MARASMIUS SACCHARI; A PARASITE ON SUGAR CANE

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Marasmius sacchari was discovered in Java and described in 1895 by Wakker who believed it to be a parasite on sugar cane and the cause of a disease of the roots. His ideas have been very generally accepted from that time to the present, but some few workers have questioned the parasitism of the organism and its importance as a pathogene. These differences of opinion led the writer to conduct the studies which are recorded in this paper.

The Java growers and their scientific advisers did not believe that this fungus was the lone cause of the troubles they were having at that time and employed Dr. Z. Kamerling to devote all his time to the problem. His studies from 1900 to 1903 resulted in several papers and a book on root diseases of sugar cane. He suggested soil conditions, poor aeration and mechanical injuries are the true causes but his evidence has not been considered as conclusive by the students of the subject.

The second report of the disease was from the West Indies where it was studied by Howard of the Imperial Department of Agriculture from 1899 to 1902. He accepted the work of Wakker but he did not demonstrate the pathogenicity of the fungus. He said,—

"The common root disease of the sugar cane in Barbados is caused by the fungus *Marasmius sacchari* Wakker, the mycelium of which is able, under certain conditions, to overcome the growing point tissues of the developing roots of the cane."

He described the symptoms as follows,—

"Black elliptical areas, surrounded by a reddish border, are also abundant on the leaf-sheaths, which are in some cases slimy to the feel on the inside after a rain, when hard, yellowish, spherical bodies, about the size of a small pea, attached to the outside of the leaf-sheaths by whitish threads are to be seen."

In his discussion he states the sporophores follow the rains and that they dry up quickly; that the mycelium is septate with clamp connections; that the root cap and cortex are invaded by the mycelium and the tissues killed; that the periblem and pleurone are invaded and the growing point destroyed; that the undeveloped roots are marked by brown spots; that new shoots may be killed; that

the vascular bundles may show gumming; and that the pea-like bodies are sclerotia.

He also states that the spore germinate in cane extract in 90 minutes and form stellate colonies; that crystals form at the growing ends of the mycelium in about seven days; that some of the filaments become gelatinous in about 12 days, which probably accounts for the cementing of the sheaths; that rhizomorphs are formed on the sides of the glass containers; that it becomes dormant very readily; and that he demonstrated that the sporophores were developed from the mycelium.

In his discussion of the symptoms, he said that the diseased canes were dwarfed and tended to throw up young shoots; that the dead leaves adhered to the stalk and were cemented together by a white, musty smelling, fungoid growth. The canes could be pulled easily, owing to the destruction of the roots and were very light. The roots do not develop or stop growing very early. The lower leaf bases are difficult to remove. The vascular bundles are reddish in color. As the canes mature, cavities are formed in the internodes and become filled with the mycelium of the fungus.

Cook and Horne (1907) reported a root disease from Cuba which was apparently due to *Marasmius*. The following year, Horne reported *M. sacchari*.

Lewton-Brain (1905) reported a *Marasmius* from Hawaii which he believed to be the same as *M. sacchari* of the West Indies. The following year, Cobb classified this fungus as a variety under the name of *Hawaiiensis*.

In 1909 Cobb wrote as follows:

"Since that bulletin was published other specimens of Marasmius have been found on the island of Oahu that correspond more nearly with the Javanese species, and leave no doubt that we have in Hawaii the same fungus that causes the root-disease of Java and the West Indies, as reported by various observers. It seems possible that the variety Hawaiiensis may have to be raised to the rank of a species, as the differences are even more marked than I had thought from a reading of the descriptions of the species sacchari."

"In the variety Hawaiiensis the young fructificactions were white, while in certain specimens, found later, they are broken. While the upper surface of the pileus in variety Hawaiiensis is smooth, in the specimens here referred to it is radially fibrous, the color being light brown and the fibres hardly projecting sufficiently to produce an actual hairiness."

"These specimens of the true *M. sacchari* are quite as large as the specimens of the variety Hawaiienses described in Bulletin No. 5, and therefore exceed the dimensions given in the original descriptions of the Javanese species."

"They accord more nearly with the size of the specimens of *M. sacchari* found in the West Indies."

In 1908 Fulton reported *Marasmius plicatus* Wakker as being the cause of heavy losses in Louisiana. Some years later Rinking reported this species growing on rotted stems in the Philippine Islands.

Edgerton (1910) writing of the root rot caused by *Marasmius plicatus* says:

"This disease attacks both the cuttings and the growing cane. On the growing cane, it kills the roots and grows in between the lower leaf sheaths. The leaf sheaths are not shed as is the case with healthy cane, but remain glued together around the stalk. If some of these are pulled apart, a network of white mycelium will be seen between them."

"On the cane which is used for seed, this disease will also develop. I have seen it to some extent in nearly every batch of cane which has been sent me this year. The mycelium enters the cut ends of the stalk and grows through them. The disease is readily told by the presence of the white strands of mycelium which may be on or in the stalk. Sometimes the eye is killed before germinating, and sometimes the young plant is killed after germination."

Johnson and Stevenson (1917) published a paper on sugar cane fungi and diseases in Puerto Rico in which they record *Marasmius sacchari* Wakker, *Himantia stellifera* Johnston, *Odontia saccharicola* Burt and *O. sacchari* Burt growing at the base of cane stalks and apparently attacking the roots.

