Breeding varieties that resist red rot and have other essential qualities is the main problem to be met in the development of sorgo for sugar production.

Neither the leaf diseases nor red rot is yet amenable to economic control through the use of fungicidal dusts or sprays. Practical control depends on varietal resistance. In the genetic material now available to the sorgo breeder, resistance to all of the important diseases fortunately is present in one or more varieties.

The task of combining through breeding this resistance with the other qualities that would be required of a commercially adaptable sugar-producing sorgo is being carried forward by sorgo breeders in the Department.

While encouraging progress has been made, hybrid varieties satisfactorily meeting all of the requirements have not yet been produced.

E. V. Abbott is a pathologist in the Bureau of Plant Industry, Soils, and Agricultural Engineering.

P. E. Bouchereau is a pathologist of the division of sugar plant investigations of the Bureau, and has headquarters at Beltsville, Md.

Sugar cane and Its Diseases

E. V. Abbott

Sugarcane is native to or is grown in some 50 countries or political units within approximately 40° north latitude to 32° south. It is an important crop for thousands of small farmers with only a few acres. It also is the basis of large plantation enterprises. It is native to the Eastern Hemisphere, but since the Second World War the Western Hemisphere has produced about 55 percent of the world’s cane sugar.

Sugarcane is commonly thought of as a thick-stemmed, tall grass, cultivated in tropical regions for the production of sugar from its juices. That conception is correct only in a limited sense. It does not take into consideration the numerous wild forms of the sugarcane genus Saccharum that are not thick-stemmed, high in sucrose content, or grown in tropical regions.

Even the present commercial sugarcanes often disappoint the person who sees them for the first time, particularly in the southern United States, where, instead of the large-stemmed, broad-leaved sugarcane of the textbook, the visitor finds a plant with narrow leaves and stalks of more slender girth—a plant that, while possibly lacking some of the physical attractiveness of its noble-type ancestors, has gained the vigor, disease resistance, and adaptability to other elements of its environment that are essential in this section. It is, in fact, a new plant, created to meet specific requirements through the
blending by cross-breeding of the so-called noble and wild forms of the genus *Saccharum*.

The known forms of sugarcane are classified into five species: *Saccharum officinarum*, the traditional sugarcanees, which have thick, soft stems, broad leaves, and attractive appearance and therefore are commonly termed "noble" canes; *S. barberi*, the slender-stemmed canes of northern India; *S. sinense*, also slender-stemmed types, native to China; *S. spontaneum*, native to continental and insular Asia and to parts of Africa, a diverse group of grassy forms, which do not have direct commercial use for sugar production, but which are important sources of vigor and disease resistance in breeding; and *S. robustum*, wild forms of great vigor, indigenous to New Guinea and some adjacent islands.

Disease epidemics are known to have occurred in Mauritius and Reunion in the 1840's and in Brazil in the 1860's. Complaints of "degeneration" were heard elsewhere. Since the true nature of the difficulties was not understood at the time, however, the outbreak of sereh disease in Java in the early 1880's, which seriously threatened the industry there, stands out as of greater historical importance because of its influence on the future of sugarcane breeding and disease investigations. Sereh disease, presumed to be caused by a virus, forced a complete change in field practices, including the adoption of an expensive system of growing seed cane in elevated areas and the abandonment of ratoons. Satisfactory control was not attained until the Black Cheribon variety was eventually replaced with more resistant ones.

Sereh did not become widely distributed over the sugarcane-growing areas of the world. But another virus disease, mosaic, which was first observed in Java in the early 1890's, was carried to practically every cane-growing country before its true nature and seriousness were suspected. In most of them it assumed epiphytotic proportions that forced changes in varieties and caused enormous economic loss. In Louisiana, where it was superimposed on varieties already declining from the combined effects of root rot and red rot, it brought the industry to the brink of ruin in the 1920's. No other sugarcane disease has attained the universal importance of mosaic; yet, while it can still be considered a potential danger wherever it occurs, it has become one of the first major sugarcane diseases to be brought under a satisfactory degree of control in most countries through the development of resistant or tolerant varieties.

