

## HISTORY AND CAUSE OF THE RIND DISEASE OF SUGAR CANE.

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### Introduction.

The rind disease of sugar cane has been one of the most widely discussed of all the cane diseases. It has been variously considered by some as being a harmless saprophyte and by others as having caused great damage in the cane fields. Chiefly owing to inaccurate and incomplete observations, literature on the subject is almost hopelessly confused as to the real nature of the fungus or the disease caused by it. That cane fields are still invaded by a serious disease of the rind which is always accompanied by a destruction of the tissues and a deterioration of the sugar content, render it important to ascertain the cause of the trouble. It is believed that a careful study of the literature in the light of numerous field and laboratory investigations will do much to clear up this subject. The writer has been studying the matter for the past three years and can come to no other conclusion than that the rind disease causes a great loss in many cane fields. When the nature of this disease is described and its history is shown, it is believed that this conclusion will be justified.

## EXTERNAL APPEARANCE OF THE RIND DISEASE.

So confused is the literature on this subject that it will make the discussion clearer to state once for all that the rind disease is considered primarily a disease of the rind of the cane. Whatever effect there is upon other parts of the cane is considered secondary in ascertaining the cause of the trouble, although it may as a matter of fact be primary in the point of time in the life history of the fungus itself.

The external symptoms of the rind disease are primarily the appearance of numerous black pustules breaking through the rind of the cane. (See Plate I.) From these pustules oozes a coherent mass of spores which on exposure to the dry air hardens somewhat in the form of a stalk, varying in size and form from peltoid to subclavate or cylindrical, up to 1 or 2 mm. in length. Sometimes they appear merely as numerous tiny black threads breaking through the rind. When these black pustules appear, the tissues of the cane itself are already discolored and diseased. The relations of other symptoms of disease are complicated with the presence of other fungi and will be left to a fuller discussion further on. It will be noted that there are a few eruptions on the rind that are caused by different fungi. These will all be discussed in their proper place. The preceding brief diagnosis of rind disease will be used as a basis for discussing the history and full nature of the fungus and the disease caused by it.

## THE AUTHOR'S INVESTIGATIONS OF THE RIND DISEASE.

### FIELD NOTES IN PORTO RICO.

Conditions under which the rind fungus have been noted in Porto Rico are extremely variable. It has never been observed in fields of young green cane excepting in shoots injured or killed by some other fungus such as *Marasmius sacchari* or by such insects as the changa, the whitegrub, the root weevil, or the moth stalk-borer. In such cases it can hardly be considered more than a saprophyte.

In cane over six or eight months old this fungus can almost invariably be found on the leaf-sheaths of the cane, not universal on all stalks, nor on all varieties, but at least common in the cane

fields of Porto Rico. The fungus occurs not only at the base outside of the leaf-sheath, but occasionally near the joint of the sheath with the leaf-blade. On the leaf-sheaths, the fungus may hasten the drying of the leaf, but does not necessarily pass from the sheath into the stalk. Numerous canes have been observed up to maturity which had remained perfectly healthy so far as the stalk was concerned, but which had had the fungus on the leaf-sheaths for some months.

In contrast with the conditions found in green cane, in mature or almost mature cane considerable damage has been observed which appeared to be attributable to this fungus.

In Naguabo in 1912 a certain field of D625 presented an excellent growth. The planting was wide, *i. e.*, 7 feet between rows, but the stalks had developed well. Before the cane was considered quite ripe enough for cutting, it began to appear diseased, *i. e.*, black pustules appeared on the rind, the canes appeared water-soaked, and the tops died. In some cases moth borers were present, but with this exception there appeared no fungus in any quantity except the rind fungus *Melanconium sacchari*. In a few weeks' time this disease had spread over the field, not affecting all stalks, but stalks in many stools. The loss in weight and sucrose before the cane could be cut was considerable.

Near Río Grande in 1912 was a field of a large yellow Demerara cane, probably D625 or D116, supposed by some to be identical canes. The growth of the cane at twelve months was excellent, consisting of an abundance of large stalks. It was generally known that this cane contained a comparatively small amount of sucrose especially on low wet soils such as in this case. It was suggested that possibly leaving the cane over for another season would produce a larger sugar content, therefore the canes were left for a period of twenty months. Long before this time had passed many of the stalks had become infected with the rind disease and become entirely rotted down, so that at the end of the period the field was almost an entire loss.

In the same vicinity in 1912 fields of the striped (*rayada*) and the native white cane (*Otaheite*), which were only twelve months old, behaved in the way.

