UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 486

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ March 19, 1917

SUGAR-CANE CULTURE FOR SIRUP PRODUCTION IN THE UNITED STATES

By

P. A. YODER, Sugar-Cane Technologist, Office of Sugar-Beet Investigations

CONTENTS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1917

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 486

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ March 19, 1917

SUGAR-CANE CULTURE FOR SIRUP PRODUCTION IN THE UNITED STATES.

By P. A. YODER, *Sugar-Cane Technologist, Office of Sugar-Beet Investigations.*

CONTENTS.

INTRODUCTION.

In the preparation of this bulletin the aim has been to present a description of the practices at present in vogue among the better class of farmers engaged in the production of sugar cane in the localities where sirup is the main product of the cane. It is intended primarily for those readers who are not already familiar with the farm operations employed in sugar-cane culture and sirup making. The present bulletin will be confined mainly to the consideration of field conditions and practices and to the farm-economics phase of the industry. The subjects of insect pests and diseases of the sugar cane will be discussed only briefly, as other publications of the United States Department of Agriculture deal with these more particularly. The scope of this bulletin is not intended to cover the making and the marketing of the sirup, though some reference to these factors needs to be made in dealing with the farm-economics phase of the subject, such as the cost of the production of the cane and the sirup and the profits accruing therefrom.

Incidentally the sugar-cane industry will be considered in its relation to other farm operations, and some of the general problems arising will be noted and suggestions made as to their solution.

63779°—Bull. 486—17——1

GEOGRAPHIC LIMITS OF THE SUGAR-CANE INDUSTRY IN THE UNITED STATES.

Climatically, the sections of the United States which are more or less well adapted to the culture of sugar cane are 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 under irrigation to cane culture, though it has not been tried extensively in these sections.

In the portions of the country to which cane culture is restricted climatically it is further limited by its soil requirements. The crop can be grown profitably only where the soil is of the best.

Table I gives the acreage in sugar cane in the several States as shown by the census report of 1909, together with the total yields of cane and of sugar, molasses, and sirup. By molasses is understood the product from the residual liquor after removing part of the sugar. Sirup is the product made without the removal of any of the sugar.

TABLE I.—*Sugar-cane, sugar, molasses, and sirup production in the United States in 1909.*

States.	Area in crop.	Production of cane.	Value of crop.	Farms reporting.		Average area per farm.	Average yield of cane per acre.
				Number.	Percentage of all farms.		
	Acres.	*Tons.*				*Acres.*	*Tons.*
United States	476,849	6,240,260	$26,415,952	278,233	4.4	1.7	13.1
Alabama	27,211	226,634	1,527,166	61,226	23.3	.4	8.3
Arizona	16	55	719	8	.1	2	3.4
Arkansas	3,330	19,868	152,298	5,286	2.5	.6	6
Florida	12,928	142,517	1,089,698	19,663	39.3	.7	11
Georgia	37,046	317,460	2,268,110	64,458	22.1	.6	8.6
Louisiana	329,684	4,941,996	17,752,537	34,487	28.6	9.6	15
Mississippi	24,861	222,600	1,506,887	52,860	19.3	.5	9
New Mexico	111	267	3,467	73	.2	1.5	2.4
North Carolina	294	1,494	10,697	596	.2	.5	5.1
Oklahoma	....	2	56	1	....	....	....
South Carolina	7,053	59,865	434,634	19,857	11.3	.4	8.5
Texas	34,315	307,502	1,669,683	19,718	4.7	1.7	9

States.	In plantation mills, covered by the agricultural census.			In factories, covered by the manufacturers' census.		
	Sugar.	Molasses.	Sirup.	Sugar.	Molasses.	Sirup.
	Pounds.	*Gallons.*	*Gallons.*	*Tons.*	*Gallons.*	*Gallons.*
United States	125,647	4,153	21,633,579	326,858	24,587,581	1,449,860
Alabama	3,351	50	3,078,531	....	....	....
Arizona	....	....	1,040	....	....	....
Arkansas	....	130	286,637	....	....	....
Florida	47,661	1,339	2,533,096	....	....	....
Georgia	22,392	319	5,533,520	....	....	....
Louisiana	38,143	1,325	4,125,083	352,497	24,342,555	[a] 942,997
Mississippi	1,665	740	2,920,519	....	....	....
New Mexico	....	....	5,088	....	....	....
North Carolina	....	....	21,677	....	....	....
Oklahoma	....	....	56	....	....	....
South Carolina	5,525	250	881,558	....	....	....
Texas	6,910	....	2,246,774	1,361	245,026	506,863

[a] The statistics from 16 factories in Louisiana making sirup from sugar cane are not included.

It will be noted from Table I that at present the production of sugar from sugar cane in the continental United States is limited exclusively to Louisiana and Texas except for small quantities made by plantation mills. In those localities where sugar is manufactured the cane industry is conducted on an extensive scale.

The sirup, on the other hand, is almost wholly made by the small farm or plantation outfits. Only a small portion of it is made by big factories, and that wholly in Louisiana and Texas. In the sirup-making section it is rare that large plantations are devoted mainly to the production of cane. The cane crop for sirup comes mostly from small fields or patches.

Half a century ago, while the price of sugar was high, certain sections of Florida were extensively engaged in cane-sugar production.

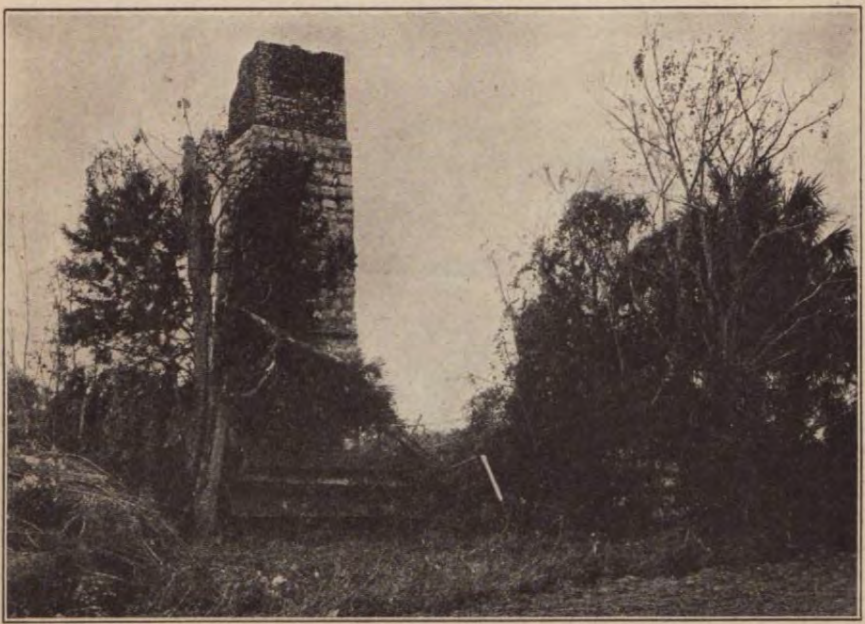

FIG. 1.—Ruins of a cane-sugar mill of antebellum days, near Manatee, Fla.

During slave days large sugar plantations were operated along the Manatee River. However, the industry never revived from the shock it received during the Civil War, when nearly all the sugar houses were destroyed. (Fig. 1.) At present, while this is still an important sirup section, the cane is produced in only small areas and it is no longer the chief industry.

THE NATURE OF THE SUGAR-CANE PLANT AND METHODS OF PROPAGATION.

The sugar cane (*Saccharum officinarum*) belongs to the family of grasses Graminaceæ. It is one of the largest of this family of plants, usually standing about 9 to 11 feet high before "arrowing," or going to seed, at the time it is usually harvested. (Fig. 2.) Unlike most of the grasses the seed is very small and either infertile or germinates very poorly; in fact, some of the best-known varieties do not produce fertile seed. The time required for a plant starting from a cutting to mature seed is usually from 14 to 18 months. It is very rare, therefore, in any portions of the continental United States that the cane goes to seed. Occasionally, in southern Florida and near the Gulf coast of Louisiana, after exceptionally mild winters the cane if not harvested will "arrow" and produce a flower panicle. For the foregoing reasons, and for the additional reason that seedling canes are usually of a quality very inferior to the cultivated varieties of cane, it is not practicable to propagate sugar cane commercially from seed.

FIG. 2.—A good stand of sugar cane.

The number of inquiries which come to the Department of Agriculture concerning sugar-cane "seed" indicates that an erroneous impression is very common or that confusion exists in the minds of many persons not acquainted with the sugar cane. The confusion comes largely through a loose use of the term "cane" or even the term "sugar cane" to designate sweet sorghums used in making sirup. Some sorghum-seed and sorghum-sirup producers give their crops names suggesting sugar cane. Thus a sorghum variety is sometimes advertised as "seeded Ribbon cane," the Ribbon cane being one of the best-known varieties of sugar cane. Another sorghum variety is listed in some seed catalogues as "Japanese Honey cane." There is a Japanese cane (see under "Varieties of sugar 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.

The method of propagating sugar cane commercially is from cuttings, i. e., the stalk of the old plant, either the whole stalk, the stalk cut into pieces, the top part of the stalk, or the underground part, is planted. New stalks sprout from the eyes that have developed at the nodes of the stalk, and roots push out in rings around the old stalk 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 and therefore relatively abundant. (See further under "Planting.") 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 and develop a new root system, thus producing another crop of cane, a so-called stubble crop or ratoon crop. However, as many of these rootstocks, because of diseases or decay, mutilation at harvesting, freezing during the winter, or other causes, do not survive, 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.

VARIETIES OF SUGAR CANE.

All the varieties of sugar cane commonly used for sugar or sirup production are of the species *Saccharum officinarum*. A variety of cane known as Japanese cane and used extensively as a forage crop, but also used to some extent for sirup production, differs so widely from the ordinary sugar cane that some botanists class it as a distinct species under the name *Saccharum sinense*, probably identical with the Uba, which is favorably mentioned in Natal.

Of the innumerable varieties of sugar cane that have found favor in the various cane-producing countries, relatively few have proved well adapted to our Southern States, primarily because they are not sufficiently quick maturing. While tropical sugar-cane countries have favorable growing conditions continuously for 12 months in the year, i. e., for an unlimited period, a season of only 9 to 10 months is available near the Gulf in our Southern States to mature the crop. Farther north, where warm growing weather does not come in the spring before April and where the first frosts in the fall usually come in October or early November, sugar-cane culture can not succeed with any variety yet known. Disappointments are frequently occasioned upon introducing some high-yielding varieties from the Tropics to find that they do not show like superior qualities in the United States. As this bulletin is intended primarily for readers interested in cane culture in the continental United States, the discussion of varieties will be limited to those that have found favor in this climate.

