen localities in Florida. These centers of infection in Georgia and Florida were then relatively small. Prompt and drastic measures taken by the Florida State Plant Board have apparently eradicated this disease at these centers of infection in the peninsular section of Florida, and so far as known the disease does not now occur in that section of the State. Since its discovery, however, it has spread over most of the sugar-cane sections of Louisiana, Mississippi, Alabama, southwestern Georgia, and northwestern Florida.

The most prominent symptoms of the disease are a paleness of the leaves, usually noticeable from a considerable distance, and a general stunting in the growth of the affected plants. When the leaves are examined more closely it is noted that the pale color is not uniformly distributed but is in small oblong spots or irregular broken short streaks of pale green on the normal green background. In extreme cases the pale-green areas may predominate. Various other causes may produce a paleness of the leaves, but after an observer has once carefully examined the leaves of a real case of the mosaic disease these other forms of paleness are not readily confused with it, because of the peculiar, irregular, finely spotted, and streaked distribution of the pale areas which are characteristic of the mosaic disease. Some well-known fungi, notably *Helminthosporium sacchari*, often cause pale spots on cane leaves, but these spots very early develop a brown or black center of dead leaf tissue, and both the pale-green spot and its brown center spread in size in irregular elongated form, finally coalescing with other spots and in severe infestation with this fungus killing the older leaves. In cane infested with *Helminthosporium sacchari*, the most recently unfolded new green leaves are free from the spots, while in cases of the mosaic disease the newest leaves have the mottled appearance as prominent as any. In case of doubt the observer should therefore examine the newest, freshly unfolded leaves at the tip of the cane plant. Uninfected cane leaves often have the leaves streaked with narrow stripes of pale green running uniformly throughout the length of the leaves, parallel to the veins of the leaf, from base to tip. This phenomenon can also be readily distinguished from the irregular broken streaks of the mosaic disease.

The mosaic disease is transmitted naturally by an insect carrier, the corn aphid, from diseased cane or other grasses to healthy cane. It may also be transmitted by artificial inoculations, thus indicating an infecting organism as its cause, but thus far no specific organism has been isolated or identified with certainty. It is also spread by man in moving diseased seed cane to uninfected areas in planting.

No treatment of the cane or the soil is known that will cure a plant affected by mosaic or prevent the spread of the disease. The measures for its control and eradication are therefore based on the destruction of the diseased plants, including the stubble, and the planting of healthy stalks only. Evidently, since the disease has natural means of spreading, its complete eradication from an infected locality can only be attained by the united action of all the

[3] Brandes, E. W., and Klaphaak, P. J. Growth stimulation and pest and disease control by hot-water treatment of sugar cane "seed." *In* Louisiana Planter, vol. 71, pp. 371–372, 392–394, 412, illus. 1923.
Yoder, P. A. Hot-water treatment of dormant and sprouted seed cane. U. S. Dept. Agr. Circ. 337, 4 pp. 1925.

[4] Rands, R. D. Snails as predisposing agents of sugar cane "root disease" in Louisiana. *In* Jour. Agr. Research, vol. 28, pp. 969–970. 1924.

cane growers in that locality. Such united action as a rule can not be secured except through compulsory measures.

A more hopeful means of counteracting losses by the mosaic disease in localities where it has become widespread is to adopt immune or tolerant varieties of cane. Fortunately a few immune varieties well suited for sirup making are already obtainable. None of these, however, are very well suited for sugar manufacture, since they do not mature well in the short seasons of our Gulf States, and consequently the common sugar in the juice is accompanied by a relatively high percentage of the so-called "reducing sugars," which hinder crystallization. Fortunately also, some varieties have already been introduced from foreign countries by the United States Department of Agriculture, which, while not immune, are highly tolerant, yielding well in the countries of their origin in spite of having the disease. Such are certain Java seedlings recently imported, and tests are now in progress to ascertain how well they are suited to our climate for either sirup or sugar manufacture. Of these the P. O. J. 234 has been most fully tried, and it appears exceedingly promising.