This latter condition of cane twelve to fourteen months old rotting back with the rind fungus is not uncommon in Porto Rico. The moth stalk-borer is often associated with the fungus, but is no more common in diseased fields than in those not diseased. The conditions under which this disease occurs are not clear, but everything points

Weakness in the cane due either to a weak soil or to drought or to excessive water. Apparently a variety of these conditions brings about much the same effect in cane.

Aside from the occurrence of the rind fungus in large mature canes, it is not uncommon to find it abundant in fields of cane that have been stunted through the presence of root disease, or some untoward soil condition. This is especially true in old ratoons that are running down. In Canóvanas in 1912 an entire field of cane failed to grow large and vigorous and before maturity almost the entire field was infected with this fungus and was a complete loss. In adjacent fields first crops have been obtained, but there, too, the ratoon crops have been lost in the same way.

In all cases in Porto Rico an infection with the rind fungus seems to be preceded by a weakening of the vitality of the cane through some other untoward condition. It happens, however, that these conditions cannot always be foreseen, and therefore the rind fungus must be considered a serious obstacle to the best results among the sugar planters. These various untoward conditions in themselves do begin to have the effect that they do together with the rind fungus.

Cane may suffer from root disease, but does not rot out unless affected by the rind fungus also.

Cane may suffer from drought, but it does not deteriorate unless attacked by the rind fungus in addition.

Cane may suffer from floods, but that does not render it worthless as does a severe infection of the rind fungus.

Altogether the field investigations appear to demonstrate that *Melanconium sacchari* is capable of doing great damage in mature canes in Porto Rico.

#### INOCULATIONS WITH THE RIND FUNGUS.

Inoculations with pure cultures of the rind fungus have been made into green canes and into almost mature canes, but in no case was there any visible infection. In all these inoculations the cane was vigorous and the inoculating wounds were slight. This would tend to show that vigorous cane was not infected by this disease. No inoculating experiments have been made on weak canes.

#### FIELD INVESTIGATIONS IN SANTO DOMINGO.

Examination of the cane fields at La Romana, San Pedro de Macorís, and Santo Domingo city show the rind fungus to be common but not doing much damage. It is present only in canes which have

been seriously injured, *i. e.*, when the top has been cut off, and in these cases the infection has spread only to the first node, leaving the base of the cane perfectly sound.

#### INVESTIGATIONS IN THE SOUTHERN UNITED STATES.

Investigation here revealed quite the same conditions as in Santo Domingo; *i. e.*, no entire rotting of sound canes, but mere infection at the point of some serious injury and on the leaf-sheaths.

#### INVESTIGATIONS IN CUBA.

No extensive investigations have been made here by the writer of this paper, but stalks completely rotted by the rind fungus have been observed in the vicinity of Nipe Bay.

#### GREENHOUSE INVESTIGATIONS, WASHINGTON, D. C.

In the greenhouses in Washington, D. C., cane has been grown to a greater or less extent for the last seven or eight years. It has been common to find large stalks completely rotted out by this fungus. It is to be expected from our observations of the behavior of this organism that this would occur. Cane grown in the greenhouse is not as hardy as that grown out of doors; its roots are apt to be confined and the tops are subject to injury. Altogether the appearance of this disease in Washington corresponds well with the condition frequently found in Porto Rico and as casually observed in one place in Cuba, but not with its appearance as seen in Santo Domingo or the Southern United States.

It may thus be expected that there will be found a similar variation in the conditions in other countries which might to a large extent account for the variation in opinions regarding the importance of the rind fungus.

In the particular cases cited the possibility of confusing the case with infection by other fungi has been avoided by special search for such as *Colletotrichum falcatum*, so while there is no direct proof by inoculation that *Melanconium sacchari* causes the trouble under all conditions, there is the fairly satisfactory proof of it, arrived at by the process of elimination.

#### HISTORY AND IDENTITY OF THE RIND FUNGUS.

The first available description of a fungus breaking through the rind of the cane is that of *Strumella sacchari* by Cooke in Grevillea,

Vol. XIX, p. 45. He described this fungus from a specimen of sugar cane labeled Bailey 871 from Queensland, as follows:

“Pustules gregarious, erumpent, black, patelloid or subelavate, with a short stemlike base, or cylindrical multiform ( $\frac{1}{2}$  mm. diam.), hyphae short, hyaline, simple; conidia cylindrically elliptical, continuous, pale fuscous, 10–12 x 3 microns.” This description is purely one of the fungus and does not indicate the symptoms of the disease other than to say that the pustules are erumpent.