OLD VARIETIES.

The two varieties best known and most widely used in the Southern States are the Louisiana Purple and the Louisiana Striped. These seem to be better adapted to a wide range of soil conditions than any others of the old varieties introduced from time to time. The Louisiana Purple is also commonly called the Home Purple. In Georgia and Florida it is generally called "Red cane." It is either identical with or closely related to the Cheribon or Black Cheribon or Black Java cane of Java. The Louisiana Striped cane, also called Home Striped, outside of Louisiana is more generally called Ribbon or Red Ribbon cane. The stalks are striped with purple and green, the purple varying from a light purple or maroon to a very dark purple and the green from a light yellowish green to a dirty purplish green. This variety is presumably identical with the Striped Cheribon of Java. The Ribbon cane is commonly reported as yielding a somewhat higher tonnage than the Louisiana Purple cane mentioned above, but with a lower percentage of sugar content.

In a field of Ribbon cane, even if the seed cane was carefully selected, one can usually find numerous stalks of solid green or greenish violet and occasionally of solid purple, resulting from bud variation. The purple stalks thus originated are apparently identical with the Louisiana Purple variety just described. Conversely, cases are also reported of plain Louisiana Purple cane throwing off sports of striped cane identical with the Ribbon cane.

The green stalks coming through bud variation from Ribbon cane are commonly known in Georgia as "bastard" cane. By selecting and propagating these green variants, a strain of cane with these characteristics may be secured. Such is supposed by some to have been the origin of a variety of green cane called Crystallina in Cuba and White Cheribon in Java. It seems to be this same variety that was introduced into Louisiana from Java by P. M. La Pice in 1872, which is now being extensively grown under the name La Pice cane on some Louisiana plantations. The Ribbon cane described above is presumably identical with the variety called Transparent in parts of the West Indies, the Louisiana Purple with the Purple Transparent, and the La Pice with the White Transparent.

A variety of cane very widely grown in small garden patches, primarily as a chewing cane, generally spoken of in Georgia and northern Florida as Green cane, is apparently identical with the Otaheite of Cuba and the Bourbon of the British West Indies. Because of the soft texture of the pith, this cane is a favorite among the inhabitants for chewing. Many farmers also plant it for sirup production, as it yields a lighter colored product than the Louisiana Purple or the Red Ribbon cane. Because of its late maturity, its low yield, and its strong susceptibility to disease, however, it is not a good commercial sirup or sugar making cane. It is also a disagreeable cane to handle at harvest time because of the numerous fine prickles that cover parts of the leaves near the stem and the leaf sheaths near the midrib of the leaf.

A variety called Green Ribbon cane in Georgia and Simpson cane in some parts of Florida is practically the same as the last mentioned except in color, and it has the same advantages and disadvantages. The two are frequently grown together and one is doubtless a bud variation of the other. The color of the Green Ribbon cane is green and yellow in longitudinal stripes.

SEEDLING VARIETIES.

While bud variation from striped varieties occurs, giving self-colored varieties, and while the opposite phenomena, viz. striped varieties coming by bud variation from self-colored varieties, have also been observed, no great success has attended experimenters in attempts to produce an improved strain of sugar cane by selection through bud variation or plant variation with respect to sugar content and purity of juice. Because of the vegetative way of propagating the cane, the plants of successive seasons are in reality but a continuation of the growth of the plants of preceding seasons. Consequently there is but little chance for variation in its economic properties. It is otherwise with plants produced from seed, whether the flowers are fertilized by chance in nature or are hand-pollinated under control. In a large number of the enterprising sugar experiment stations, work has been started in producing and testing seedling canes. In most cases the fertilizing of the flowers is left to chance, or, at most, resort is had only to planting in proximity the two varieties from which it is desired to obtain a cross, thereby increasing the chance of getting the desired cross. In a few instances the experimenters have undertaken to cross-fertilize the flowers under control, thereby producing strains with known pedigree. However, as the flowers are almost microscopic in size it is very tedious work, and as a large percentage of the progeny is unpromising or worthless, progress toward better strains by this means is very slow.

Among the immense number of seedlings that have been produced, a goodly number have already proved of economic value and are now being grown extensively on sugar plantations. A number is assigned by the originators to each of the seedlings tested, and to this number is prefixed an initial denoting the country or place in which the station is located. Thus we have the D 74 and the D 95 varieties of sugar cane, now extensively grown in Louisiana, which were originated by the Royal Agricultural Society of British Guiana, in Demerara, South America, and were introduced into Louisiana by Dr. W. C. Stubbs in 1873.

FIG. 3.—Two varieties of sugar cane (crops equally large) on the same farm after a storm: Upper, Palfrey cane, one of the old home varieties, badly lodged; lower, D 74 cane, standing erect.

Both these varieties of cane on the rich alluvial lands along the lower Mississippi and its tributary bayous generally yield both a better tonnage and a crop of higher sugar content and have the added advantage over the old home varieties of being more rigid and therefore not lodging so easily in storms, thus lessening the labor of harvesting. This erect habit of growth is especially marked in the D 74 cane. (Figs. 3 and 4.) Among the Louisiana planters these varieties have the reputation of being more sensitive to lack of fertilizer and to poor soil conditions than the Louisiana Purple and the Ribbon canes. Possibly this accounts for the fact that these varieties have not found much favor among the cane growers of Georgia and Florida, where the soil is of a lighter, more sandy character and the rainfall less abundant than in Louisiana.

The D 74 cane is a green variety which produces a sirup notably lighter in color than the Louisiana Purple and the Ribbon canes. The erect habit of growth of the plant keeps the ground from being shaded as early as with other varieties, thus necessitating (or permitting) somewhat later cultivation. As the leaves are quite stiff and the leaf sheaths do not so readily drop away from the stalk as it matures, there is slightly more trouble in stripping it at harvesting time than is experienced with other varieties. Unlike the green chewing cane previously mentioned, the D 74 cane has no prickles on the leaves and leaf sheaths.

FIG. 4.—Sugar cane of the D 74 variety (at the left) and of the Louisiana Purple variety (at the right) after a storm (crops equally large).

Because of the hardness and brittleness of this variety of cane, it is not so easily milled, especially with the small farm outfits that are not provided with crushers. The D 95 cane is of a dark-purple color and can therefore not be expected to yield as light colored a sirup as the D 74 cane. It is a somewhat softer cane, however, and is therefore more easily milled. Both these Demerara varieties deserve a more thorough trial in sections where they are not now being grown.

In the fall of 1915 the writer observed in a field of D 95 can on a farm in Alabama, near Muscogee, Fla., some striped stalks. The same phenomenon has since been reported from some other fields of D 95 cane in Louisiana. We thus have another example of a bud variation in a self-colored cane (i. e., with solid color on the stalk) yielding a striped variety. This striped D 95 looks very much like the common Ribbon cane.

Since 1906 the Louisiana Sugar Experiment Station at Audubon Park, New Orleans, has been actively engaged in the production and testing of seedlings, using seed matured in the Tropics and sprouting it in the greenhouse under carefully controlled conditions as to heat and moisture. Several varieties of much promise have already been produced and multiplied in sufficient abundance for trial under field conditions. Among those favorably reported are L 511, L 218, L 219, L 231, and L 226, samples from all of which have been supplied through the kindness of Mr. W. G. Taggart, in charge of the Sugar Experiment Station at New Orleans, and are now being propagated by the United States Department of Agriculture at Apalachicola, Fla., and at Cairo, Ga. The tests in Georgia are in comparison with a number of the older varieties and some new seedlings from foreign countries.

Because of the great diversity of characteristics among sugar-cane seedlings, seedling production and testing is the most hopeful method of attacking many of the problems in sugar-cane production, such as the increase of sugar content, earliness of maturity, disease resistance, and adaptation to soil conditions. Since the soil and climatic characteristics in different cane-growing localities vary greatly, and since the success of cane varieties depends so much upon these characteristics, it is highly desirable to carry on the testing of seedling varieties in many different typical localities.

SOIL REQUIREMENTS.

Since all varieties of cane make heavy demands upon the soil for plant-food constituents and water, the soil must be suitable to provide these under the conditions otherwise prevailing. If the rains are not well distributed and if periods of drought are to be expected without provision for irrigation, it is essential that the soil be a medium-heavy loam or a clay with an abundance of humus. If the soil is very sandy and lacks humus, it is practically impossible to supply the necessary plant-food constituents economically just when the plants need them, even if rains are abundant and well distributed. Such soils do not retain well the commercial fertilizers and therefore make necessary frequent applications and occasion much wastage.

While such sandy flats as those that occur so extensively near the southern Atlantic and eastern Gulf coasts can be made to produce big crops of sugar cane, this can not be done continuously without involving so much expense as to make it unprofitable. Frequently such land produces a fairly good crop while it is new ground and while the vegetable mold from the native forest growth supplies an abundance of humus. In succeeding years, after this is exhausted, it is only by the liberal application of mineral plant foods and of organic matter in the form of green-manuring crops and barnyard manure or their equivalent that good yields can be secured. It is otherwise with the so-called hammock lands and with the rolling lands farther from the coast, or with the delta lands near the rivers, where a considerable percentage of fine silt and clay is mixed with the sand, making a good loam or clay-loam soil. Too heavy a clay is likewise not well adapted for sugar-cane production, because it is practically impossible to keep it in good tilth. Thus, along the lower Mississippi River and the various bayous in Louisiana, the lands immediately adjacent to the streams are usually well adapted to sugar-cane production. These lands were formed by the sediment first deposited on occasions when these streams, during past ages, overflowed their banks, and they contain therefore much of the coarser silts and some sand. The land of the swamps lying farther back from these streams is composed almost entirely of a heavy clay, which is difficult to get in good tilth and is thus poorly adapted to cane culture. The conditions are vastly better if this clay has much vegetable mold or humus in it. In that event, provided the land is properly drained, good crops of cane can be grown so long as this supply of humus lasts.