A third trouble, which caused widespread concern to the sugarcane world beginning in the late 1890's and continuing into the present century, was attributed to what was variously termed root rot, root disease, or root disease complex. In Java, the West Indies, Hawaii, Louisiana, and elsewhere, the declining yields and crop failures of the period were attributed in varying degree to root disease, but with less than universal agreement as to the specific cause. In the West Indies in particular, some of the losses at first attributed to root disease were later found to be due to red rot.

Species of the fungus genus *Marasmius*, to which the noble cane varieties are susceptible, were at first believed to be the main cause of root disease, but *Rhizoctonia* and other fungi were also blamed by some workers. Those fungi, however, are much less aggressive parasites than a member of the genus *Pythium* (*P. arrhenomanes*), which later was found to be the chief cause of root rot. Nevertheless, while all of the factors concerned in the growth difficulties of the period were not correctly diagnosed at the time, it was concern over root disease that stimulated the search for resistant varieties and the investigations that led to a better understanding of this and other diseases and their control.

**Besides sereh and mosaic, five other diseases of sugarcane assumed to be**
of virus nature have been identified—Fiji disease, streak, chlorotic streak, dwarf, and ratoon stunting.

There have been unverified reports of the occurrence of serch in the Philippines, Formosa, and India, but it has not assumed commercial importance outside Java. The disease has no certain diagnostic symptoms. Its effects vary widely on different varieties. A composite picture would include the extreme stunting of affected plants, with the arrested growth of successive shoots in the stool and a bunch-grass appearance; sprouting of the lateral buds on affected canes into leafy shoots; and excessive production of aerial roots at the nodes. No insect vector has been determined.

Fiji disease, named for the islands in which it was first observed, was identified in 1910, although it is believed to have been present there for at least 20 years before it was recognized as a disease. It caused serious loss to the industry of the islands before being brought under control by the use of resistant varieties. It has been definitely identified only in New Guinea, Queensland, and the Philippines, outside of Fiji. The disease causes extreme stunting of affected plants. It has one distinctive diagnostic symptom—the elongate galls it produces on the veins of the under surface of the leaves. Its insect vectors are members of the genus Perkinsiella.

Streak is also of limited geographic distribution. Its known occurrence is confined to South Africa, Egypt, India, and the island of Mauritius. It is characterized by the production of many narrow, elongate, sharply defined white streaks on the leaves. Its principal effect on the plant is reduced growth, with consequent loss in tonnage. While causing important loss to the Uba cane predominant in South Africa at the time of its discovery, losses have been greatly reduced by the substitution of more resistant clones. Its insect vector is Cicadulina mbila.

A comparative newcomer in the list of sugarcane diseases is chlorotic streak, first observed and described in Java in the late 1920s. It has since been found in Hawaii, Australia, Mauritius, Puerto Rico, Louisiana, and British Guiana. It is most prevalent and severe in cane growing on heavy, poorly drained soils, where it may markedly reduce germination, growth, and ratooning. Its only known insect vector is the leafhopper Draculacephala portola.

Two other diseases, presumed to be caused by viruses, dwarf and ratoon stunting, have been described in Queensland. Dwarf is not known to occur elsewhere, but what is apparently the same as the ratoon stunting disease was identified in the United States in 1952. This disease is of particular interest because it has no well-defined symptoms other than the retarded growth of affected plants. Because of this insidious nature, its presence was not suspected until experiments showed that the growth stunting could be transmitted. It is transmitted in infected cuttings, by knife cuts, and by inoculation of seed cuttings with juice of infected plants.