In 1878 Cooke published a description (8)<sup>1</sup> of one of Berkeley's species as follows:

*Darluca Melaspora* Berk. in litt. Pustulis prominulis, nigris, sporis oblongis binucleatis, cirrhis nigris. .015 x .115 mm. From sugar cane in Australia.

In 1892 was published a new species by Ellis and Everhart in a paper by Cockerell (7). The name of the new fungus was *Trullula sacchari* and its description as follows:

Acervuli innate-erumpent or entirely black, conicglobose,  $\frac{1}{3}$  to  $\frac{1}{2}$  mm. diam., resembling perithecia. Conidia catenulate, forming at first a continuous, hyaline filament, 70–75 microns long, soon separating into oblong 2–3 nucleate, olivaceous conidia, 8–11 x  $2\frac{1}{2}$ –3 microns, rounded at the ends, and closely resembling the sporidia of some *Hypoxyton*. The chains of conidia are densely crowded and simple. The erumpent acervuli blacken the surface of the culm with the discharged conidia, but some of the acervuli are entirely buried in the inner substance of the culm and are apparently never erumpent. Found in Jamaica, Barbados and Trinidad on sugar cane.

In 1893 Massee (26) described the black erumpent fungus on sugar cane as a *Melanconium* stage of *Trichosphaeria sacchari*. In a later paper (27) he gave the succession of these various stages as follows: from *Melanconium* stage to macro- and micro-conidial stages and thence to the ascigerous stage which he called *Trichosphaeria sacchari*. His work was based on material received from Trinidad and other English colonies.

Fawcett (14) in 1894 wrote that he found *Trichosphaeria sacchari* (the *Melanconium* stage) present in Jamaica, but he found other diseased material, which he sent to Kew and which was examined by Massee and pronounced *Colletotrichum falcatum*. Later he wrote (15) that he found *Trichosphaeria* (*Melanconium* stage) and that Massee considered it only a form of *Colletotrichum falcatum*.

In 1895 Saccardo (32) changed the name of Cooke's *Darluca melaspora* to *Coniothyrium melasporum*. In the same year Prillieux and Delacroix (31) studied material from Mauritius which showed the same black erumpent fungus on the cane as did *Darluca* and

<sup>1</sup> Figures in parenthesis refer to bibliography at the end of the article.

*Melanconium* and the others. They called the fungus *Coniothyrium melasporum* following Saccardo's name, as they believed their fungus to be identical with *Darluca melaspora*.

Thistleton-Dyer (34) published a summary of the cane diseases in Barbados, in which he reiterates the statement that at Kew *Colletotrichum falcatum* Went is considered merely as one phase in the life history of *Trichosphaeria sacchari*. It should be noted that it was not claimed that *Colletotrichum falcatum* was the same as any other stage of *Trichosphaeria*, for from its appearance there could be no confusion as to that. It was stated that *Colletotrichum* was considered a stage in the life history of *Trichosphaeria*. There was, however, no proof brought forward to support this claim and subsequently the idea was given up. At present they are believed by investigators in general to be distinct fungi.

Went (39) published in 1896, in an article on sugar-cane diseases, criticisms of Masee's work on *Trichosphaeria*, together with the statement that Masee's macro- and micro-spores of *Trichosphaeria* were remarkably like the macro- and micro-spores of Went's *Thielaviopsis ethacetica*. Went's opinion was strengthened by examination of West Indian material. He also found *Melanconium* spores in Java and from pure cultures obtained both the *Melanconium* spores and macrospores. Thistleton-Dyer (l. c.) believed Went's *Melanconium* was not really the *Melanconium sacchari* of the West Indies.

Masee (l. c.) had claimed that *Thielaviopsis* was the same as his macro- and micro-spores of *Trichosphaeria*, thus agreeing on this point with Went except that the latter did not connect them with the perfect stage of *Trichosphaeria*.

Prillieux and Delacroix (l. c.) agreed with Masee in considering *Thielaviopsis ethacetica* to represent the macro- and micro-spore condition of the *Melanconium* fungus which they called *Coniothyrium*.

Finally in the history of the rind disease Howard issues a paper (19) in which he shows that *Colletotrichum falcatum* and *Melanconium* are not stages of the same fungus, but he claims that the former is the cause of the rind disease and not the latter. As Howard has made a most unfortunate confusion between cause and effect here, it will be necessary to discuss the matter more fully.