The muck soils, provided they have a high mineral content, will produce big yields of cane if well drained. With muck land that is very low in mineral content or with peat land, it is doubtful whether it can be used successfully for sugar-cane production even if drained. A disadvantage with muck land is that it affords such poor anchorage for the cane roots that the cane very easily lodges, and this gives a tangled mat of stalks instead of relatively erect rows. In Georgia it is commonly reported that the rich dark soils along the edge of swamps, while producing high yields of cane, exert a deleterious effect upon the color, clearness, and flavor of sirup made therefrom. The farmers there, in consideration of the quality of 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 attained if possible.

MANURIAL REQUIREMENTS.

The use of commercial fertilizers in sugar-cane growing is almost universal in the United States and in other cane-growing countries. As to the particular feritlizer elements required and the forms and proportions in which they are applied, the various localities differ widely.

Some form of nitrogenous fertilizer can be applied with profit or is absolutely essential in practically all localities. The amount of nitrogen that is applied on the best-managed farms of the Southern

States usually ranges from 20 to 50 pounds per acre. In many of the tropical countries, where much larger yields are produced, this amount can be increased one or two fold with profit.

To the application of phosphoric acid there is a good response from the soils of nearly all sugar-cane localities both in this country and in foreign countries, but the amount to be applied most advantageously varies considerably. Most of the soils of Java are a notable exception to this rule, in that they do not respond to phosphate applications. The amount of soluble phosphoric acid applied in Louisiana is usually from 40 to 80 pounds per acre. To the lighter soils of Georgia and Florida it is not unusual to add considerably more, even up to 120 pounds per acre.

To applications of potash there is 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 common practice to buy the fertilizers ready mixed. However, many farmers do their own mixing in the interests of economy. In trade the mixed fertilizers are commonly described by three figures, referring in their order to the percentages of available phosphoric 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 from 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. 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 formula 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.

The most common sources of nitrogen in the manurial mixtures are cottonseed meal, tankage, and ammonium sulphate for early applications and sodium nitrate (Chile saltpeter) and ammonium sulphate for late applications. Of these, cottonseed meal is most extensively used in the Southern States, being near the source of its production the cheapest commercial fertilizer. It contains about 7 per cent of nitrogen, 3 per cent of phosphoric acid, and 2 per cent of potash. Tankage is also extensively used, especially at times when the price of cottonseed meal is unusually high. Its composition varies according to the proportions of blood, meat, and bone entering into its manufacture, but it averages about 7.5 per cent nitrogen and 5.5 per cent phosphoric acid. Dried blood and fish scrap are also occasionally used, mainly for their nitrogen content. In the tropical countries ammonium sulphate containing about 22 per cent nitrogen is very extensively used. For quickly available nitrogen, nitrate of soda (Chile saltpeter), containing about 15 per cent nitrogen, is the favorite. Synthetic nitrogen manures have been introduced recently to some extent.

The source of phosphoric acid in the fertilizer mixtures is nearly always acid phosphate, except to the extent that it is furnished by the nitrogenous manures, such as tankage or cottonseed meal. The acid phosphate contains 14 to 16 per cent of phosphoric acid. For soils deficient in lime and with an acid tendency, it is better to supply the phosphoric acid in the form of basic phosphate (basic slag or Thomas slag).

The potash was supplied in the past almost exclusively in the form of potash salts from the mines near Strassfurt, Germany, either the natural mineral, especially kainit with 12 to 14 per cent of potash, or the more nearly pure salts, the sulphate of potash and the chlorid (muriate) of potash, either one containing about 40 to 48 per cent of potash.

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 contained can account for. Practically all soils in the sugar-cane localities, both the heavy soils like these in Louisiana and the lighter ones of the States farther east, are very responsive to increases in the humus content. The farmer should therefore be on the alert to 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 off to make the field cleaner for the cultivation of the stubble crop of cane during the next season and in the hope of thereby destroying insect pests. Recently, however, since the entomologists of this department 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 incorporating it with the soil without burning it. Whether or not this practice, and whether returning to the field the bagasse, suitably rotted or chopped fine, tends to increase the damage from diseases, remains yet to be determined, and experiments along this line are being instituted. It is common experience among 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.

In consideration of the quality of the sirup, cottonseed meal or even the cottonseed itself is a very popular manure for cane. Such practice, however, seems to be rather illogical, in consideration of the high food value which these substances possess. The cottonseed contains about 17 per cent of fat, which has no fertilizer value, but which if pressed out and purified has a high food value. The press cake remaining, if ground up, becomes cottonseed meal. If this is properly prepared it is an excellent high-protein concentrated foodstuff. In spite of the high food value of the oil and the high feeding value of the meal, the prices of these articles usually prevailing in the cotton sections are so low and their value as a fertilizer so high that they are both extensively used as fertilizers. Doubtless, with the upward trend in prices for animal products and with a fuller appreciation on the part of the farmers of the value of barnyard manure, these conditions will gradually change and more cottonseed meal will be fed and more barnyard manure will be produced to be available for crops in rotation with sugar cane.

TIME AND MANNER OF APPLICATION OF FERTILIZERS.

Between what is theoretically best in the time and manner of application of fertilizers and what is least expensive, compromises must necessarily be made. To economize labor in distributing the fertilizers, the several constituents are usually mixed and distributed at one time. For cane planted in the spring it is customary to put a rather liberal application of mixed fertilizer, the nitrogen of which is in a form becoming gradually available, into the furrow 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 the fertilizer is used very sparingly, if at all, at the time of planting, but the main amount is given 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, in that 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 the crop by, July 15 to August 1. Thus, a very common fertilizer program among the Georgia cane growers is to apply in the furrow at the time of planting 600 to 1,000 pounds of mixed fertilizer of a formula similar to the 8–2–3 formula before mentioned, then about the middle of May to give a side application of about two-thirds that amount of a similar mixture, and finally at the "laying by" of the crop to give a top-dressing of 100 to 200 pounds of Chile saltpeter. Many prefer to apply less of the mixed fertilizer at the time of planting and more later. It would doubtless be better for the cane if the same amount were divided into smaller quantities and applied more frequently, but this is generally considered to involve more expense than the gains justify.

CROP ROTATION.

The fertilizer requirements depend very largely upon the crop preceding the cane. A very good practice is to precede the cane with a crop of corn and cowpeas, plowing the latter under. It is still better if this is done for two successive years. The common rotation on the sugar plantations in Louisiana has been one year of corn and cowpeas, followed by two years of sugar cane from one planting. With the growing interest in stock raising, some planters during the last few years have changed their system to a 4-year rotation, with two successive years of corn and cowpeas, plowing under the peas each time, then two years of cane. The results obtained were exceedingly encouraging, half of the plantation yielding almost or quite as much cane as previously two-thirds of the plantation did with a 3-year rotation.

In the principal sirup-producing sections, unlike the sugar plantations, the farmer can usually select a location for his cane patch that had a specially favorable treatment. Thus, for small 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 amount of manure, the cane bagasse (also called pomace or mash) is put in liberal quantities into the stables or corrals, to be worked up into manure, and then, after it has had about a year to rot, it is applied to the sweet-potato ground.

PREPARATION OF THE LAND.

Not much need be said in regard to preparing the land that might not be said with equal propriety for any other crop. 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 8 or 10 inches. This deep cultivation is especially advantageous during seasons with periods of drought. In the experimental field at Cairo, Ga., in the season of 1915, the yield was fully twice that of adjacent fields, which could reasonably be attributed in large measure to deeper plowing and subsoiling, coupled with the fact that the season was characterized by very heavy rains in late winter and a drought of unusual severity in midsummer. With very sandy subsoil, lacking humus, deep plowing may be disadvantageous. With a clay subsoil which previously has always 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.

In Louisiana and parts of Florida it is deemed desirable to plant in the fall, as late as is safe to 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 what is not planted by that time is left to be planted 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 universally 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. Availability of labor is also in favor of spring planting.

The advantages of fall planting are threefold:

(1) There is economy of labor. The cane is taken directly from the field where it is growing to the place where it is planted, thus avoiding the labor of storing it in windrows or banks and later digging it up to plant. (Fig. 5.)

(2) There is thought to be less spoilage of cane in the furrows than if planted in the windrows or banks.

(3) Fall-planted 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 spacing 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 the most common spacing. 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.

On the flat plantations in Louisiana, with the fields divided by permanent headlands and drainage ditches, it is customary to plow in beds, maintaining the same rows and consequently the same spacing from year to year. On the rolling uplands of southern Georgia and adjacent States there is need of special precautions against soil erosion. 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 hundred feet. If the field is terraced these terraces afford the neces-

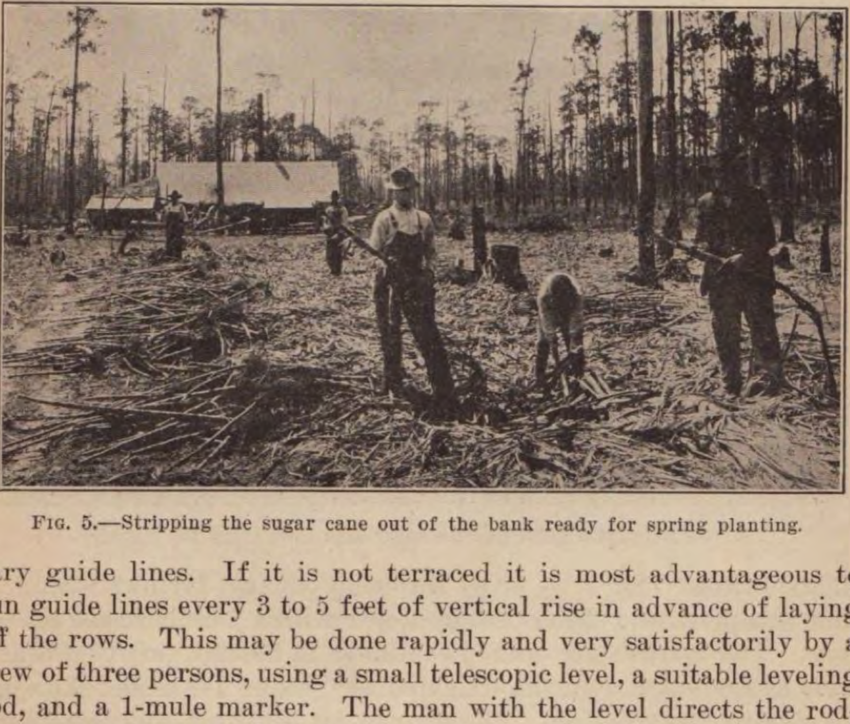

FIG. 5.—Stripping the sugar cane out of the bank ready for spring planting.

sary 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 may be done rapidly and very satisfactorily by a crew of three persons, using a small telescopic level, a suitable leveling rod, and a 1-mule marker. The man with the level directs the rodman up or down the hill slope until he has the proper altitude for the guide row that is to be run. (Fig. 6.) The rodman then steps off a distance of about 50 yards approximately on a level along the hillside. The man with the level again directs him up or down the slope until he has an elevation of 6 to 8 inches higher or lower than at the previous station. They thus locate a series of stations about 50 yards apart, each varying 6 to 8 inches in elevation from the preceding. The man with the marker meanwhile follows immediately behind the rodman, marking the gradually rising or falling contour line along the hillside, guided by the stations marked by the rodman. A small telescopic farm level with tripod and leveling rod suitable for this purpose, constructed on the principle of the surveyor's level, can be purchased for about $20. The slope or direction of drainage of the furrows is ordinarily made from the center of the field toward both sides or is otherwise suited to the existing watercourses.