In any plant that is propagated vegetatively, as sugarcane is, with the seed pieces consisting of succulent stems rich in carbohydrates, it is not surprising that rots of the seed cuttings are serious causes of poor stands. At each node of the stem is an axillary bud, which, when planted under required conditions of moisture and temperature, germinates to produce a new plant. Also at the node is a narrow band of rudimentary root buds from which the rootlets develop as the shoot bud germinates. The young plant depends on these roots, called seed roots, until it has produced sufficient stem tissue of its own for the permanent root system, or shoot roots, to develop. The seed roots are only temporary, but they serve the plant during a critical period between germination of the bud and establishment of the system of shoot roots.
Commercial practice with respect to the use of planting material varies in different countries. In the Tropics, where the high temperatures and adequate moisture usually favor a quick germination of the buds, the immature upper parts of the stem are used for planting. The more mature lower part of the stalk is left to be milled. In the subtropical sugarcane areas, such as Louisiana, where low temperatures following planting often mean a delay of several weeks before the new plants are established, the whole stalk is used as seed. It may be planted without segmenting, but more often is cut into shorter sections before planting, or, as in Louisiana, after being laid down in the furrow. In the Tropics, where there is little delay in germination of the buds after planting, seed-rotting diseases are much less important than in the subtropical fringes of the sugarcane-growing area, such as Louisiana, India, South Africa, and Queensland.

Of the seed-rotting diseases, red rot is one of the most serious. It rivals mosaic in its nearly universal distribution in the sugarcane world. First described in Java in 1893, it has since been identified in all countries where sugarcane is important.

A second widely distributed seed-rotting disease is caused by Ceratosporium sacchari, and Phytophthora species (in Louisiana).

Although association of a species of Pythium with sugarcane roots was noted in Java in the 1880's, a member of this genus was not implicated as a primary cause of root rot until some 30 years later. During the intervening years, when root disease occupied such a prominent place in the minds of those concerned with the varietal troubles of the period, its true cause was not recognized.

In fields of young cane where the plants have a general unthrifty appearance, pythium root rot (Pythium arrhenomanes) is to be suspected. On the highly susceptible noble varieties, destruction of roots by the disease causes severe wilting and yellowing of the leaves, stunting, and sometimes death of the plant. Deficient tillering is also characteristic. On the more resistant hybrid varieties now commonly grown, the above-ground symptoms are less marked, though the effects of the disease may be recognized in the stunted growth, shortened internodes of young plants, deficient tillering, and (during hot, dry weather) varying degrees of yellowing of the leaves and wilting. When such plants are dug up, pythium injury is evident in the flabby, water-soaked appearance of the young roots, rotted root tips, and a deficiency of secondary roots. In stubble or ratoon fields, root rot often prevents or greatly delays sprouting of the stubbles, with resultant gappy stands and frequent failure.

Differences in the physical, chemical, and biological conditions of the soil exert an important influence on the severity of root rot. So marked is this influence that early workers sometimes
cited one or another soil condition as the sole cause of root rot. In Louisiana, as elsewhere, the disease is more severe on soils with a high percentage of clay, mainly because of the greater moisture-holding capacity of those soils and their poorer drainage, which results both from their texture and commonly lower-lying position in the field. Aside from the fact that the higher moisture content generally associated with soils of heavy texture is favorable to the Pythium, the presence of toxic organic compounds in such soils may predispose the cane plant to infection by the fungus.

The main injury occurs during winter and early spring, when low temperatures and commonly excessive moisture resulting from heavy rainfall and poor drainage provide good conditions for the root rot fungus. Destruction of the seed roots by root rot or other causes may thus interfere directly with satisfactory establishment of the new plants and indirectly by favoring the spread of rots in the seed piece as a result of the delayed germination. Injury caused by root rot during the winter may not be fully evident until some months later, when during hot, dry weather the plants with deficient roots may suddenly wilt and die.

As with other diseases of cane, the losses caused by root diseases have been greatly reduced by the breeding of resistant varieties. Nevertheless pythium root rot is still a factor in areas such as Louisiana, where on inadequately drained soils the disease may cause injury in winter. It may, in fact, be more important than is generally believed, because of the absence of well-defined symptoms and the difficulty of fully appraising the role of a growth-retarding disease that is active only on the roots and that has effects so closely related to those of seed-rotting diseases.

Basal stem rot, attributed to Marasmius sacchari, was found in Java in 1895, but it was soon discovered that the organism only rarely was associated with true root rot. However, during the next 20 to 30 years it was quite generally assumed in several other countries that the conspicuous Marasmius (including also M. stemphyllus) was the cause of root rot. On the susceptible noble varieties then grown, Marasmius doubtless was a contributing factor in the root-disease complex, but later investigations disclosed that Pythium is the primary cause of root rot troubles. The disease caused by Marasmius has therefore assumed an historical role out of proportion to its true importance.