Several distinct groups of cane varieties contain one or more varieties immune to mosaic. All the immune varieties thus far grown commercially here are of the Chinese type, with slender, tough, fibrous stalks, slender deep-green leaves, and prolific stooling and good ratooning qualities. Of these the Cayana, imported from Brazil, has been widely adopted in southwestern Georgia for a sirup-making cane. The Uba, imported from South Africa, is very similar to the Cayana, if not identical with it. A number of Japanese varieties of the Chinese type have also been introduced and were at one time thought to be immune to the mosaic disease. In one of these, however, a few plants were observed by the writer in the summer of 1919 to exhibit the mottling of the leaves characteristic of the disease. Since then similar isolated cases in other Japanese varieties have been reported by other observers.

Several immune varieties belonging to different groups of cane have been found among foreign varieties, and recently additional ones of promise have been developed in the sugar-cane breeding work of the Department of Agriculture now in progress. Most of the latter are hybrids resulting from crosses between varieties of the thick-stemmed group (*Saccharum officinarum*) and the wild cane of the Orient (*S. spontaneum*). For more detailed information on mosaic the reader is referred to Department Bulletin 829, "The Mosaic Disease of Sugar Cane and Other Grasses," and to articles in the Journal of Agricultural Research by E. W. Brandes.[5]

Nematode injury to cane.—Recently in sections having light sandy soils, very serious losses have been occasioned by an organism not generally recognized as a dangerous pest of sugar cane, namely, a nematode (*Heterodera radicicola*) causing root-knot. The cane becomes stunted in its growth, and on examination the roots are found to be largely of short lengths, ending with small elongated bulbs about one-sixteenth to one-eighth of an inch in diameter. No very effective means of ridding the land of this organism at a nonprohibitive expense are known, but measures of field sanitation should be practiced; especially the danger of carrying soil from affected to unaffected areas on the plant cane, on farm implements, on the hoofs of work animals, and on the shoes of laborers should be avoided. Rotation with crops that do not support this particular organism or a clean fallow for a year or more may lessen the infestation.

A number of other dangerous diseases and insect pests of sugar cane have appeared in many foreign countries, so that it is unwise to import cane except through approved quarantine stations.

[5] Brandes, E. W. The mosaic disease of sugar cane and other grasses. U. S. Dept. Agr. Bul. 829, 26 pp., illus. 1919.
——— Artificial and insect transmission of sugar-cane mosaic. *In* Jour. Agr. Research, vol. 19, pp. 131–138. 1920.
——— Mosaic disease of corn. *In* Jour. Agr. Research, vol. 19, pp. 517–522, illus. 1920.
——— Mechanics of inoculation with sugar-cane mosaic by insect vectors. *In* Jour. Agr. Research, vol. 23, pp. 279–284, illus. 1923.
——— and Klaphaak, P. J. Cultivated and wild hosts of sugar-cane or grass mosaic. *In* Jour. Agr. Research, vol. 24, pp. 247–262, illus. 1923.

FIG. 13.—A sirup-making outfit for a farm producing 5 to 15 acres of cane. This has a capacity of about 200 gallons of sirup a day. The mill is operated by a 6-horsepower gasoline engine. The evaporator uses wood for fuel. The cost of the outfit at pre-war prices was about $600

EQUIPMENT REQUIRED

Since the sugar-cane crop makes high demands upon the land, as indicated under "Selection of sugar-cane land," the land required in the cane-growing industry must necessarily be the most valuable which the sirup-producing sections afford, in so far as quality of land determines the value.

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

The types of sirup-making outfits in use on the farms and their costs vary greatly. An outfit (fig. 13) now very commonly installed on small farms producing 5 to 15 acres of cane and having a capacity of about 200 gallons for a day of 12 hours, cost in 1914, before the World War, about $600, divided as follows:

Mill with three rollers, each 1 foot long	$125
Gasoline or kerosene engine of about 6 horsepower	250
Evaporator, galvanized iron, 15 feet long and about 42 inches wide, with baffle plates and skimming troughs	20
Bricks (about 2,500) and lime (3 barrels) for building the hearth furnace for the evaporator, together with belt, juice receptacle, juice pipes and valves, and sirup receptacle	100
Material and labor for shelter and labor for building the furnace	105
Total	600

The cost of such an outfit, in October, 1924, was about one-half more than that specified.