Most farmers prefer marking the rows, properly spaced, in advance of opening the furrows. This is usually done by a 1-mule 1-point marker (a "scooter") provided with a guide stick, hinged to the beam, to extend on either side the right distance to trace the next row.

After providing in one manner or another for the correct spacing and the course of the rows, the furrows are opened by using a 2-mule

FIG. 6.—Running a guide line for sugar-cane rows along the hillside.

middle breaker (fig. 7, *b*) or by throwing out two furrows with a 1-mule turnplow, and then opening deeper with a 1-mule round shovel plow. The furrows are opened shallower in the flat, poorly drained fields of Louisiana. In the irrigated sections of Texas and Arizona the planting is extra deep. The commercial fertilizers and sometimes also the barnyard manure are distributed in the furrows (fig. 7, *a*), and mixed with the soil by again driving through with a suitable implement. The cane is then distributed (fig. 8) and covered to a depth of 1 to 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 to 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. With reference to cutting away the diseased parts before planting, practice varies. On the basis of ordinary field sanitation it is advisable to trim off 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 in trimming.

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

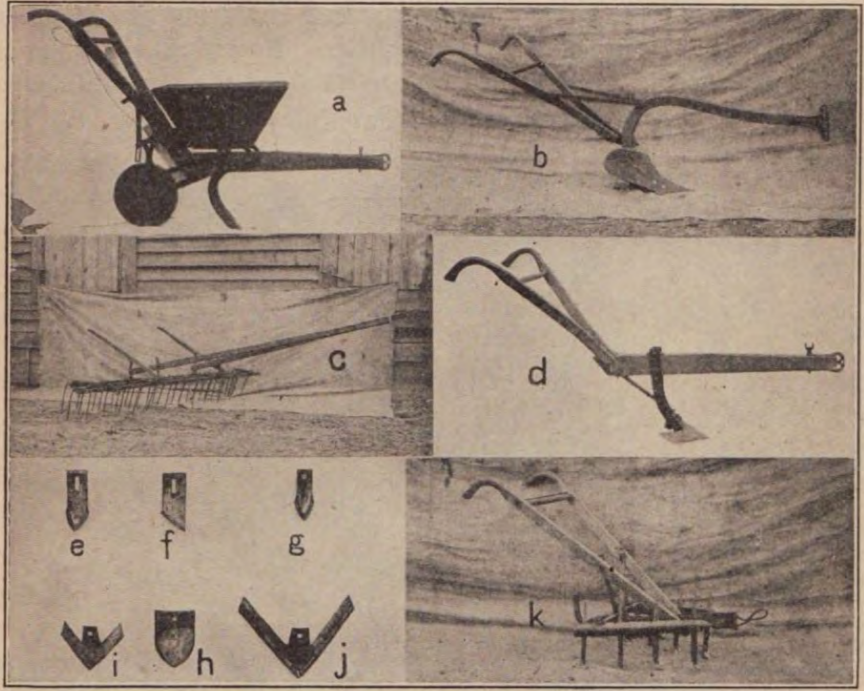

FIG. 7.—Some types of implements in common use for cultivating sugar cane on small farms: *a*, Fertilizer distributor; *b*, middle breaker; *c*, weeder; *d*, common 1-mule stock, with sweep point attached; *e*, *f*, *g*, scooter points; *h*, round shovel point; *i*, *j*, sweep points for stock (*d*); *k*, spike-tooth cultivator, useful for early cultivations.

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. Cane has a strong power of adapting itself to the space given it, stooling out when planted thin, so as largely to compensate for thin planting. Therefore, if the plant material is scarce and the available area plentiful, e. g., in the multiplication of a valuable rare variety, it is advantageous to plant quite thin. 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. 9) 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 months subjected to disease, it is common practice to plant only the tops of the stalks, which are less valuable for sugar manufacture and yet are quicker to start growing than the older, more mature parts of the stalks. It is still an open question whether or not some system of top planting could not also be used to advantage in our sugar-cane localities. Rootstock planting is sometimes resorted to, but with rootstocks alone the uncertainty in the germination is too great to assure a regular stand.

FIG. 8.—Planting sugar cane in Georgia.

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 $4\frac{1}{2}$-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 to plant. Such stalks, including the rootstocks, may be expected to weigh about 3 pounds apiece; hence, the weight of plant cane required is 7,260 pounds, or $3\frac{5}{8}$ 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, and herein lies an incentive to Government or State experimental institutions for making strong efforts to find or originate cane varieties that are more resistant to disease and that will consequently not require such frequent replanting, or canes that stool better, so that the planting may be thinner. With Japanese cane this drain is far less, first, because this variety ratoons well, giving good yields for three to six years from one planting, and, second, because the stalks are so slender that a ton will go a long way in planting

FIG. 9.—Planting sugar cane in Louisiana.

However, as heretofore stated, this variety is not very good for sirup or sugar making.

CULTIVATING THE CANE.

If in the spring, before the newly planted cane is up or while it is still small, the ground gets 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 (fig. 7, *c*), covering the field once or twice in a direction diagonal to the rows. If this does not remove the weeds, it is advisable after the cane is up to clean them out of the rows by hand hoeing. A second or third hand hoeing may be necessary later to keep weeds out of the rows. After the cane is well up, the space between the rows is cultivated to kill the weeds and to keep the soil in tilth, much as for any other crop. (Fig. 7, *k*.) The early cultivations, before the root systems have developed much, should be relatively deep, but later in the season shallow cultivation must be practiced, 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 planting 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 will start. 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 in the fall under a covering of 4 to 6 inches. This ridge is then raked off by hand with hoes or by cultivating crosswise with a harrow, leaving only 1 to 2 inches of soil over the cane.

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 to rake the stubble with a harrow, about as already described for fall-planted cane. On the big plantations in Louisiana, where the rows are on high ridges and the rootstocks consequently are relatively long, instead of thus raking the extra soil off the stubbles it is customary to "shave" them. For this a special implement is employed, having either a horizontal, obliquely placed, straight, flat cutting bar or two horizontal disks, to cut through the ridge left at the time of barring off and to cut off the partly decayed upper ends of the old rootstocks. Suitable plates on the implement brush the loosened soil into the furrow at the sides and thus leave the tops of the shaved stubbles exposed. This removes from the rows all the weeds and most of the weed seeds and thus aids greatly in keeping the row clean during the early growth of the crop. Later, and before the crop has made much progress in growth, it is advisable to loosen the soil with a special implement, the stubble digger. (Fig. 10.)

Neither stubble shavers nor stubble diggers have been adopted to any notable extent in the sirup sections east of Louisiana. As to the implements for further cultivation, practice in the sirup sections differs widely from that of the large plantations of Louisiana and from that with other crops in the Northern and Western States. After the preparation of the land, nearly all the work is done with 1-mule implements, using a 1, 2, or 3 point single cultivator in the early cultivation (fig. 7, *d* and *e* to *j*) and sweeps for the later shallow cultivation. To one accustomed to the 2-horse or larger implements used in other sections of the country (fig. 11), this farming with 1-mule implements seems like very inefficient utilization of farm labor. It has a partial justification, however, in the facts that the farms and fields are mostly small; that there are many short rows, especially where they are laid off along contour lines on the hill slopes; that no headlands for turning around are provided; and, finally, that the wages of laborer and mule are nearly equal.

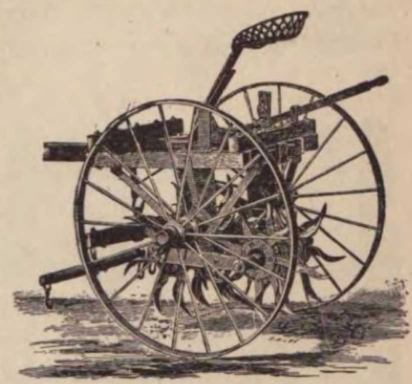

FIG. 10.—A type of stubble digger used for sugar-cane tillage in Louisiana.

When we consider, however, that not uncommonly the operations of marking the rows, opening the furrows, distributing fertilizer, and covering the cane require altogether eight trips of laborer and single mule along each row, there seems undoubtedly room for improvement in efficiency. Practically the same disproportion of trips per row to the work accomplished exists in the later cultivation in these sections.

Cultivation generally ceases and the crop is "laid by" about the middle of July or 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, which is 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 sections with but small crops to dispose of prefer to wait till near the middle of November. In southern Florida, where winter frosts are rare, they can afford to wait till 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 to somewhat higher latitudes, i. e., colder climates, than for sugar manufacture. If, however, the cane is too immature, the sirup can not be made sufficiently clear and light colored and has an objectionably strong, bitter flavor.

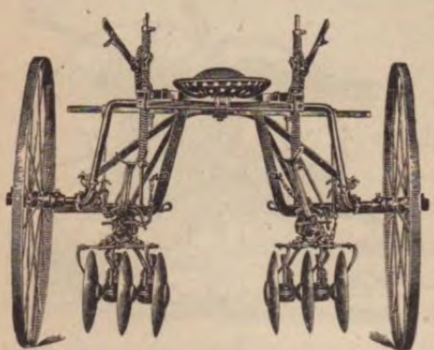

FIG. 11.—A type of 2-horse disk cultivator used on large sugar-cane plantations.