They say:

"The exact status of root diseases with respect to the parasitism of *Marasmius, Himantia, Odontia* and possibly other forms is uncertain, and while it is generally held that *Marasmius* at least is a true parasite, really definite evidence is lacking. Studies under control conditions must be carried out working with pure cultures of the fungi which has not yet been possible."

In their discussion of *Marasmius sacchari*, they said,—

"The injury caused is primarily upon the roots. The mycelium enters the roots, disintegrates the tissues and prevents a proper absorption of water and nutriment from the soil. As a result of this injury to the roots there is the secondary effect upon the development of the plant. According as the attack is severe or mild, the host shows a varying amount of leaf curling, a dwarfing of the stool, and often an early succumbing to less vigorous parasites such as *Melanconium.*

"Injury to the roots can be ascertained by direct examination, a slow tedious process, or to a certain extent can be diagnosed by symptoms above ground. The fungus itself eventually appears on the cane above ground, growing within and upon the lower leaf-sheaths, sometimes one-half or two-thirds the height of the stalk. The external appearance is a white mycelial growth, which is conspicuous by its rather smooth membranous appearance in contrast to a distinct filamentous growth. Tearing away the affected leaf-sheaths reveals the fact that they are decayed, and are glued together as it were by the membranous growth, to the underlying sheaths and the stalk. The decay of the lower sheaths may or may not in itself be of great importance, but the binding of the leaf-sheath to

the stem is very undesirable from the view point of the mill worker who prefers clean cane.''

''This fungus, like some others, appears to make great headway when once it has attained a strong foothold on the host. Thus the fungus may develop well on plant cane without doing appreciable injury, but may increase its foothold on the ratoons so as to do double the injury. As a result of this action it is a common sequence that plant crops are fair in certain localities, the first ratoon is considerably poorer, and the second ratoon often dies out completely. The damage may be restricted to one or a few stalks on a stool, or more commonly it may affect an entire as well as one or more adjacent stools to form the characteristic spots, or more rarely large portions of the field are entirely affected.''

''The injury to the plant may be considered threefold: the growth of the plant is checked often to the point where no merchantable cane is produced, the matter of clean cane is rendered difficult, and the cane becomes more susceptible to other diseases.''

The geographical distribution of *M. sacchari* and related species may be summarized as follows,—*M. sacchari* has been reported from Java, India, Australia, Formosa, Hawaii, Porto Rico, Jamaica, Lesser Antilles, British Guiana and South Africa. *M. plicatus* from Java, Philippines and United States; *M. stenophyllus* from Santo Domingo and Lesser Antilles; *Marasmius* sp. from Fiji, Central America and Brazil; and *Hypochnus sacchari* from Cuba and Jamaica.

Matz, Earle and some others did not believe that *M. sacchari* was an important parasite. In 1920 Earle said:

''*Marasmius* is at best a very feeble parasite. It may over-run new healthy roots or other organs without killing them.''

After a discussion of *Rhizoctonia* and *Pythium* he says:

''Nothing could be more convincing than that these heretofore unsuspected species and not *Marasmius* and its allies are the true root-killing agents.''

Matz (1920) said:

''It was noticed that in the *Marasmius* pots, although the white threads of the fungus had penetrated through the upper three or four inches of soil, the growing roots of the cane seed were not affected in any unusual way. Mycelium was observed on some roots but no rotting took place. However, after three months from inoculation there could not be seen any appreciable difference in the growth between any of the inoculated plants and those used as checks.'' * * * ''Four months from inoculation the pots inoculated with *Marasmius* produced the fruiting stage of the fungus at the same time the cane plants were among the tallest and most vigorous ones.''

When the inoculated plants were removed from the soil, Matz states that—

''in the case of *Marasmius*, although the fungus mycelium was plainly visible in amongst the soil particles, yet the roots did not show as much decay as in

the first two (i. e. *Rhizoctonia* and *Pythium*). * * * The roots of the check plants were normal.''

In speaking of another experiment he says:

''Although the fungus mycelium of *Marasmius* was in contact with the roots there were no signs of decay in them.''

Van der Bijl (1921) of South Africa says:

''A soil fungus common in cane fields is *Himantia stellifera*, 'the stellate crystal fungus'. This fungus is evident at the base of the cane, cementing the basal leaves together, and when the cane stool is opened interwoven white threads of the fungus are also seen in the ground between the cane roots.''

''In smothering the young buds the fungus lessens the stand in ratoon crops, and it has also been observed to prevent the growth of planted cuttings.''

''It is responsible for killing the rootlets, of the cane, and it thus weakens the plants and makes them more liable to attacks by other fungi; and with a diminished root system the plants are in periods of drought not in the best position to obtain from the soil the water it still contains. Plants having their roots attacked by this fungus invariably suffer more from the effects of drought.''

''Under the microscope this fungus is easily distinguished from all others by the stellate crystals which are borne on branches of the vegetative threads of the fungus. These crystals have given the fungus the popular name of 'Stellate Crystal Fungus'.''

''In addition to cane, the fungus has been observed on the 'umthente' grass *(Imperata arundinacea)*, and it probably occurs and vegetates on other grasses as well.''

''On cane the fungus is of the nature of a weak parasite and control methods should aim at thorough cultivation to ensure a vigorous growth of cane, conservation of soil moisture, and aeration of the root system.''

In 1921 there was a severe outbreak of root rot on EK 28 in Java, which was studied by Dr. J. Kuyper. In his opinion this disease was not due to a parasite but to soil conditions and to stagnant water in the soil.

