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

STORING CANE BY BANKING

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

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

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

WHEN TO STORE

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

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

DISEASES OF SUGARCANE

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

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

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

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

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

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

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

RED ROT

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

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

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

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

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

MOSAIC

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

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

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

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

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

CHLOROTIC STREAK

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

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

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

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

ROOT DISEASES

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

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

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

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

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

RED STRIPE

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

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

BROWN STRIPE

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

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

POKKA BOENG

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

OTHER DISEASES

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

INSECT PESTS OF SUGARCANE

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

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

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

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

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