For a smaller area of cane, 1 to 4 acres, the farmer will probably be content with a horsepower mill and round-bottom kettle outfit having a capacity of about 60 gallons for a day of 12 hours, costing, in 1914, altogether hardly more than $125. For a production of 15 to 100 acres it is usual to have some form of steam outfit, with a capacity of 800 to 1,600 gallons for a day of 24 hours.

SUPPLIES REQUIRED IN GROWING THE CANE AND MAKING THE SIRUP

Certain supplies are always required in growing the sugar-cane crop. These vary somewhat with different farms, varieties of cane, and seasonal conditions, as may be seen from the discussion in preceding sections. The following is an estimate of the requirements per acre of a medium-heavy plant-cane crop, based on experience in southern Georgia:

1. Seed cane (usually grown on the same farm).

Variety	Number of stalks averaging 4 feet long	Tons of cane ready to plant	Fraction of acre required to produce it
Large varieties	2,000 to 2,500	2 to 4	¼ to ⅛
Cayana cane and other similar slender prolific varieties	1,500 to 2,000	¾ to 1½	⅛ to ⅓

2. Commercial fertilizer, 1,500 to 2,000 pounds medium high-grade complete fertilizer.

3. Barnyard manure, from none up to 5 tons.

4. Fuel to boil the sirup in small outfits or an approximately equal amount to grind the cane and boil the sirup in larger steam outfits, 3 to 5 cords of wood (assuming 100 to 150 gallons of sirup made per cord of wood used).

5. Gasoline or kerosene, in an outfit with a gasoline or kerosene engine to do the grinding, 20 to 25 gallons.

6. Containers for the sirup, 12 to 16 small barrels, holding 33 gallons each; or 8 to 10 barrels holding 50 gallons each; or 80 to 100 cases of cans, each case containing six 10-pound cans, twelve 5-pound cans, or twenty-four 2½-pound cans.

In producing the stubble crops, of course, no seed cane is required. Usually no barnyard manure is applied, and the amount of commercial fertilizer is reduced to about two-thirds or three fourths the quantity applied to the plant-cane crop. Since the yield of sirup commonly is only about two-thirds that of the plant-cane crop, the wood fuel, gasoline or kerosene, and containers required are reduced in the same proportion. If a second stubble crop is produced, the yield is usually still less, averaging hardly over one-half as much as that from the plant-cane crop; consequently the amount of commercial fertilizer is further reduced, and the fuel, the gasoline or kerosene, and the container requirements are reduced in the same proportion as the yield.

REQUIREMENTS IN LABOR AND WORK ANIMALS

The labor and work-animal requirements also vary considerably with the kinds of soil, seasonal conditions, and management. To the inexperienced cane grower the following report may be helpful in arriving at an estimate of these requirements. This report on field operations is by a farmer in southern Georgia, planting usually 35 to 50 acres each year, and it refers to such crews as he customarily employs. The estimates on sirup making are based on the reported experiences of representative farmers with mills driven by gasoline or kerosene and a continuous-stream type of evaporator with a capacity of about 200 gallons per day of 12 hours.

Labor and mule requirements (in days) per acre of plant cane grown

Cane growing and sirup making	Men	Women	Mules
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	2.7	6.0	
Hauling to mill, assuming a haul averaging three-fourths 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	9.9	12.7	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	19.5	12.7	11.7

From this farmer's report it appears that he required about 9.9 days' work of men, 12.7 days' work of women, and 11.7 days' work of mules 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.

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.

In operating on a larger scale in the manufacture of sirup, a material saving can be effected in labor and fuel. In a larger outfit the mill would most likely also be stronger, extracting more of the juice from the cane. On the other hand, a large manufacturing unit may also involve the longer hauling of the cane to supply the mill, thus increasing that item of labor.