Basal stem rot affects the lower part of the stem both above and below ground level. The sheaths commonly are tightly cemented to the stem by the mass of grayish-white mycelium, from which the toadstool fruiting bodies arise. Young shoots may also be invaded and are sometimes killed. Healthy and actively growing plants are seldom attacked, but the disease may further injure those already weakened by root rot, which probably accounts for its greater development during periods of drought when the effects of true root rot are most pronounced. Of minor economic importance, the disease now is less prevalent than formerly because the more resistant hybrids have replaced the susceptible noble types.

Smut (Ustilago scitaminea) is characterized by the production from the growing point of a long, whiplike shoot, often several feet in length. The smut spores are scattered when the membrane covering this shoot bursts. Infection takes place through the seed piece and through the axillary buds of the growing plant. Germination of buds from infected cuttings may be seriously reduced, the plant is stunted, and ratooning ability is weakened.

Until 1941 we thought the disease occurred only in the Eastern Hemisphere. It was discovered in 1941 in Argentina and later in southern Brazil. It has caused serious losses in
Argentina. In Brazil it appears to be localized in occurrence.

The noble canes are resistant. Where they have been the predominant varieties, the disease has been of less importance than where varieties carrying ancestry of S. spontaneum and S. barberi were grown. The latter fact makes it potentially important for the southern United States, where breeding lines and commercial varieties carry a strong infusion from those two species.

Two fungus top-rotting diseases are of minor importance, pokkah boeng, caused by Fusarium moniliforme (Gibberella fujikuroi), and dry top rot, caused by Plasmodiophora vascularum. First described in Java, pokkah boeng, a Javanese term meaning damaged top, has since been noted in most of the important sugarcane countries. Injury varies from slight chlorosis and splitting of the base of young unfolding leaves to top rotting, which may kill the growing point. While common in certain susceptible varieties during warm, rainy weather, it is seldom of commercial importance.

Dry top rot causes drying, wilting, and sometimes death of the plant because of clogging of the vascular tissues of the lower part of the stalks. First described in Puerto Rico, it has not been found outside the Caribbean area.

Of the several fungus leaf diseases of sugarcane, only two, eyespot (Helminthosporium sacchari) and downy mildew (Sclerospora sacchari), are of major importance.

Eyespot is widespread and was serious in Hawaii and Florida until susceptible varieties gave way to resistant ones. The principal loss is from the reduced growth and lowered sucrose content of the juice that result from the destruction of leaf area. The disease produces elongate, oval spots, which at first are water-soaked, then yellowish, and later reddish brown, and are surrounded by a yellowish halo. Size of the lesions varies accord-

ing to the resistance of the variety. On susceptible varieties long runners develop from the ends of the lesions. Sometimes they extend most of the length of the leaf. Coalescence of the reddish-brown lesions and runners may give a fired appearance to the leaf. The disease is favored by cool, moist weather.

Downy mildew occurs only in the Eastern Hemisphere. Once a major disease in Queensland, it has been controlled by the use of resistant varieties. It makes yellowish-green streaks on the leaves between the veins, a whitish down on the under surface composed of the mycelium and spores of the fungus, and pronounced abnormal elongation of some of the canes, causing them to stand out like flags 2 to 3 feet above the surrounding plants. The elongated part of the stem is extremely thin. The leaves are sparse and stunted. In the late stages, affected leaves become shredded by the death of tissue between the bundles. The disease seriously reduces growth. Transmission is by wind-borne spores that infect the immature lateral buds, through which the disease is transmitted to the new plants.

Corn and teosinte are also susceptible. Species of the genus Sorghum become infected, but they are resistant and there is little likelihood that they are factors in spreading the disease.

Other leaf diseases that are generally of minor importance, but sometimes of local importance, are brown spot (Cercospora longipes), yellow spot (Cercospora kopkei), brown stripe (Helminthosporium stenospilum), and ring spot (Leptosphaeria sacchari). All but yellow spot occur in the Southern States.