Matz (1921) of Porto Rico described and discussed the relationship of several species of *Rhizoctonia* to root rots and Bourne of Barbados gave proof of the pathogenicity of *R. solani* and *R. palida*. Bourne said:

''The writer has confirmed the observations made by Matz relative to the absence of the fungus *Marasmius sacchari*, Wakker, binding the basal leaf sheaths to the stalk in otherwise typical cases of root disease. Indeed, in some instances other common saprophytic fungi, e. g., *Trichoderma lignonum* were present to the exclusion of *Marasmius*. Thus it is evident that in Barbados as in Porto Rico the presence of either one or both of these latter fungi commonly associated with decaying leaf sheaths and cane bases is of no significance whatever and may or may not be associated with typical cases of root disease, depending on whether they happen to form part of the fungus flora of the soil giving rise to root diseased plants. Some plants are so seriously attacked that they are only about

one-half the size of those in their immediate vicinity which apparently have not yet contracted the disease but which did so a few weeks afterwards. The yellowish unhealthy appearance of the leaves of these attacked stools was very significant when a comparison was made with those plants which were not yet suffering from the disease although growing in the same field quite close to the former."

"*Marasmius sacchari* has never been isolated from freshly diseased and dying cane roots but only from dead ones."

Nowell in his Diseases of Crop Plants in the Lesser Antiller (published about 1922 or 1923) says:

"Instances have on several distinct occasions come under the observation of the writer in young plant canes in Barbados, and recently in fields of first ratoons in Trinidad, in which plants growing in good well-tilled soil and previously healthy and vigorous have rapidly failed, and have been found to be heavily infested with *Marasmius*, not only on the roots and leaf-sheaths, but in the tissues of the basal joints of the cane. In such cases the fructificactions of the fungus have been produced with unusual readiness and in considerable quantity."

"The attacks on plant canes have occurred in somewhat scattered stools during the dry season. On one occasion numbers of stools Ba. 6032 were quite killed out in this way, while plants of B–6450, in the same field, which were not nearly so forward, were unaffected. The basal joints, and the sprouting buds in all stages were internally reddened and filled with *Marasmius* mycelium. This type of disease agrees with the effects of *Marasmius sacchari* as first described by Wakker in Java, where the ordinary West Indian type, presumably owing to the scarcity of ratoons, does not seem to be familiar. In Barbados *M. sacchari* was the species met with in the cases described."

"The most striking instance seen in Trinidad was in a field of Hill's Seedlings 6 to 12, unusually well-grown first ratoons in deep and fairly heavy loam, sufficiently drained. Very many of the large canes were badly infested or completely rotted for several joints at the base, the parts above remaining sound until dried up by the cutting off of their supply of water. The young leafy shoots were also dying upwards owing to infestation in their base. The stools were exceedingly loose in the soil, and many were turned out by the weight of their own canes. An unidentified species of *Marasmius*, with bluish black stalks, was fruiting abundantly from the roots, the root 'eyes' on the stem, and the young shoots. Other fungi were not conspicuous."

"While no proof can be offered, the cases described, and others similar, present the appearance of active parasitism by *Marasmius* species. The Barbados examples were attributed to the weakening of resistance by drought, and stools not completely killed recovered after rain. The sudden failure of the Trinidad field described could only be attributed to the effect of a second dressing of sulphate of ammonia on a soil already almost depleted of its small supply of lime."

Lyon (1923) of Hawaii published a paper in which he said,—

"An intensive study of root-rot in the field and laboratory conducted by Larsen and Lyon served to demonstrate that *Ithyphallus* * and *Marasmius* had no

* This fungus was reported as the cause of a root-rot in 1906, but further studies have failed to prove its pathogenicity.

primary connection with epidemic root-rot in Hawaii and that other fungi were responsible for the destruction of the cane roots. These fungi were taken up in turn but each failed to qualify under test as the primary cause of root-rot. Finally by transferring diseased cane stools from diseased to healthy fields, it was demonstrated that these fungi could not materially check the growth of the cane plant if the soil conditions were right. Evidence deduced from extensive field studies and many experiments performed seem to prove that the cause of root-rot in Hawaii was some non-parasitic factor resident in the soil and to indicate that this factor was in the nature of a poison.''

''It is a fact recognized by all pathologists that the ultimate destruction of the tissues of the root system is brought about through the action of organisms dwelling in the soil. This is, of course, the fate of all roots that die from any cause whatsoever, so the decay of roots induced by organisms does not, by any means, prove that the death of the roots was due to these organisms. Among the organisms found in cane roots in areas where root-rot is prevalent are several forms with pronounced parasitic abilities. They are capable of attacking, and do attack, live cane roots, bringing about the destruction of the latter. The only question is: can they, unaided, destroy the roots rapidly enough to produce root-rot in cane? Some pathologists say that they can, while others say that they cannot unless the vitality and resistance of the cane is first reduced or broken down by some non-parasitic factor in the soil. We are, therefore, confronted with two opinions regarding the primary cause of root-rot and we may profitably consider each in turn as correct and see what course should be followed under the circumstances.''

Earle in 1927 referred to the work of Matz on *Rhizoctonia* and *Pythium* and said:

''He also showed that pure cultures of *Marasmius* had not such effect, but that the cane roots continued sound even when envolved in masses of conspicuous white mycelium. * * * No evidence has been adduced to show that either *Marasmius* or the other hymenomycetes found on cane roots are ever parasites. They may interfere somewhat with normal growth but they do not kill roots.''