The operation of harvesting (fig. 12) consists of stripping the leaves off the stalk, topping the cane, cutting off at the bottom, dropping it in bundles, loading, and hauling to the mill. The stripping, topping, and cutting of the cane are usually accomplished by hand with a cane knife. This implement has a small hook at the tip of the back of the blade (fig. 13, *b*) that helps in raking or beating off the leaves with the back of the knife. About two strokes down the sides of the stalk will remove the leaves if the stalk stands straight. If it has been lodged by a storm and has consequently grown crooked, as is frequently the case with the old home varieties, it is more troublesome to strip off the leaves. Thus in the stripping, and in the further handling also, there is a decided advantage in growing varieties of rigid, erect characteristics, such as the D 74, which do not readily lodge. Some planters prefer to strip the cane a few weeks in advance of the actual harvesting, thinking thereby to hasten maturity. This, however, is of doubtful value except to get that much of the work disposed of before the busy harvesting time comes. The practices in harvesting in the eastern Gulf States differ somewhat from those in Louisiana and of cane-growing countries. Three different tools are used in stripping, topping, and cutting the cane, and the work is done in three stages. First, the cane is stripped by the use of a flat stick about 3 to 4 feet long or, better, with a tool consisting of two curved and forking narrow blades of spring steel on the end of a stick, so disposed that the operator can beat the leaves down from both sides of the stalk with a single stroke (fig. 13, *a*). The second operation, the topping, is done with an ordinary cane knife. Finally, the cane is cut off at the ground with a heavy, short-handled hoe (fig. 14).

Persistent efforts have been made by a number of very capable inventors to design and build machines to harvest the cane, and encouraging progress has been made. Stripping and topping the

FIG. 12.—Harvesting sugar cane in Louisiana.

cane satisfactorily without making the machine unwieldy offer the great difficulty. Possibly we may hope for the solution of the machine-harvesting problem when means for utilizing the tops are worked out, e. g., siloing and feeding, so as to pay for their transportation to the mill or to some central loading station. Then the inventors could attack the problem of stripping and topping by means of stationary machines without being so closely limited in the weight or size of the machines.

The loading of the cane is done by hand except on some of the large sugar plantations, where loading machines are in use, operated either by mules or, better, by gasoline power. (Fig. 15.) Suitable grabs and hoists pick up the cane from the small heaps into which the cutters have dropped it and swing it over, to be tripped off into the wagon box. The wagons or carts may be provided with slings to unload the cane at the mill or at the field railway by the use of power hoists.

A light frost on the cane may kill the leaves without seriously damaging the cane except to check its growth. A somewhat heavier frost that kills the growing tip and the eyes renders the cane worthless for planting, but occasions no serious loss for sugar or sirup manufacture if the cane is not left standing in the field very long. Fermentation proceeds but slowly from the injured tips and eyes, resulting in no serious deterioration if harvesting is delayed even for a week or two. If, however, a hard freeze, sufficient to freeze the interior of the stalks, catches the crop still in the field, then the rind of the stalks is burst open. If warm weather follows and the cane is exposed to it, fermentation beginning along the injured stalks will in a very few days cause a souring of the cane to an extent that makes it worthless for either sugar or sirup manufacture. In case of a heavy frost or of a freeze much may be done toward saving the cane or extending the time in which it can be ground profitably by promptly windrowing it. If possible, before the weather turns warm, the cane should be cut and laid in windrows, with the tops overlapping the stalks, the same as in putting away seed cane, but omitting the soil covering. The foliage will then protect the stalks in a measure from the heat of the sun, and fermentation proceeds much more slowly. Windrowing is the more effective if the cane is put down while it and the ground are cold. It is much better if the frost can be anticipated and the cane put in windrows just before the frost. Some deterioration will still take place, but it is relatively small. Of course the possibility of further growth is sacrificed. It thus occasionally happens that, with weather conditions threatening a freeze, or immediately following a freeze, the plantation manager shuts down the mill and puts all available hands at windrowing cane, working under pressure almost night and day until the cane is all down. It is later stripped out of the windrows and topped as fast as the mill can work it up. If the cane is not badly frozen and time permits, it is more economical and equally effective in protecting the cane to strip, top, and cut it, drop it in small heaps, and cover it with trash until it can be milled.

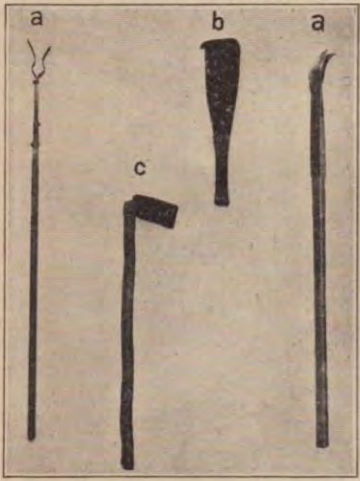

FIG. 13.—Harvesting tools used in Georgia and Florida: *a*, *a*, Stripping tools; *b*, cane knife; *c*, hoe.

YIELD OF CANE, SUGAR, AND SIRUP.

For rich Mississippi Delta land, with good care and a good season, 25 to 35 tons per acre would be considered a fair crop from plant cane, i. e., the first crop from a planting. About two-thirds of this yield may be expected from the first ratoon crop (first-year stubble crop) and about one-half the plant-cane yield from the second ratoon crop (second-year stubble crop). In most sections farther east, with a lighter soil, the yields are lower, viz, about 18 to 25 tons per acre from plant cane under favorable conditions, and about two-thirds and one-half of this from the first and second ratoon crops, respectively.

The ratios here given between the yields of the plant-cane crop and the first and second year stubble crops are estimated to be the

FIG. 14.—Harvesting sugar cane in Georgia.

average ratios for all seasons and all farms; however, these relations are subject to great variations in different seasons and on different farms. Thus, in southern Georgia during the season of 1914 the stubble crops made an exceptionally good stand and growth, the first-year stubble on many farms exceeding in yield the plant-cane crop. The succeeding year, 1915, on the other hand, showed an equally abnormal divergence in the other direction, in that the first-year stubble crop on most farms yielded less than half of what the plant-cane crop yielded, while the stand of the second-year stubble crop in most cases was so poor in the spring that the farmers plowed up this cane and planted the fields in other crops.

The composition of the cane varies with the variety, the season, the time of harvesting, and other factors. It may be expected to contain on an average about 88 to 90 per cent of its weight in juice. The best modern sugar-factory mills with 9 or 12 rollers and with "saturation" (addition of water between successive pressings) can extract about 80 to 85 per cent of the weight of cane in juice. Power mills with a single set of three rollers may effect an extraction up to about 68 per cent. Those of small design, as used on the sirup-making farms, rarely exceed 65 per cent. The small mills driven by 6 to 8 horsepower gasoline engines usually give an extraction of 55 to 65 per cent, and the horsepower mills frequently even less. With average cane and good management of the mill, the extraction, even with these small mills, should not be below 58 to 63 per cent of the weight of the cane.

The sucrose (common sugar) content of cane is especially subject to variation with degree of maturity, seasonal conditions, etc. About 11 to 14 per cent may be taken as the usual sucrose content of the

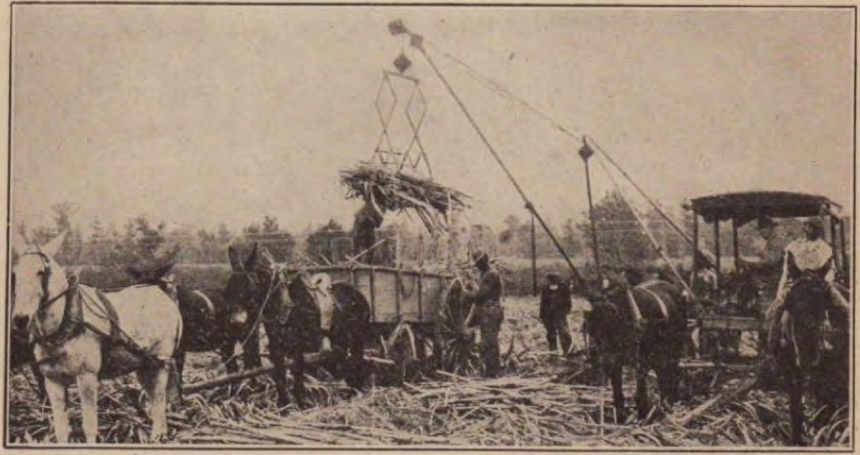

FIG. 15.—A gasoline-power sugar-cane loader.

juice in the Southern States. Accompanying the sucrose we may expect to find 1.5 to 2 per cent of reducing sugars (dextrose and levulose, frequently spoken of as glucose). In the earliest part of the harvest season the sucrose content is lower and the reducing sugars higher than they are later. With good mature cane, such as is usually produced in tropical countries, the reducing sugars almost vanish. Besides these sugars, the juice contains from 1.3 to 2 per cent of solids other than sugar. With the usual losses in extraction and other unavoidable losses in the manufacture of sugar and sirup, the actual yield of sugar under favorable conditions in a large factory is 140 to 180 pounds per ton of cane, or about 2 to 2.8 tons of sugar per acre of good plant cane on Mississippi River Delta land. The actual yield of sirup is about 18 to 24 gallons per ton of cane, or about 400 to 525 gallons, equal to 12 to 16 barrels of sirup, per acre of plant cane on good Georgia or Florida farms. The average yields, as shown by the census reports, are much below these, showing that many farms and factories are not producing yields up to the normal for good, well-managed farms.

STORING CANE FOR PLANTING.

In localities subject to winter frosts, if the new plantings of cane are not made in the fall, planting the cane directly from the field as it is harvested, some means must be employed for storing the cane until time to plant it, which is usually in the spring. Two somewhat different modes of storing are in common use, viz, 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,

FIG. 16.—Putting sugar cane in windrows in Louisiana.

are content to cut the cane about even with the surface of the ground, thus sacrificing the short rootstock, which bears a large number of eyes.

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. 16.) The ridge cultivation results in deep furrows being formed in the middles between rows during 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 a 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 cover such gaps as the plows and cultivator failed to cover. At planting time the cane is pulled out of these windrows by the use of a mule pulling a specially constructed implement with prongs or hooks crosswise of the rows. 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 convenience. Only the edges can be covered with plows and the center strip of the bank must be covered by hand with shovels. (Fig. 17.) About 1 to 2 inches of soil is put on the bank. Some prefer to leave a strip of about 8 inches in the middle of the bank uncovered until colder weather or all winter. At planting time the soil is shoveled off these

FIG. 17.—A bank of sugar cane in Georgia ready to cover.