In growing the stubble crops from the same planting, the work of breaking the land and planting the cane is avoided, as well as the expense for seed cane, previously mentioned. In its place, however, a small amount of work is required to "wrap the stubble" for winter protection, if the farmer follows that practice, and later in barring off the stubble. The harvesting, hauling, and sirup-making expenses with the stubble crops are also reduced in nearly the same proportion as the yields.

It is thus apparent that the stubble crops are produced at much less expense per acre than the plant-cane crop; so much less, in fact, that even at a considerably lower yield of sirup per acre, the cost of production per gallon of sirup may still be less than in the case of plant cane. If, however, the yield in a stubble crop is reduced to as little as half the plant-cane crop, as is often the case with second-year stubble crops, the expense per unit of the product is likely to be greater than in the plant-cane crop. These considerations emphasize the desirability of finding and planting such varieties as ratoon well, as has been found to be the case with the Cayana.

If the price for the finished product, the sirup, is high in comparison with the wages of laborers, the hire of mules, and the cost of supplies, there is more profit in growing the high-yielding crop, i. e., the plant-cane crop. On the other hand, a low price of sirup in comparison with the wages of laborers, hire of mules, and cost of supplies might present a combination that would make it more profitable to take additional stubble crops from the same planting.

Keeping an accurate record through a series of years of all the labor and other expenses involved in producing the plant-cane crop of sirup and each stubble-cane crop and of the total receipts for the sirup should prove very helpful to a farmer in planning the system of cropping calculated to bring him the greatest net returns per acre of land. Since both plant-cane yields and stubble-cane yields vary greatly from year to year, due to seasonal conditions, and since the price of sirup fluctuates, the farmer needs to be on guard against drawing general conclusions from the results of but few years, and especially from years that are exceptional in labor requirements, cost of supplies, or yields and prices for the product. He should rather base his system of cropping upon averages through a long series of years.

MARKETING THE SIRUP

The general market for sirup—i. e., the price paid for it as a commodity to ship—is governed somewhat by the price of sugar, since many sugar houses are equipped to turn out sirup instead of sugar should the market for sirup be better than for sugar. From the reports from the New Orleans market, December 17 to 31, 1914, it is noted that fine granulated white sugar sold at wholesale at 5.05 cents a pound and 96° test raw sugar at 3.75 cents a pound, and at the same time the sirup quotations on that market were 28 to 33 cents a gallon. The sirup from the cane grown on the lighter soils of the Gulf States farther east, and mostly made with the small farm outfits, commanded at the same time a somewhat higher price, usually about 5 cents a gallon more than the New Orleans quotations when sold in bulk in barrels. When put up in cans it sold for 10 to 15 cents a gallon more than when put up in barrels. In localities where the local demand exceeds the supply the sirup producer usually gets a higher price than the general shipping market affords, especially if he has the reputation of making a fancy product. Under such circumstances it was not unusual in 1914 and earlier for good local sirup makers to sell their product for 50 to 75 cents a gallon, put up in cans or bottles. This, however, commonly involved more or less retail delivery to the customers.

Since 1914 the prices of sugar and sirup have been disturbed so much, due to the World War, that the prices during these years do not afford a good basis for judging what the future of the market for these products will be. In 1918, when the public was rationed in sugar and sirup could be sold in unlimited quantity, the price of sirups rose to over $1 per gallon. This stimulated overproduction, and the deflation in price that followed was rapid and swept on in its downward trend far below the pre-war normal, bringing on a panic among producers in the winter of 1921–22 and leading them to dump their crop on the market at a price scant half the cost of production.

Under present practices the farmer's income from the cane-sirup industry is confined almost exclusively to the sales of the cane or the sirup therefrom. It is but natural that he thinks of higher prices for the product as the main hope, if not the only chance, of increasing his profits. As the price of the product, however, may be beyond his control, he is forced to turn to the cost of production and to the individual factors contributing thereto for possible opportunities to increase the profits. There is yet another phase of the industry that merits consideration while striving to increase profits, viz, the utilization of by-products.