Four diseases caused by bacteria have been described: Gummosis (Xanthomonas vasculorum), leaf scald (X. albilineans), red stripe (X. rubrilineans), and mottled stripe (X. rubrisulbicans). Gummosis and leaf scald are regarded as major diseases. Local outbreaks of red stripe have been serious. Mottled stripe is of minor importance.
Gummosis is the oldest disease of sugarcane to be recognized as such. It was described in Brazil in 1869. Its cause and true nature were not determined until some years later. It is believed to be native to Brazil, from which it was apparently carried in seed cuttings to Mauritius, Australia, and Fiji. It also occurs in several islands of the Caribbean area. In all countries where it occurs it has caused epidemics that were brought under control only by changing to resistant varieties. Consequently it has subsided to a position of potential rather than actual major importance.

It is primarily a disease of the vascular system. It receives its name from the slimy gum that oozes from cut ends of affected stalks. Yellowish streaks, usually dotted with red or brownish spots, are produced on the leaves, usually near the tips. Narrow at first, they may broaden to about one-half inch in width and elongate to nearly the length of the leaf. Frequently they widen to a V-shape toward the apex of the leaf, the tips and margins of which become dried and withered. Top rotting may result when the terminal bud is invaded. That often is followed by shooting of the lateral buds. The disease is transmitted in infected cuttings used for seed and by knife cuts and other means of physical contact.

Leaf scald used to be confused with gummosis, but the two were eventually recognized as distinct diseases. Like gummosis, scald is primarily a vascular disease, but differs from the former in the type of streaks produced on the leaves and in the absence of oozing of gum from cut ends of diseased stems.

The leaf streaks begin as sharply defined, narrow, white pencil stripes which may extend the entire length of the blade and onto the sheath. As the leaves grow older the streaks tend to broaden and become more diffuse. There may be only one or several streaks on a leaf. Sometimes, instead of the definite stripes, the entire shoot is chlorotic to nearly white. Diseased plants have a characteristic stunted appearance and the terminal whorl of leaves curves inward at the tips, which are often dried or withered. Sprouting of the lateral buds beginning at the base of the stalk is characteristic and may occur when there is no apparent injury to the top. In the acute stage, some shoots or the entire stool may suddenly wilt and die. The disease causes marked reductions in growth, tillering, and ratooning ability of susceptible varieties.

The known distribution of leaf scald was limited to the Eastern Hemisphere and Hawaii, but in 1944 it was found in Brazil and in 1950 in British Guiana. The disease is highly infectious. It is spread through infected cuttings, knife cuts, and probably by other means of physical contact. Insect vectors of the disease are not known but the disease may be spread by rats.

Red stripe produces narrow, sharply defined blood-red stripes, which may be short or extend nearly the length of the leaf. They are usually more prevalent on the younger, fully unfolded leaves; when conditions particularly favor the disease, however, infection spreads to the younger leaves and the growing point, often resulting in top rotting. The rot may extend into the mature portions of the stem to ground level, and is accompanied by a characteristic disagreeable odor. At one time the disease had some importance in several countries, but outbreaks now are infrequent and localized.

Weather markedly affects the severity of several diseases of sugarcane and sometimes may be a determining factor in their distribution. Red rot, for example, is important as a rot of seed cuttings only in the subtropical fringes of cane-growing regions in the Temperate Zone, while in the warmer Tropics, where uniformly high temperatures favor quick germination of the cuttings after planting, it is of minor importance.

Prolonged periods of wet, cool weather, such as commonly occur in Louisiana in winter, are unfavorable
for the germination and growth of sugarcane, but they favor the development of fungi that cause seed rots and root rot. Growth of cane is slow between 60° and 70° F., temperatures which may occur for considerable periods during the winter months, but the fungi causing red rot and root rot are able to grow at those temperatures. Consequently, if the red rot fungus has gained entrance into the seed piece, it will continue to develop during cool periods when the cane is unable to grow. Likewise, the young rootlets produced by the cane during relatively warm periods may be attacked and largely destroyed by root-rotting fungi when their growth is checked by cool weather. For the same reason, freezing temperatures that kill leaves and shoots of young cane in winter or spring may cause more damage than merely killing the foliage itself. The cane plant loses what progress it has been able to make during favorable periods and because of exhaustion of food reserves may not be able to recover. But the disease organisms do not lose the progress they have made. Instead, they may continue to develop, destroying roots and further depleting food reserves in the seed cuttings. Therefore young cane that apparently has established a good stand may fail to recover following a freeze, and stands may die out during cool, wet spells in the spring even though a freeze does not occur.