He also said,—

''A considerable number of contributory causes of root disease have already been indicated. Doubtless the list could be extended, but the fact would remain that the great majority of cases are caused by a bad physical condition of the soil, resulting in lack of aeration for the roots. Like all living things, the cane roots must have oxygen in order to function properly. If the soil is unduly compacted or heavily crusted the supply is interfered with. If the soil becomes waterlogged for even a few days, trouble is almost certain, for cane is not an aquatic plant and its roots cannot take their oxygen supply from water. Probably lack of drainage is responsible for more cases of root disease than all other factors combined. Standing water for even a few days is almost certain to weaken the roots. The effects will probably not be observed until the first sharp drouths, when the rolling of the leaves and other symptoms of root disease will appear in all those spots where there has been standing water. Obviously such cases could be avoided by proper drainage, especially if accompanied by prompt tillage as soon as possible after heavy rains to break up surface crusting and to so open up the compacted soil as to permit air to enter freely.''

Faris and Allison (1927) said,—

"The field studies show root disease to be associated with lack of aeration in undrained soils, with high salt content of the soil, with drouth and resultant cracking of the soil, with high cutting and surface application of fertilizers, with infertile soils, and with the attacks on the roots of several * * * insects and other small animals."

In 1929 Bell published A Key for the Field Identification of Sugar Cane in which he gives the following discussion:

"Root-rots of the *Marasmius* type are those caused by weak parasites which are only capable of entering and parasitising the roots after the latter have been weakened by unfavorable soil conditions or damaged by the small animal life inhabiting the soil. These rots are characterized by the fact that they affect the cortex only, and the fungi are apparently unable to penetrate the endodermis and destroy the stele or conducting tissue. The roots consequently retain their rigidity and do not become flaccid as happens in the pythium type of rot, where the stele is destroyed. A fungous rotting of the cortex of the older portions of the roots is accepted as a normal process and probably does little or no harm. When the plant is weakened these fungi are enabled to enter the cortex of the young roots, causing a brownish-red, and destroying the growing tips of the primary and secondary roots. Abnormal branching of the roots follows and the tips of these branches are in turn killed, and as a result of the greatly reduced root system diseased stools are often very easily uprooted from the soil. Such fungi are often associated with a cementing of the lower leaf sheaths, a common occurrence in the rot caused by *Marasmius sacchari,* when the leaf sheaths are bound together by a white mycelium. In the later stages of the rot caused by *Marasmius sacchari* it is often possible to find the small mush-room-like fruiting bodies at the base of the diseased stools."

Carpenter (1932) of Hawaii presented a paper to the International Society of Sugar Cane Technologists in which he said,—

"Growth failure of cane in Hawaii embraces a division of the diseases coming within the category of root disturbances into two main forms: (1) Miscellaneous failures fundamentally nutritional in nature, caused by faulty soil conditions in restricted areas, (2) root disease caused by *Pythium aphanidermatum* accelerated by excessive amounts of nitrogenous nutrients for the particular variety."

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"Emphasis in our growth-failure investigations has gradually shifted from studies of the parasitic root diseases which have now been clarified, to consideration of the soil conditions at fault in the localized areas where cane does not grow normally. The great majority of persistent growth-failure areas appear to be naturally poor soils where cane has never grown well."

During the past few years the writer's attention was called very frequently to plants which were making poor growth: The lower leaves were dead and bound together and to the base of the plant with a weft of white mycelium which extended both above and below ground. Young canes were sometimes killed but it was impossible to

say that they had been killed by this fungus. The roots were very generally in bad condition but it was impossible to say that it was due to the fungus. The symptoms, character of the fungus and the presence of occasional sporophores indicated that we were dealing with *Marasmius sacchari* but it was evident that no definite statement could be made from field observations only.

Laboratory studies proved that the fungus could be isolated very easily and that it grew well in culture, especially on pieces of cane that had been sterilized in the autoclave, but some difficulty was experienced in growing it on living cane. This was overcome by growing sterilized cuttings in glass cylinders and inoculating with the fungus grown on sterilized cane plugs as follows:

(1) A small amount of water was put in the bottoms of glass cylinders which were about 15 inches in height and sterilized in the autoclave. (2) Pieces of cane about two inches in length and bearing one bud were sterilized in 1 to 1000 corrosive sublimate solution, dipped in sterilized water and then dropped into these tubes. (3) The fungus was isolated and grown first on agar and then on plugs of sterilized cane in test or culture tubes. (4) A reasonable time was allowed to make sure that the cuttings were sterile and that the fungus was making a good growth on the plugs. (5) The inoculated plugs were then dropped into the tall tubes at intervals so that young plants of various ages might become infected. Sometimes the plug was placed in contact with the cuttings and at other times in contact with the young shoot.

The fungus grew rapidly, spreading over the surface of all parts of the cutting except the part which was submerged in the water. It also covered the roots above the water but not those that were below the surface. It attacked any part of the young shoot with which it cane in contact, gradually penetrating and completely covering the smaller ones. Buds that were covered early never germinated. Young shoots were killed more quickly than the older shoots.

Young cane plants were grown in sterilized soil and inoculated by pushing infected cane plugs down into the soil beside them. The growth of these plants was dwarfed but none of them killed.

Large plants grown in unsterilized soil in the green house were cut and infected plugs were pushed into the soil beside them. Some of these plants did not grow well but it was impossible to say definitely that the fungus was the cause of the poor growth.