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 proportionally much more hand labor, and it can therefore be practiced only where the cane areas are small and the labor available is relatively abundant.

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, thus sacrificing some in maturity of the cane. Cool, wet days are chosen, if possible, for the work of storing. If it must be banked when the ground is warm and dry, it is advisable to scrape away the warm and dry surface soil immediately before putting down the cane.

INSECT PESTS AND DISEASES OF CANE.

The reader is referred to other publications for details in regard to insect pests and diseases that are likely to infest sugar cane.[1] In this more general treatment of the subject, however, attention will be called to a few of the more dangerous pests and diseases that the farmer should avoid if possible.

The moth borer (*Diatraea saccharalis*) is by far the most destructive insect pest with which cane growers have to contend. It infests the fields throughout most of the Louisiana cane belt and parts of Texas. East of Louisiana it has been found in only a few rather restricted localities. The moth lays its eggs on the leaves of the cane and the larvæ from the eggs bore into the stalk, reducing the yield of cane and, much more, the yield of sugar or sirup from it and killing many eyes of the cane stored for planting.

The mealy bug (*Pseudococcus calceolariae*) comes next in importance in regard to the damage done in the cane areas of the United States. It is widespread in the Louisiana cane districts and does much damage to the cane. These bugs collect around the stalks of the cane, mostly near the joints, and suck the juice out of the cane. They are covered with a downy white fuzz, making it appear as if the stalk were covered with a white mold. It is practically impossible by any means yet worked out to eradicate either the moth borer or the mealy bug when once they have become well established in a cane-growing locality. For localities not infested, an ounce of prevention is worth many pounds of cure. Great caution should be exercised to prevent their introduction. Cane for planting or other purposes should not be imported to a free section from an infested section except under the direction of an expert.

Termites, also called wood lice and white ants, at times do some damage to cane. They are most likely to occur where there is much coarse vegetable matter in the soil, therefore in new-ground fields. Fertilizing by dropping raw cottonseed in the furrow at planting time frequently leads to increased damage to the cane from the termites. They enter the growing stalks from the planted cane, causing hollows which become surrounded with hardened tissue. Usually, if termites get started in a planted stalk, they enter all the young stalks sprouting from it. For this reason it is recommended,

---

[1] Holloway, T. E. Insects liable to dissemination in shipments of sugar cane. U. S. Dept. Agr., Bur. Ent. Cir. 165, 8 p. 1912.

Field, Ethel C. Fungous diseases liable to be disseminated in shipments of sugar cane. *In* U. S. Dept. Agr., Bur. Plant Indus. Cir. 126, p. 1–13, 7 fig. 1913.

in fields where they give trouble, to cut the stalks for planting into short lengths, 12 to 18 inches, and to drop these pieces in the furrows somewhat diagonally or otherwise, so that the ends will not touch.

Of sugar-cane diseases the one causing by far the greatest damage in the United States is the red-rot, caused by the fungus *Colletotrichum falcatum*. This disease is distributed throughout most of the sections where cane is extensively grown. The most serious damage from it has been reported from Louisiana and from the sections of southern Georgia and northern Florida where large areas are devoted to sugar cane. It does not seriously damage the growing cane or affect its sugar content, but it has caused great losses in the banks or windrows while 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. Until the nature of this disease, the manner of its propagation, and effective means for its control have been better worked out for our climate it is advisable to employ ordinary measures of field sanitation, such as (1) to avoid, as far as feasible, the devotion of the same area to cane without an interim of several years of planting to other crops; (2) putting away seed cane from new ground or from areas where there is reason to think the infection is not so great; and (3) trimming away the badly diseased portions of the stalks at planting time. It should be said, however, that it is not at present known to what degree these measures are efficient in lessening the damage from red-rot.

Root-rot (*Marasmius sacchari*) is responsible in some localities for considerable reductions in yields and especially for the dying out of stubbles, resulting in a poor stand. In the growing cane that is diseased it is noticeable in the earlier stages and in wet weather as a slimy growth between the leaf sheaths and the stalks near the ground, and later by a cementing of the lower leaf sheaths to the stalks with a whitish mold. In putting away seed cane such stalks, or at least the affected lower ends of them, should be rejected.

A number of other dangerous diseases and insect pests of sugar cane have appeared in many foreign countries, so that it is unwise to bring cane from any foreign country except through approved quarantine stations. Recognizing these dangers, the Federal Horticultural Board has instituted a strict quarantine against cane from all foreign countries. Any proposed exceptions to this quarantine against individual countries or parts of countries will have to be considered by this board on their merits, exemptions being made only after it is ascertained that the localities in question are free from dangerous diseases and pests or after methods of treatment are worked out which can be depended upon to exclude them. For the introduction of small quantities of cane of hopeful new varieties for propagating and testing, an avenue is open through the United States Department of Agriculture. They will be propagated under suitable quarantine isolation until it is ascertained that the samples harbor no dangerous pests or diseases.

The risk incurred in introducing cane from other regions is illustrated by an incident that occurred a few years ago. The United States Department of Agriculture introduced a small mail shipment of cane of a rare variety from Hawaii for propagation in Porto Rico, observing the precaution of planting it the first season in one of our quarantine greenhouses. In spite of the fact that the cane had been carefully selected and prepared for shipment by an official of the Hawaiian Sugar Planters' Experiment Station and that when the package arrived at Washington, D. C., it seemed to be free from pests and diseases, it developed during that season an abundant crop of the Hawaiian leafhopper, one of the most destructive insect pests that have ever been known to attack sugar cane. This simple precaution, which led to the subsequent destruction of the cane, doubtless saved the Porto Rican planters from losses by this pest such as the Hawaiian planters suffered, amounting in Hawaii at one time to millions of dollars annually and threatening the complete destruction of their great sugar industry.

SOME BUSINESS CONSIDERATIONS IN CONNECTION WITH THE SUGAR-CANE AND SIRUP INDUSTRY.

One of the first questions that a new settler in a sugar-cane and sirup-producing section will ask is "What profit can be expected from this branch of the farm business?" Even the old settlers and old sirup producers as a rule can profit by making a closer study of the farm-economics side of their industry. The publication here of data on the business side of the industry, collected from some of the best-informed farmers in the sirup belt of southern Georgia and northern Florida, may therefore be of interest. The subject will be considered under the several headings: (1) Equipment and capital invested, (2) cost of producing the cane, (3) cost of manufacturing the sirup, and (4) value of products and profits.

EQUIPMENT AND CAPITAL INVESTED.

Sugar-cane growing requires the best of land that the sections in question afford. While vast areas of land in these States can be bought at $10 an acre and less, it is not to be expected that such cheap lands have much value for cane production. There are large areas of flat coastal plains that are too sandy for profitable cane culture. One must expect to pay from $20 to $60 for good cane land in Georgia or Florida and about double this price in Louisiana. Good land well located for citrus fruits would command higher prices, and consequently would hardly be used for cane. Additional allowance must be made for the investment in improvements. To cover the interest on the land investment, together with expenses for upkeep, taxes, etc., the farmers in computing the cost of production of the cane in sections east of Louisiana must allow about $2 to $4 an acre as the annual rent for the land.

The implements required in the present practices in these localities are about the same as for other field crops, e. g., corn or cotton, and usually include small and large turnplows, middle breakers, harrows, a weeder, various forms of 1-mule cultivators with one or more points, a fertilizer distributor, and wagons; also hand implements, including hoes, shovels, etc. About the only special implements required for the cane are the cane knives and the stripping tools. Under such circumstances as have been suggested under the headings "Preparation of the land" and "Cultivating the cane" the farmer may add to his equipment a disk plow, a subsoiler, and 2-horse cultivators. There is thus to be charged to the sugar cane for implements such proportion of the total equipment of the farm as the area of sugar-cane land bears to the total area of cultivated land on the farm, or somewhat more, because the cane requires more work. The same may be said of the equipment in the line of work animals. In computing the cost of production of the cane in this bulletin the interest on the investment for work animals and implements is presumed to be covered by the expense for mule hire and labor.

It is proposed in another bulletin to give a detailed discussion of the sirup-making equipment. A summary only can here be given. An equipment very commonly used for small farms with the approximate cost of the several items consists of the following:

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 capacity of such an outfit would be about 6 barrels per day of 12 hours, disposing of one-third to one-half an acre of good cane a day. Assuming a 24-day grinding period, this outfit would suffice for a cane area of 8 to 12 acres.

For a small acreage, up to 3 or 4 acres, a horse mill and a round-bottom iron kettle outfit are frequently used, especially in old installations, the total outfit, including shelter for the kettle, costing about $125. For a larger area than 12 acres the tendency now seems to be to put in additional evaporators of the kind first mentioned and to install a larger mill, using steam power. Others, in order to secure a higher capacity, prefer to put in a steam outfit, including a boiler, steam engine, and steam vats for boiling the sirup. Such outfits with capacities ranging from 10 to 18 barrels of sirup per day of 12 hours (or more than double that capacity per day of 24 hours) may be estimated to cost from $2,000 to $6,000.

COST OF PRODUCING THE CANE.

Estimates of the cost of individual items in the production of sugar cane and sirup were obtained by the writer from many practical farmers in the sirup sections. These estimates varied somewhat as to itemization and operations, but the detailed statements of two of them, selected as representative, are here reported in full.

DETAILED ESTIMATE BY A GEORGIA FARMER.