During the growing season, particularly in summer, hard, dashing rains and winds aid in the spread of fungus and bacterial diseases that affect the leaves and stalks of cane. Dissemination of the stage of the red rot fungus occurring on the leaf midribs is favored in this way. The leaf disease, brown spot, spreads most rapidly during the rainy summer months. The top-rotting diseases, pokkah boeng and red stripe are most severe during hot, humid weather. Eyespot, on the other hand, is favored by cool, humid weather. The leaf diseases, brown stripe and mottled stripe, and the basal stem rot caused by Marasmius are more prevalent during dry weather.

Certain diseases are more severe on some soils than others. It is common experience that root rot, red rot, and other seed-rotting diseases are more severe on the heavy clay soils than on the lighter-textured sandy soils. That largely is due to the higher moisture content of such soils resulting both from their physical structure and consequent greater moisture-holding capacity, but often also from their lower-lying position in the field, which makes drainage more difficult. Those conditions are unfavorable for germination of sugarcane seed cuttings and for root development, but they do favor root- and seed-rotting organisms.

Aside from those more obvious relationships, other biological factors are involved. Toxins may develop under the partial anaerobic conditions that often prevail in waterlogged soils. Antibiotic organisms affect sugarcane pathogens. Soil biological problems as related to sugarcane diseases have not been studied adequately. From practical experience, however, it is known that improvement of drainage results in increased yields, partly because there is less injury from diseases. Chlorotic streak is more prevalent and severe on heavy, poorly drained soils than on lighter, well-drained ones. That fact has been observed in all countries where the disease has been studied, but the reason for it is not known. As we have no proof that the causal agent is soil-borne or that the activity of the one known vector (Draculacephala portola) is related to soil differences, it may be that the less favorable growing conditions for cane on heavy soils influences the metabolism of the sugarcane plant in such a way as to make it more susceptible to the disease.

The sugarcane grower controls diseases mainly by replacing susceptible varieties with resistant varieties.
As a result of the ceaseless race between the growers and diseases, with the resultant never-ending varietal changes, probably no group of farmers is as conscious of varieties as are the growers of sugarcane. So spectacular have been some of the past achievements resulting from replacement of disease-susceptible with resistant varieties that to many growers a new variety still holds the possibility of a miracle and often, unfortunately, a fascination that cannot be resisted when the opportunity arises to obtain a new variety from other than approved sources.

Many diseases owe their spread from their native habitats to other countries to this search for new varieties. An unrecognized disease often is introduced in a variety that was brought into a country in an effort to overcome one already there. Before it was recognized as an infectious disease, mosaic was thus distributed over most of the sugarcane areas, and gummosis moved from the Western to the Eastern Hemisphere. Belated recognition of what was occurring resulted in the institution of quarantines in most countries, prohibiting the importation of sugarcane except through authorized government-controlled agencies. While those measures have greatly deterred the further distribution of diseases, as evidenced by the numerous interceptions that have been made in quarantine, they have not been entirely successful. Smut and leaf scald have become established in South America and chlorotic streak in Louisiana since the institution of quarantines.

Doubtless some of the earliest spread of diseases from one country to another resulted from the desire of migrating peoples to carry their favorite eating canes with them in moving from one region to another. It may be assumed that some of the early unrecorded dissemination of disease occurred in this way, while in more recent times importation of contract laborers who carried chewing canes with them is believed to have been the means of spreading the diseases.

The chance discovery of Kassoer, the supposedly natural hybrid between the wild cane of Java and the Noble Black Cheribon, which proved to be resistant to sereh, presented dramatically to the Dutch scientists the possibilities of obtaining disease-resistant varieties through the crossing of different parent stocks. The result has been the development in many cane-growing countries of breeding programs, a primary aim of which is the production of resistant varieties.