HISTOLOGY

When small amounts of agar containing mycelium were placed in contact with the young canes growing in glass cylinders, the results were negative in most cases, probably because of the rapid drying of the agar. When plugs of sugar cane, which had been inoculated with the fungus were placed in contact with young canes growing under the same conditions, the mycelium spread over the surface of the cane very rapidly and caused a darkening and a killing of the tissues and eventually a killing of the plant. Micro-preparations were made from these infected plants and the story is told in figures 1 to 5. The fungus formed a mass of mycelium over the surface and between the leaves (Fig. 3). It penetrates the cells of these young plants very readily and could be found in all cells except those with very thick, hard walls such as are found in the fibro-vascular bundles. In case the inoculated plugs are brought into contact with the tip of the young cane the mycelium may penetrate the young part of the fibro-vascular bundles.

Sections were made of infected roots and the fungus found in all parts, although less abundant in the cells of the fibro-vascular bundles (Fig. 1).

DISCUSSION

The studies recorded in this paper indicate that *Marasmius sacchari* is a very common and widely distributed saprophyte which grows abundantly on dead fragments of cane and that under favorable conditions it may become an important parasite.

It attacks leaves, stems and roots and there is no more reason for calling it a root parasite than for calling it a leaf or stem parasite. It attacks young canes and kills considerable numbers of them. I am unable to say just how important it is or just what conditions are most favorable for its growth. When the growth of the cane is retarded it may come in as a secondary factor and do much damage to the crop. It is a common parasite on old and dying cane.

It attack seed cuttings, covering them with a weft of mycelium, killing the buds and causing them to rot, but the decay is not so rapid as that cause by *Thielaviopsis paradoxa*.

The symptoms are quite definite but some of them may be due to other causes. The binding of the leaves at the base of the cane is one of the most distinctive characters on growing cane. Young canes may be killed and completely covered with mycelium. Seed pieces may be completely covered with mycelium and the buds killed. The presence of the fungus on cane does not necessarily indicate that it

is the cause of retarded growth or the death of the cane. The cane may be weak or have died from other causes and *M. sacchari* may be secondary. The writer has never found sporophores or any other than dead canes.

The parasitism of the fungus cannot be doubted. The writer has demonstrated that the mycelium will penetrate the tissues readily and kill growing cane.

The environmental factors are very important and there is much truth in statement of Kuyper, Earle, Lyon and Carpenter concerning soil and water but none of these workers have demonstrated that the fungus is not a parasite. The fungus can nearly always be found on cane that has made a poor growth as a result of soil and water conditions that are unfavorable for the growth of the cane and it can be found also on cane that has been injured or retarded by other fungi.

The writer has found many dead shoots in fields which were evidently killed by this fungus although most of the cane was making an excellent growth. Poor drainage is an extremely important factor, especially in the killing of the buds on seed pieces.

In general it is of minor importance but the losses are sometimes greater than are attributed to it by most growers. Good soil, proper use of fertilizer, good preparation before planting, good drainage and good cultivation are most important factors in the control of this fungus.

SUMMARY

1. The fungus is a vigorous saprophyte, which can be found in abundance on fragments of cane and cane leaves in and on the surface of the soil. Also on the old dead leaves of growing canes.

2. The mycelium frequently cements the leaves and checks the growth of the canes, but its presence does not necessarily indicate that it is the cause of the retarded growth or the death of the cane.

3. The fungus is a parasite and penetrates roots, leaves and stalks of young canes very readily.

4. It kills a small percentage of young canes and sometimes injures older canes. These losses depend on soil and climatic conditions and vary with the seasons. They are probably less than some reports indicate and greater than is indicated by others.

5. The fungus sometimes attacks seed cuttings and kills the buds. The writer has one record of a killing of 20 per cent.

6. The writer has not observed the pea-like bodies which Howard described as sclerotia but has observed the large sclerotia formed by

Rhizoctocnia grisea which was described several years earlier as *Sclerotium griseum* Stevenson.

7. The writer has demonstrated that the fungus will grow from old material or from a pure culture and penetrate the living tissues of canes growing in glass cylinders or in sterilized soil in pots.

8. The fungus penetrates the canes, leaves and roots and will kill many of them when the conditions are favorable.

9. A considerable amount of the fungus either in or outside the cane appears to be necessary for the production of sporophores.

10. Sporophores were produced in my cultures, on cane grown in cylinders, in from two to four months after inoculation.

Explanation of Plates

PLATE XIX

A young shoot killed by *Marasmius sacchari* in the field.

PLATE XX

Two shoots grown in glass cylinders. The one on the right shows the first mature sporophore grown by this method.

PLATE XXI

right shows the first mature sporophore grown by this method.

Left; cane grown in ordinary field soil.

Right; cane grown in soil of the same kind that had been sterilized and then inoculated with *Marasmius sacchari* by pushing infected pieces of cane in the soil.

PLATE XXII

Seed cutting covered with *Marasmius sacchari*. One bud killed. Two shoots heavily infected with the fungus.

PLATE XXIII

Figure 1. Cross section of root from surface to center showing mycelium in the cells; also (*a*) mycelium on surface, c marks the center of the root.

Figure 2. Cross section of young leaf showing mycelium in the cells, a, upper epidermis.

Figure 3. Cross section of older leaf showing mycelium in cells and on surface a.

Figure 4. Large parenchyma cells containing mycelium.

Figure 5. Parenchyma cells next to fibro-vascular bundles, showing mycelium in cells.