The first of these detailed estimates was given in 1914 by a farmer in southern Georgia, basing the calculation on his extensive experience in cane culture and sirup manufacture, operating on a scale that would there be characterized as extensive. All common labor is computed at 75 cents a day for men and 50 cents a day for women. Mule hire is computed at 75 cents a day. To prepare the land, it is calculated that 1 man and 3 mules with a disk plow will break 2 acres a day, making the cost per acre as follows:

Breaking	$1.50
Harrowing	.50
Laying off, marking, and opening the furrows	1.00
Total (to prepare the land for planting)	3.00

In planting, a crew sufficient to plant about 6 acres a day is employed and the expense is computed as follows:

Hauling cane (4 men and 8 mules), hauling fertilizer (1 man and 2 mules), distributing fertilizer and helping to cover (1 man and 1 mule), covering (1 man and 1 mule); total for 7 men and 12 mules at 75 cents each per day	$14.25
Stripping the cane, cutting it into short lengths, and trimming off diseased portions (25 women), dropping the cane in the furrows (6 women); total for 31 women at 50 cents each per day	15.50
Overseers, two, at $1.25 each per day	2.50
Total (cost of planting 6 acres)	32.25
Cost of planting 1 acre	5.38

The cultivation and cost of fertilizer are computed as follows: Hoeing twice by hand, $1; six cultivations, 1 man and 1 mule covering 3 acres a day at each cultivation, for 2 days, $3; hauling and distributing fertilizer for second application, 50 cents; total cost of fertilizer, 1,500 pounds (10–3–5 formula), at $20 a ton (the normal wholesale price before the European war), $15.

Harvesting costs about $5 per acre. Hauling to the mill, assuming that the average distance is three-fourths of a mile and that 1 man and 2 mules will haul about eight loads a day, will be about $5 per acre.

Summarizing, the cost per acre, according to this farmer's estimates, is as follows:

Rental of land	$2.50
Seed cane in the banks	10.00
Breaking the land, harrowing, and marking and opening the furrows	3.00
Preparing the cane, hauling, and planting	5.38
Hoeing by hand	1.00
Cultivation	3.00
Second distribution of fertilizer	.50
Total fertilizer, 1,500 pounds	15.00
Harvesting	5.00
Hauling to mill	5.00
Additional time of overseers	3.00
Total cost of 1 acre of cane delivered at the mill	53.38

The allowance made for mule hire, 75 cents a day, is the usual rate. With good management, however, employing the mule profitably 200 days a year, the expenses for mule hire may be somewhat reduced, as is shown by the following computation made by the same farmer: Original cost of mule old enough to work, $250; average length of service of a mule, 10 years, with $75 per year for his keeping, $750; total cost for 10 years' service, $1,000. Assuming that the mule is employed profitably 200 days per year, the cost per day is 50 cents. However, as the time that the mule is actually employed profitably rarely averages 200 days per year, and to cover also the rental and deterioration of implements, the allowance of 75 cents a day is reasonable.

ANOTHER DETAILED ESTIMATE, BY A GEORGIA FARM MANAGER.

Another detailed estimate of the cost of cane production was obtained from the manager of a large estate in the same locality. He allowed the same wages for common laborers and for mules as was allowed in the preceding estimate, viz, 75 cents a day for men and mules and 50 cents a day for boys and women. He employed less labor, but for fertilizer he allowed more, making the total practically the same.

Breaking the land (1 man and 2 mules with a turnplow, about 3 acres a day); cost per acre	$0.75
Laying off the land (running occasional guide lines along hill slopes by the use of a farm level, leveling rod, and marker, 1 man at $2 a day, 2 men and a mule at 75 cents each per day); total $4.25 a day (to lay off about 30 acres); cost per acre	.15
Opening the furrow (with a spacing rod attached to the beam of the middle breaker, or judging the distance between rows by the eye, 1 man at $1 a day with 2 mules); total $2.50 a day (to open the furrows of about 7 acres); cost per acre	.35
Planting (stalks not cut in short lengths nor diseased parts trimmed off, with 5 women to take the cane from the banks and strip it, 1 man and 2 mules to haul it, 6 women to drop it in the furrows, 1 man and 1 mule to cover, 2 overseers at $1.50 and $2, respectively); total $12.75 a day (to plant about 5 acres); cost per acre	2.55
Commercial fertilizer, 9–2–3 mixture (first application, 800 pounds per acre in the furrow at planting; second application, 500 pounds during cultivation; third application, 500 pounds at laying-by time); total 1,800 pounds, at $22.50 per ton	20.25
Distributing the fertilizer by hand (with 2 men and 2 mules hauling and 2 boys and 2 women distributing); total $5 a day (to cover 6 acres at each distribution); expense per acre (3×⅙ of $5)	2.50

Summarizing the above, together with the other items involved, the cost per acre is shown to be as follows:

Rental of land	$2.50
Breaking the land	.75
Harrowing	.25
Laying off guide rows	.15
Opening the furrows	.35
Preparing, hauling, and planting the cane	2.55
Cane, 5 feet long, 2,000 stalks, at $5 per 1,000	10.00
Fertilizer, 1,800 pounds, at $22.50 per ton	20.25
Hoeing twice by hand	1.00
Cultivating 6 times	2.00
Distributing fertilizer 3 times	2.50
Harvesting	5.00
Hauling	5.00
Additional time of overseers	2.00
Total cost per acre of cane delivered at mill	54.30

SUPPLEMENTARY CONSIDERATIONS.

The estimates of a farmer in northern Florida who computed rent, labor, and seed cane much higher and fertilizer lower give a total of $69 an acre.

On smaller farms where the farmer and his family do much of the work the cost per acre will be about the same if reasonable wages are allowed for their time.

The total cost of production will be changed but little if seasonal conditions cause the yield to be extra small or extra large. Only the harvesting and hauling expenses would be decreased or increased.

The amount charged for seed cane, $10, assumes that there was only a moderate loss in storage. If the cane kept very well, this amount would be less, and if it kept very poorly, as has often happened in recent years, it would be more.

The cost of producing the first stubble crop is, of course, considerably less, owing to the fact that all expenses for preparing the land and planting are avoided, amounting in the first of the above calculations to $18.38. In its place, however, would come the relatively small expense of "wrapping the stubble," plowing the middles, barring off, and raking off the stubble, amounting to about $3.50 per acre. Since a poorer stand and a smaller crop are to be expected, the amount of fertilizer applied is also less. This reduction may be estimated at $4 an acre. The harvesting and hauling expense would be reduced about $1.50. Thus the cost of the stubble crop per acre would be about $53.38—($18.38+$4+$1.50)+$3.50=$33.

For the second-year stubble crop, with a further reduction of $2 in the fertilizer, harvesting, and hauling expenses, the cost would be about $31 per acre.

If we assume that $54 per acre is the cost of producing the first or plant-cane crop and delivering it at the mill, and if we further assume a yield per acre of 22 tons of cane and from it 15 barrels (equal to 495 gallons) of sirup, the computed cost of producing the cane and delivering it at the mill will be—

Per ton of cane	$2.45
Per barrel of sirup	3.60
Per gallon of sirup	.11

Similarly, if we assume that $33 per acre is the cost of producing the first-year stubble-cane crop, and if we further assume a yield per acre of 15 tons of cane and from it 10 barrels (equal to 330 gallons) of sirup, the computed cost of producing this crop of cane and delivering it at the mill will be—

Per ton of cane	$2.20
Per barrel of sirup	3.30
Per gallon of sirup	.10

Again, assuming that the cost per acre of the second-year stubble crop is $31, as above, and assuming a yield of 11 tons of cane and from it 7.3 barrels (equal to 240 gallons) of sirup, the computed cost of the second stubble crop delivered at the mill will be—

Per ton of cane	$2.82
Per barrel of sirup	4.25
Per gallon of sirup	.12

The assumptions as to the cost of production and yields made in the above calculations are based on good land under good management. In actual practice, the yields average considerably lower without a proportional decrease in the expense per acre. It will be noted that under the above assumptions the first-year stubble crop is produced more economically and the second-year stubble crop less economically per unit of the product than the plant-cane crop.

COST OF MANUFACTURING THE SIRUP.

Without going into details in this bulletin with respect to the manufacture of sirup, it must suffice here to give merely a summary of the manufacturing expenses, under two sets of conditions, viz: (1) With the small farm outfit, which includes a mill driven by a gasoline or kerosene engine and an evaporator of the Cook type; and (2) with the larger steam outfit, suitable for large farms. With the smaller of these two outfits, costing, as indicated under "Equipment and capital invested" (p. 34), about $600, the annual allowance for interest on investment, repairs, and deterioration should be about 22 per cent of the original cost. With the larger or steam outfit, assumed to cost $5,000, about 17 per cent should be allowed.

With the smaller outfit a capacity of about 6 barrels of sirup per day of 12 hours may be assumed. Assuming a grinding period of 24 days each year, the amount chargeable to each day of operating for interest on investment, repairs, and deterioration will be $600×0.22÷24, or $5.50. To operate such an outfit, putting the sirup into barrels, not cans, a crew of four men is required, with wages totaling about $4 a day.

Summarizing these and other items, the estimated cost per day to operate this plant will be as follows:

Interest on investment, repairs, and deterioration	$5.50
Wages of crew of 4 men	4.00
Gasoline, 9 gallons at 20 cents	1.80
Fuel (good-quality wood) for boiling, 2 cords at $1.50	3.00
Six empty barrels at $1.25	7.50
Total manufacturing expense:	
Per day, producing 6 barrels of sirup	21.80
Per barrel	3.63
Per gallon	.11

With the large steam outfit, assumed to cost $5,000 and to have a capacity of 40 barrels a day, running 24 hours a day on a double shift, with a crew of 8 men on each shift operating 24 days in the year, the daily expenses would be about as follows:

Interest on investment, repairs, and deterioration ($5,000 ×0.17÷24)	$35.42
Wages of two crews of 8 men each	22.00
Fuel (second-quality wood, but a long haul), 15 cords, at $1.50	22.50
Forty empty barrels at $1.25	50.00
Total manufacturing expense:	
Per day, producing 40 barrels of sirup	129.92
Per barrel	3.25
Per gallon	.10

Comparing the figures for the two outfits the following will be noted:

(1) The charges for interest, repairs, and deterioration are higher per barrel capacity in the large factory, because of the relatively larger amount invested.

(2) The labor employed is of a more expensive character in the large factory. The total outlay for labor, however, is less per unit capacity.

(3) A lower grade of wood can be used in the steam plant. However, the larger quantity needed necessitates hauling it for longer distances, thus making the cost per cord about the same. The total expense for fuel in the steam plant is considerably less per unit capacity than that of wood and gasoline combined in the small outfit.

(4) Upon the whole, the large steam plant, operating night and day, produces sirup at a cost of about 38 cents per barrel (or 1 cent per gallon) less than the small outfit, operating only 12 hours a day.