Observations of differences in reaction to disease among varieties of different species of sugarcane led to a search for resistant germ plasm by breeders and pathologists.

Forms of *S. officinarum*, noble canes, were almost universally the world's commercial sugarcanes before the outbreaks of epiphytotics of disease. Because of disease susceptibility, few now remain in large-scale commercial cultivation. They are, however, important in breeding work as sources of many of the qualities required in a commercial cane other than disease resistance, such as large diameter of stalk, low fiber, and good quality of juice. With few exceptions, the noble varieties are susceptible to the major diseases, including mosaic, sereh, streak, red rot, root rot, and gummosis. As a group, their greatest resistance is to smut, although some varieties are also resistant to leaf scald.

Varieties of *S. barberi* are generally susceptible to red rot. They are susceptible to, though tolerant of, mosaic. They are intermediate in resistance to pythium root rot, moderately susceptible to smut, and resistant to sereh, streak, and gummosis.

The wild, grassy members of *S. spontaneum* are important sources of resistance to several diseases. They are resistant to sereh, pythium root rot, and gummosis; some of them are resistant to red rot and (with the
SUGARCANE AND ITS DISEASES

exception of the forms from Turkestan) are resistant or immune to mosaic. On the other hand, they are susceptible to smut, Fiji disease, red stripe, downy mildew, and some of the leaf-spotting diseases.

Forms of *S. sinense* are resistant to sereh, pythium root rot, gummosis, and generally to mosaic. They are very susceptible to smut. Most forms for which there are records are susceptible to red rot and streak. This species has been used relatively little in breeding.

Relatively few forms of *S. robustum* have been tested for disease resistance. In the United States they have proved to be susceptible to mosaic, pythium root rot, and intermediate in resistance to red rot. Both resistance and susceptibility to gummosis have been recorded. Fiji disease and downy mildew have been observed on them in their native habitat in New Guinea.

Compared with the use of resistant varieties, other means of controlling sugarcane diseases are less important. Disease injury sometimes may be minimized by planting at such time as to escape severe infection or by avoiding the planting of varieties susceptible to certain diseases in soils where the effects of such diseases are most severe.

Progress has been made in the control of the seed-cane rot, pineapple disease, by the use of protective fungicides in South Africa, Hawaii, and Queensland. For several reasons, economical methods for the use of fungicidal seed treatments have not been developed in the southern United States. Certain leaf-spotting diseases could be controlled by the application of fungicides but the losses caused by them are not sufficient to justify the expense.

Considerable work has been done on the control of the diseases by treating the seed cuttings with hot water. The pioneer experiments in this field were done by the Dutch in Java in an effort to control sereh, and it has since been tried there and elsewhere as a curative for other diseases that are transmitted in the seed cuttings. Various temperatures and time intervals have been used, as a result of which exposure at 125.6° F. for 20 minutes is generally considered the standard treatment. Mature buds of most sugarcane varieties can be subjected to the treatment without injury; in fact, it usually results in stimulation of germination. Lower temperatures or shorter periods of exposure may not be effective in killing the disease organisms, while higher temperatures or longer intervals of exposure frequently injure the cane buds.

The standard hot-water treatment eliminates infection by the virus diseases sereh and chlorotic streak and the bacterial disease gummosis. It is partly effective against leaf scald and is not effective against mosaic or streak. Spores of some leaf-spotting fungi that may be present on the cuttings are killed by the treatment. Although certain diseases can be controlled by the hot-water treatment and some increase in germination and yields of cane often results aside from any control of the diseases, the treatment has not been widely adopted in plantation planting. That is because the benefits derived generally have not been sufficient to justify the expense. A deterrent also is the fact that the very exact temperature control required is often difficult to maintain in large-scale handling of the bulky seed material. If the temperature falls below the required level, the purposes of the treatment will not be accomplished; if it goes much above, the cane buds may be injured. Hot-water treatment is widely used by quarantine authorities in the movement of planting material from one country to another.

E. V. Abbott is a pathologist in the division of sugar plant investigations of the Bureau of Plant Industry, Soils, and Agricultural Engineering. He is stationed at Houma, La.