UTILIZATION OF BY-PRODUCTS

There are three sugar-cane by-products—(1) the leaves and tops, (2) the bagasse (pomace or mash), and (3) the skimmings—all of which are almost completely wasted under present practices.

LEAVES AND TOPS

The leaves and tops, removed from the cane at harvesting, are usually allowed to remain in the field until they become dry and are then burned. The production of tops per acre, if weighed fresh, is 3 to 4 tons. To a small extent they afford pasturage for stock, but as a rule they soon become weathered and worthless for feed. Some attempts have been made to cure the tops for feed in the winter, but the weather conditions are usually unfavorable unless the farmer has a shelter in which to cure them. A more hopeful method of preserving them is by making silage. At the experiment field at Cairo, Ga., experiments were conducted during two years which indicate that siloing for feed is an excellent way to utilize the tops. The cattle ate the silage readily and thrived on it. The chemical analysis showed its nutritive value to be but little inferior to that of silage from whole corn. The shortage of available roughage for winter feeding in the cane-sirup sections makes this silage more valuable than its chemical composition would indicate. To assure good silage from the cane tops, the silo should be filled before the cane is frosted. In filling it, as with other forage, it is essential to tramp it in the silo very thoroughly, not only in the middle but near the walls as well. The importance of thus compacting it is not generally appreciated by those not familiar with making silage.

THE BAGASSE

The bagasse, or pomace, accumulates in vast heaps at the sirup mills and at present finds little use. Some farmers even go to the expense of hauling it off to waste woodland areas without getting

any use from it. These small mills effect too incomplete an extraction of the juice to admit of using the bagasse as fuel, as is done by the big sugar factories. The most profitable disposition of it now being made is to use it in large quantities as litter to mix with the barnyard manure, and when rotted for about a year in this form to apply it to sweet-potato land or to land for some other crop not injured by applications of fresh manure. As a result of the low extraction of the juice by small horsepower or gasoline-power farm mills, which recover only 50 to 60 per cent of the weight of the cane in juice out of the 88 to 90 per cent of juice present, the bagasse has a feeding value while fresh that is not insignificant, especially where roughage is at a premium. While fresh, stock will eat it readily, but it soon sours when exposed. If it were dried without loss, its chemical composition should indicate a feeding value about equal to that of oat straw. Drying it artificially is undoubtedly too expensive for such a low-grade product. Making silage of it is suggested, but it yet remains to be determined whether the slight unavoidable fermentation in the silo would too nearly exhaust it of its remaining nutrients to make a palatable silage. If no better use can be made of the bagasse, it should be heaped in a manner to facilitate rotting, and after one or two years, when sufficiently rotted, applied to land where humus is needed. Within the last few years remarkable progress has been made in the manufacture of lumber substitutes from the bagasse, and it is probable that because of such utilization the bagasse, in the near future, will attain a much higher value.

SKIMMINGS

The skimmings on most farms are wasted. Some sirup makers allow them to settle over night or for half a day, then draw off the clear, slightly sour juice between the sediment and the floating scum and boil it back into the sirup. There is danger of injuring the flavor of the sirup by this practice, especially if the containers for the skimmings are not kept thoroughly clean or sterilized. It was found in the experiments at Cairo, Ga., that sheet-iron vessels, e. g., ash cans, if used to collect skimmings, can be rinsed out readily each morning sufficiently clean so that fermentation will start but slowly after refilling with skimmings. In these it was possible to hold the skimmings, even in moderately warm weather, as long as 24 hours without serious souring, thus affording ample time to effect good settling. By providing a suitable tap hole about 1½ inches from the bottom of each container, the clear juice from the preceding day's boiling can each morning be drawn off and boiled with fresh juice to make sirup. Some farmers feed all the skimmings while fresh to hogs, which is a good way of utilizing them where feasible, but less profitable than to save the cleared portion for sirup making. One farmer near Cairo utilizes them by boiling them down to a thick molasseslike feed, which keeps indefinitely and is greatly relished by his stock at any time of year. Where a silo is being filled while boiling sirup, a good utilization of the skimmings might be to work them in with the silage while fresh.

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