If the steam plant were operated only 12 hours a day the daily fuel consumption would be more than half and the daily sirup capacity would be less than half the estimates given, so that the large steam plant would be operated at an expense per barrel fully as high as that of the small outfit. An advantage, however, of the large outfit not shown in the operating costs is the fact that the mill would be more powerful, resulting in a higher extraction of juice from the cane, equal to about 4 or 5 per cent of the weight of the cane, thereby increasing the sirup yield from 5 to 7 per cent. In this increased yield appears to be the principal advantage of the big steam plant over the small outfit when both are run intermittently 12 hours a day.

VALUE OF PRODUCTS AND PROFITS.

Under the preceding two headings calculations were made upon the cost of production of the cane crop and of the sirup therefrom, basing the calculations mainly upon the experience in actual practice of well-informed farmers of southern Georgia and applying to a well-managed farm in that locality having good soil. In Table II are brought together the figures thus obtained, together with the calculated total cost of the finished sirup per acre, per barrel, and per gallon. The total cost is obtained by adding the cost of the cane, the expense of manufacture, and an allowance of 1 cent per gallon as the expense of marketing the sirup in bulk. For the expense of manufacture, the figures applying to the small outfit under the preceding heading, viz, $3.63 per barrel (or 11 cents per gallon), are used. Assuming a yield of 22 gallons (two-thirds of a barrel) of sirup per ton of cane, the cost per ton for making the cane into sirup is calculated at two-thirds of $3.63, or $2.42.

TABLE II.—*Summary of assumed yields of cane and cost of sirup production.*

Cane crop.	Computation based on tonnage yield of cane per acre.			Computation based on sirup production from an acre of cane.					
	Yield.	Cost of—		Yield.	Cost of—		Yield.	Cost of—	
		Cane at mill, per ton.	Sirup from ton of cane.		Cane at mill, per barrel of sirup.	Sirup, per barrel.		Cane at mill, per gallon of sirup.	Sirup, per gallon.
	Tons.			*Barrels.*			*Gallons.*	*Cents.*	*Cents.*
Plant cane	22	$2.45	$5.09	15	$3.60	$7.56	495	11	23
First-year stubble	15	2.20	4.84	10	3.30	7.26	330	10	22
Second-year stubble	11	2.80	5.44	7.3	4.25	8.21	240	12	24

The varying degrees of remuneration or profit per acre which will accrue to the manager (who is ordinarily the owner) in return for his time, at different prices for sirup, are shown in Table III.

TABLE III.—*Remuneration or profit per acre to the manager or owner.*

Crop.	Profit per acre when the price of sirup per gallon is—			
	23 cents.	25 cents.	30 cents.	40 cents.
Plant cane	0	$9.90	$34.65	$84.15
First-year stubble	$3.30	9.90	26.40	59.40
Second-year stubble	[1] −2.40	2.40	14.40	38.40

[1] No remuneration; crop produced at a loss.

Table III shows that under the favorable conditions assumed in these calculations and with normal seasonal conditions the price for sirup in bulk must be above 23 cents a gallon to afford any remuneration or profit to the owner or manager. In actual practice the conditions average less favorably, as is shown by the fact that the average yields of cane, as given in census reports, are far below the above-assumed normals. This may be due to a variety of causes, such as poor soil, unfavorable seasonal conditions, and poor management.

It is not assumed that the conditions shown by the calculations here used fit the case of other farmers without some modifications, or even of the same farmers for other years. The figures, however, have here been set forth in such detail that it should be easy for any farmer to make a similar calculation as to the cost of production on his farm. He may have more expensive land and will have to compute higher rental; he may be able to get along with less fertilizer; he may be able to use his labor more efficiently with better implements or otherwise; he may get smaller yields or perchance larger ones, etc. He can substitute figures fitting his conditions and compute the cost to him of the production of the cane or the sirup. Thus the Florida farmer previously mentioned who estimated the cost of the plant-cane crop at $69 an acre will find that his sirup from this crop costs him $8.56 per barrel (or 26 cents per gallon) if the yield and the manufacturing expense are the same. In the case of the second illustration of the cost of cane production, if the farmer could by a different rotation, plowing under a leguminous crop or otherwise, reduce his fertilizer bill by half without reducing his yields, it would increase his profit per acre $10, reducing the cost of sirup by 67 cents per barrel, or 2 cents per gallon. The fuel item is bound to increase as timber gets scarcer unless means are provided for using a cheaper grade of fuel (dead and down timber, slab wood, or coal if near the railway). If varieties or methods of treatment could be discovered that would enable the farmer to increase the yields of his stubble crops or allow him to take off more stubble crops with high yields before replanting, the profits per acre would be greatly increased. Table II shows that the higher the price of sirup the greater is the advantage in profit per acre of the plant-cane crop over the stubble crops, provided our assumption that the yield of the first-year stubble crop is only two-thirds and the second-year stubble crop only half that of the plant-cane crop corresponds to the facts.

The price of sirup in the general market in recent years has ranged from 28 to 35 cents per gallon. In the fall of 1914 the price was abnormally low, leading many farmers to go out of the business or to reduce their acreage. In the fall of 1915 it took a sharp upward trend, reaching 40 cents, or even more. This was when sugar also was abnormally high, but it was due mainly to the abnormally short crop. This shortage in turn was due to two causes: (1) Severe droughts in the principal sirup-producing sections and (2) a small acreage, which, in its turn, was due to low prices the previous year and to much spoilage of seed cane reserved for planting. In many sections the local demand for sirup exceeds the supply. In such cases the sirup producers usually get a much better price, viz, from 35 to 50 cents a gallon—even higher if they have the reputation of making a product of extra good quality.

By present practices the farmer's income from the sugar-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 by-products: (1) The leaves and tops, (2) the bagasse (pomace, or mash), and (3) the skimmings, all three of which are almost completely wasted under present practices.

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 to stock, but as a rule they soon become weathered and worthless for feed. Some attempts have been made at curing the tops to feed in the winter,

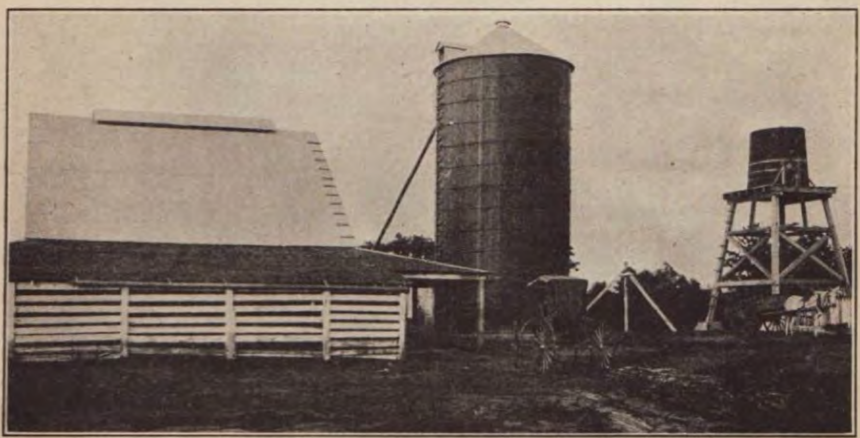

FIG. 18.—A silo in Louisiana built especially for sugar-cane tops.

but the weather conditions are usually unfavorable unless the farmer has shelter in which to cure them. A more hopeful method of preserving them is by making ensilage of them. (Fig. 18.) At the experiment field at Cairo, Ga., experiments were conducted during the last two years which indicate that siloing for feed is an excellent way to utilize the tops. The cattle took the silage readily and thrived on it. The chemical analysis showed it to be but little inferior to silage from whole corn in nutritive value. A characteristic sample upon analysis gave percentages as follows: Moisture, 75; ash, 1.71; crude protein, 1.93; crude fiber, 9.23; ether extract, 0.47; nitrogen-free extract, 11.66. The acidity, normal alkali per kilo, was 124 c. c. 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 in filling 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 ensilage.

From these experiments it is evident that the main question with the farmer in this method of utilizing the tops is no longer whether it makes good feed, but rather whether he has the labor and teams available at the time to collect and haul the tops and to fill the silo. It was found in these experiments to require only an insignificant amount of extra time on the part of the toppers to throw the tops into heaps, 8 to 10 feet apart, while they top the cane. The work of collecting the tops and filling the silo is therefore the main consideration. Important additional value comes from the manure resulting from feeding these tops. In these same localities, where the systems

FIG. 19.—A pile of bagasse, or pomace, after sirup-making time.

of farming in vogue tend so strongly to deplete the soil of its humus content, the manure has unusually high value.

The bagasse, or pomace, accumulates in vast heaps at the sirup mills and at present finds but little use. (Fig. 19.) 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 in 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 fresh applications of 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 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 ensilage 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 ensilage. In a single test made at the experiment field at Cairo, Ga., the results were encouraging, but the product was abnormally sour, probably owing to insufficient tramping and to the fact that the cane was badly frostbitten before grinding. Fermentation had proceeded so far that the bagasse was thoroughly infected with the acid-forming microorganisms before it was put into the silo. For making ensilage the bagasse has the advantage that it would involve practically no extra expense for collecting and hauling, assuming that the silo is not far from the mill. To pack well in the silo, some water must be supplied while filling. 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.

The skimmings on most farms are wasted. Some sirup makers allow them to settle over night, or for a half 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 readily be rinsed out each morning sufficiently clean so that fermentation would start but slowly after refilling with skimmings. It was thus 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 suitable tap holes about 1½ inches from the bottom of each such container, the clear juice from the preceding day's boiling could each morning be drawn off and boiled with fresh juice to make sirup. Wooden containers can not be cleaned so satisfactorily and in them fermentation starts more rapidly. 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, Ga., 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.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO SIRUP PRODUCTION.

AVAILABLE FOR FREE DISTRIBUTION.

Sorghum Sirup, Manufacture. (Farmers' Bulletin 477.)
Muscadine Grape Sirup. (Farmers' Bulletin 758.)

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Manufacture of Table Sirups from Sugar Cane. (Chemistry Bulletin 70.) Price, 10 cents.

Experiments in Culture of Sugar Cane and Its Manufacture into Table Sirup, Report on Investigations Conducted at Waycross and Cairo, Georgia, in 1903 and 1904. (Chemistry Bulletin 93.) Price, 20 cents.

Experimental Work in Production of Table Sirup at Waycross, Georgia, 1905, together with Summary of Four-Year Experiment on Fertilization of Sugar Cane. (Chemistry Bulletin 103.) Price 10 cents.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
10 CENTS PER COPY
▽