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PLATE XIX

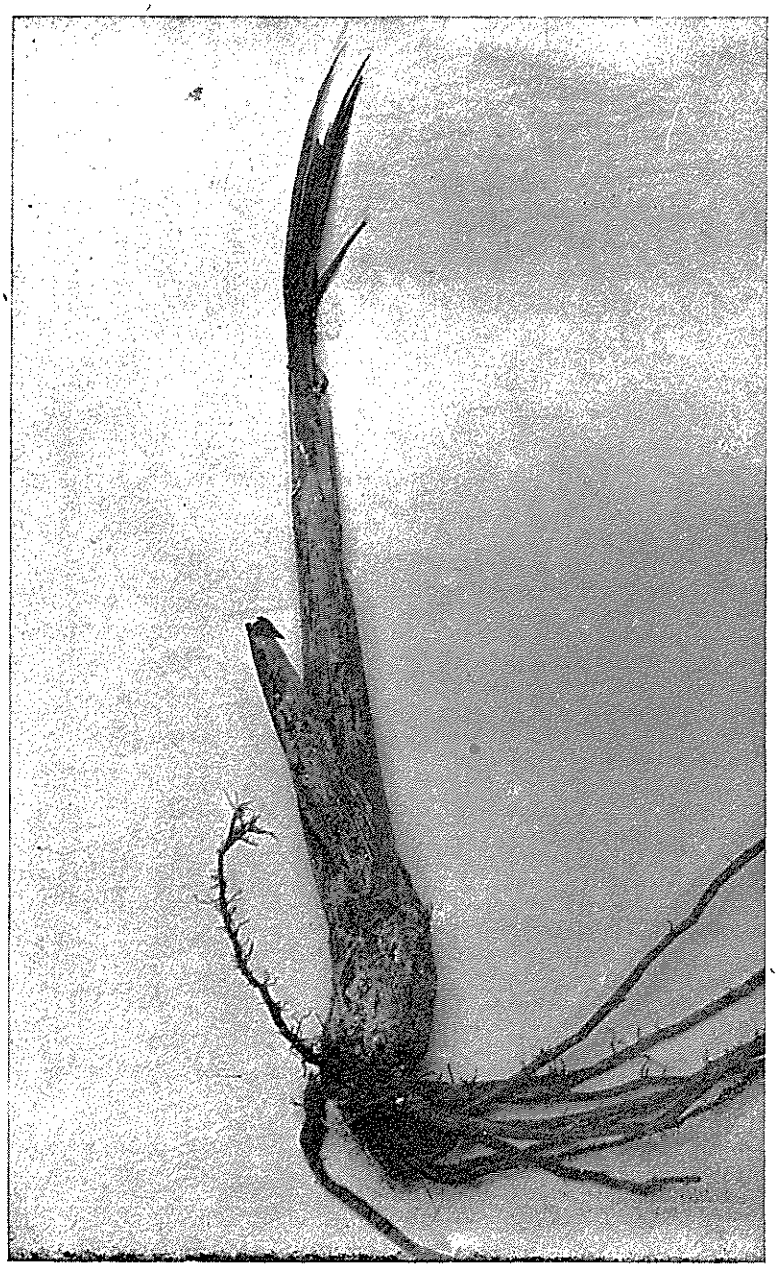


PLATE XX

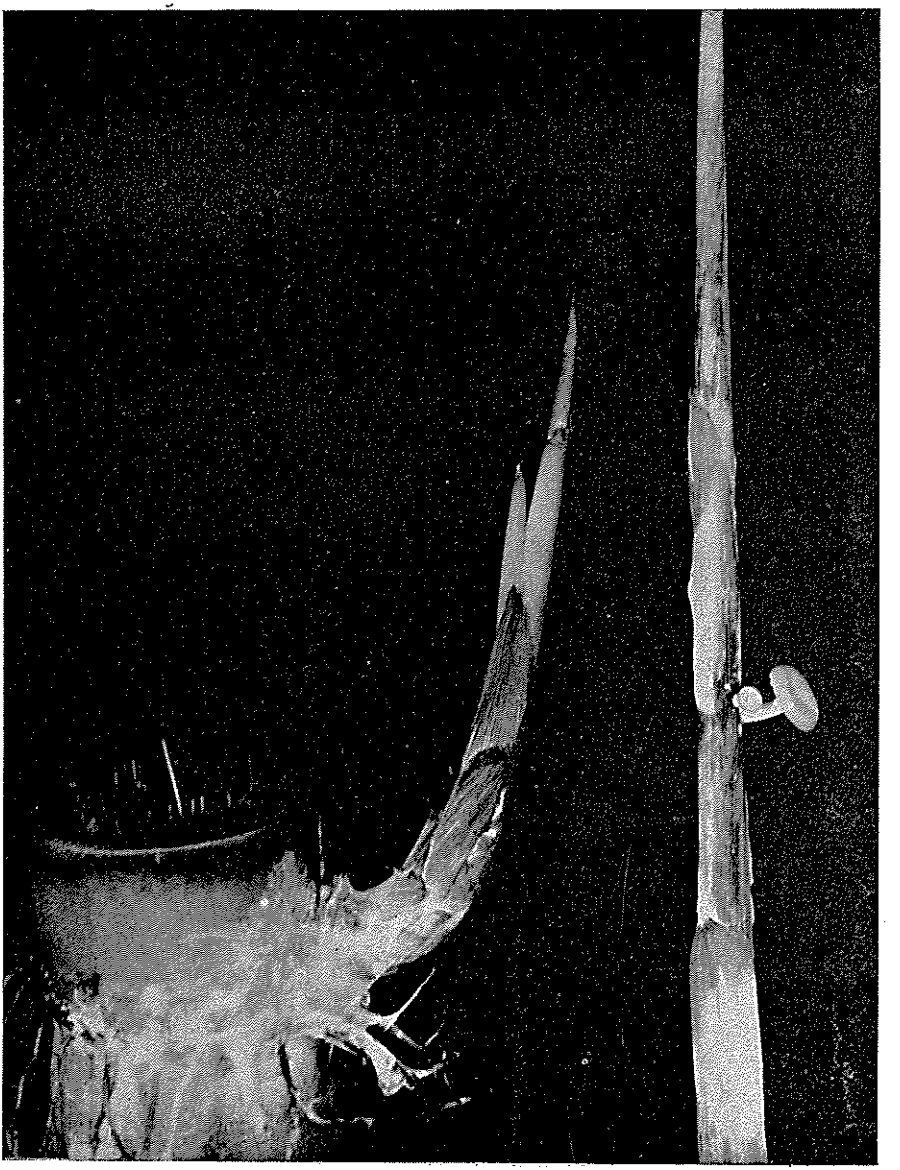
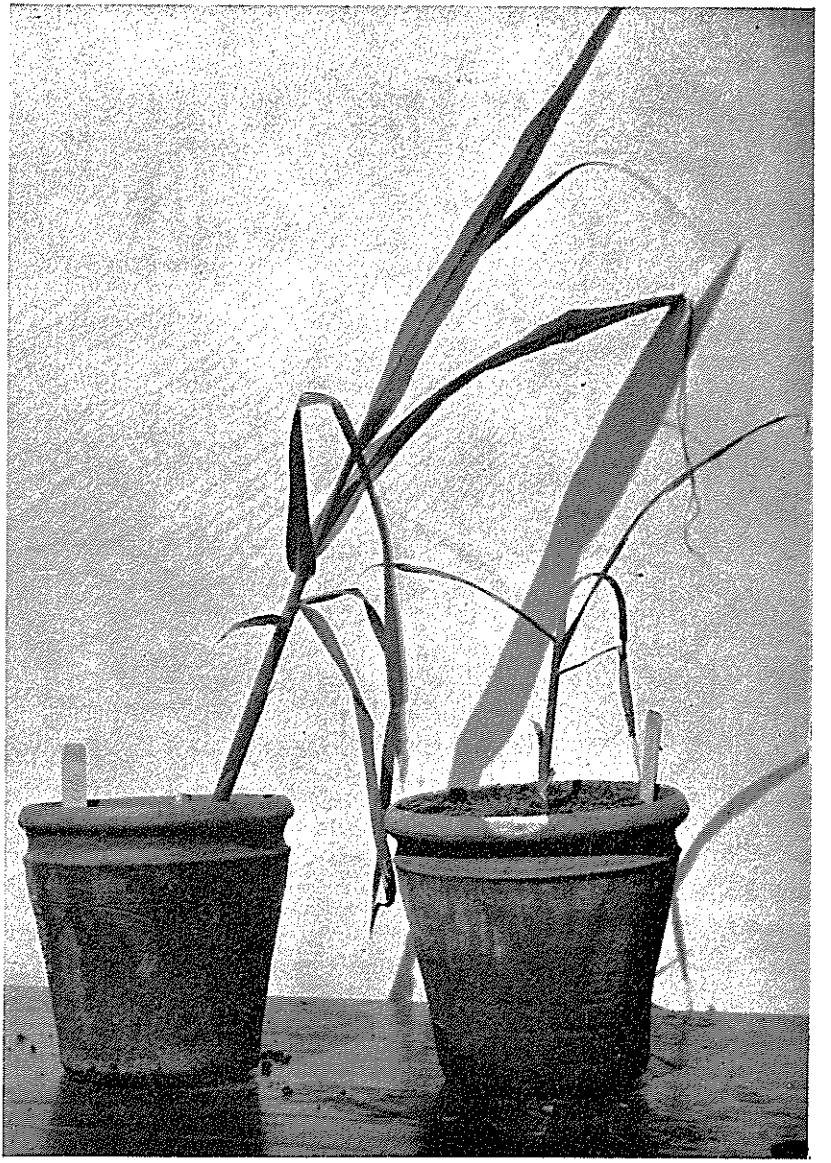


PLATE XXI



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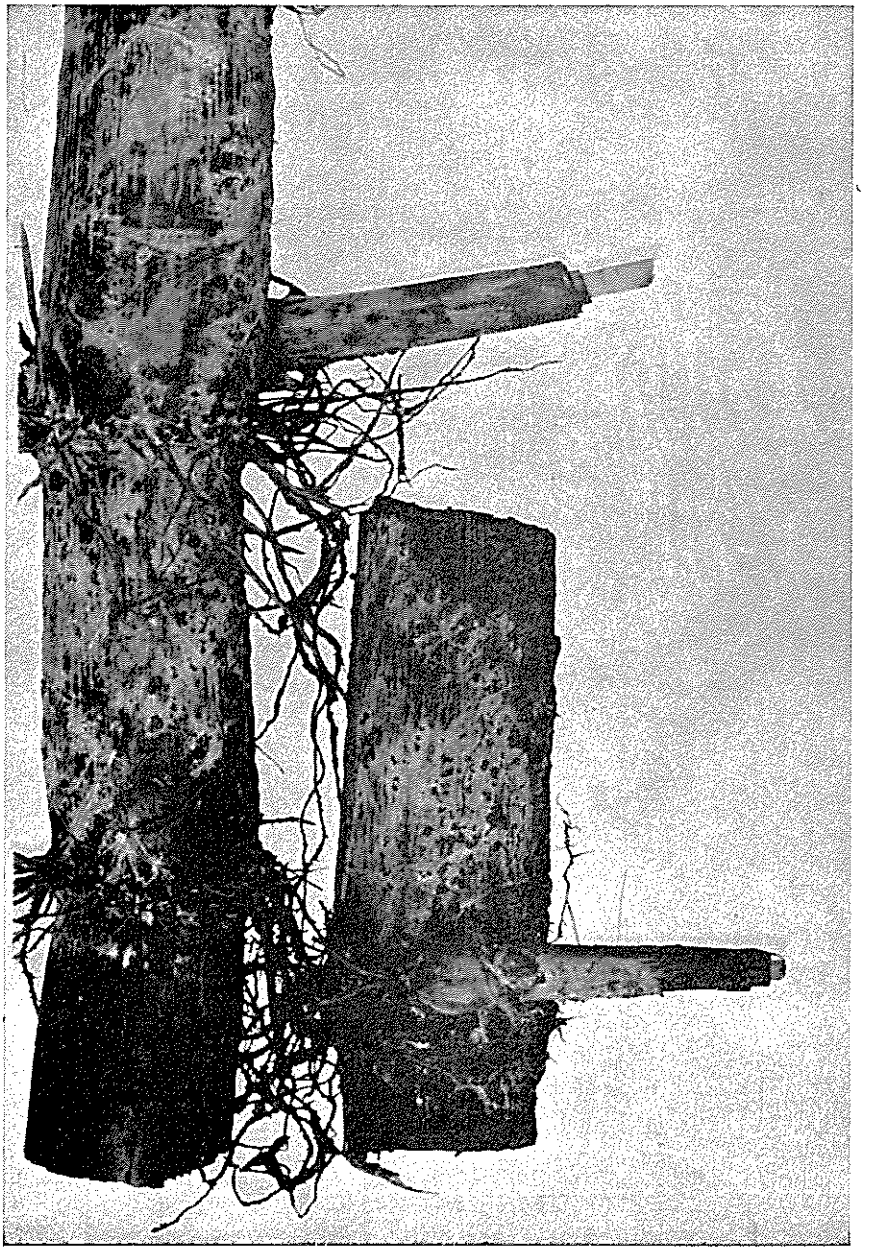
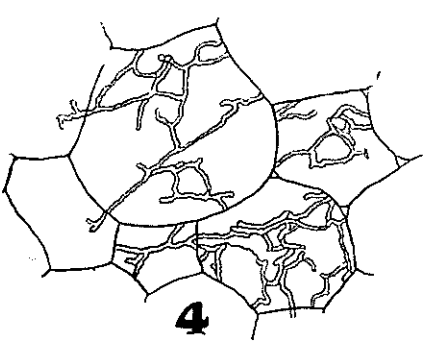


PLATE XXIII



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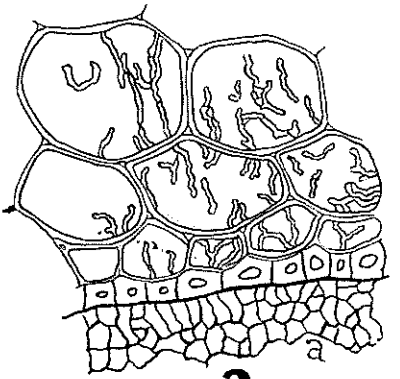

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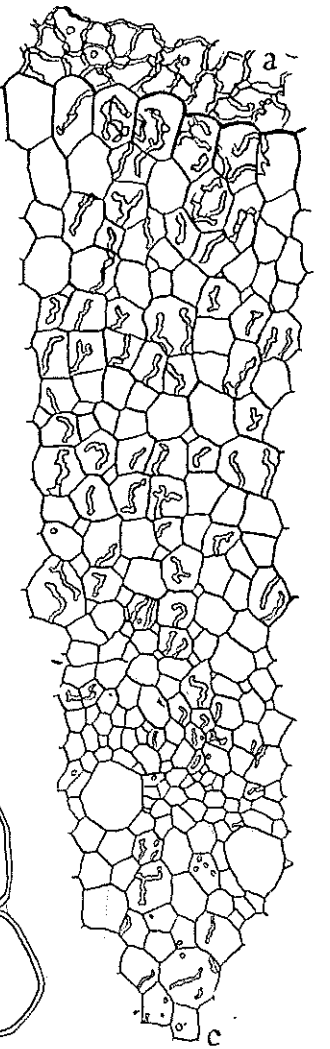

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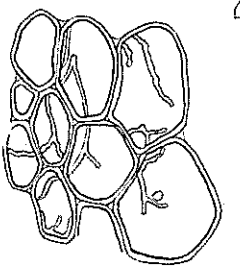

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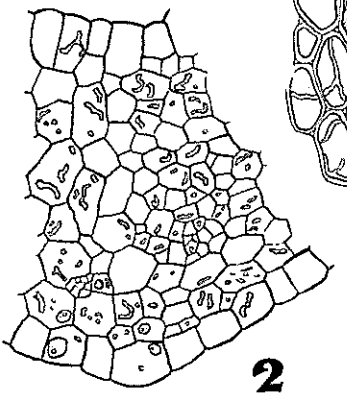

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