In preceding pages of this paper there was given a description of the fungus causing the rind disease and producing those symptoms commonly recognized as belonging to the rind disease, i. e., numerous eruptions of the rind from which issue black masses of spores. As to whether this disease causes further destruction of the

tissues or as to whether there are other fungi that cause the destruction of the rind or of other tissues, that matter has not been discussed. The description of *Colletotrichum falcatum* as given by Went is as follows:

Setis nunc seriatis, nunc in psuedo-conceptaculum, congregatis, cuspidatis, 100-200 x 4, conidiis falcatis, 25 x 4, hyalinis, ad basim setulorum, basidiis ovoideis, 20 x 8, hyalinis vel fuscis, suffultis.

Went found the fungus on living cane, but most of the reports definitely state that while the vegetative hyphae are common on living cane, fruiting bodies are very rare except on dead cane. Such being the case, it is not clear how *Colletotrichum falcatum* produces any eruptions on the rind. As to whether it does cause a serious disease of the cane is entirely a different matter.

From the foregoing descriptions it will be seen that five different names have been given to black erumpent fungi on sugar cane, *Strumella sacchari*, *Darluca melaspora*, *Trullula sacchari*, *Melanconium sacchari* and *Coniothyrium melasporum*, the last being admittedly the same as *Darluca*. It will be desirable to ascertain if all these names may apply to one and the same fungus. It must first be stated that the common fungus producing these black eruptions on cane throughout the West Indies, Hawaii, Mauritius, Natal, Australia, and other places appears to be one and the same and to be correctly classed as *Melanconium sacchari*. More rarely are found similar forms which might be mistaken for *Melanconium*. It will be desirable to review the descriptions of the fungi already mentioned in order to judge whether they may be considered to be *Melanconium* or distinct fungi.

1. *Strumella sacchari*.—Said by Thistleton-Dyer (35) to be the same as *Melanconium sacchari*. *Strumella* belongs in the *Tuberculariaceae*, quite a distinct group from that containing *Melanconium*. There is nothing in the description to indicate that the fungus is a true *Strumella* or that it cannot go in *Melanconium*. In fact, investigators seem agreed that these two names really belong to one and the same fungus.

2. *Darluca melaspora*.—Masseé (28) states that this species is founded on material sent to Berkeley in 1878 from Porto Rico and not from Australia as stated by Cooke. Furthermore he states that the material itself shows the fungus to be a *Diplodia* and not a *Darluca*. It would seem that Masseé's examination ought to settle the question, but it is not clear how Cooke's description of *Darluca melaspora* can apply to a *Diplodia*. Rather does it resemble *Melanconium* with the one-celled binucleate spores, 12 x 5 microns, and



black threads. To what the "cirrhis nigris" or "black threads" applies is not evident whether to pustules or to spores, but in neither case it would apply to a *Diplodia*. It would seem more likely that there were both forms in the material or that the material had been mislabeled. It would appear that Cooke's *Darlucina melaspora* is really *Melanconium sacchari*.

3. *Trullula sacchari*.—This fungus has been said by Masee (27) to be similar to the macroconidial stage of *Trichosphaeria sacchari*. However, Masee evidently did not note that while his macroconidia measure 18–20 x 12 microns, the spores of *Trullula* measure 8–11 x 2½–3 microns, too great a difference to permit of their being considered as identical. It is possible that *Trullula sacchari* corresponds to the microconidia of *Trichosphaeria sacchari*, especially as the general description answers fairly well for it. Thus "conidia catenulate, forming at first a continuous, hyaline filament, 70–75 microns long, soon separating into oblong 2–3 nucleate, olivaceous conidia," answers fairly well for either fungus. However, "Acer-vuli innate erumpent or entirely black, conic-globose, ⅓–½ mm. dia. resembling perithecia" does not apply to the microconidia stage of *Trichosphaeria* but to the *Melanconium* stage. To no other known fungi does this description apply, and as the material is reported from at least three islands it is believed that the description was meant for one of the common cane fungi, *i. e.*, *Melanconium*, and possibly mixed with the microconidial stage of *Trichosphaeria*.

4. *Melanconium sacchari* described by Masee is placed in its proper genus. Masee, however, believed that he found also other stages of the same fungus. The perfect stage he called *Trichosphaeria sacchari*. This work will be discussed fully further on. It is sufficient to state here that *Melanconium sacchari* is the generally accepted name for the common erumpent black fungus found on the rind of sugar cane in many countries.

5. *Coniothyrium sacchari*.—This is Saccardo's name for *Darlucina melaspora*, which has already been shown to be in all probability identical with *Melanconium sacchari*. Masee (l. c.) states that Prilleux and Delacroix in their paper (l. c.) have fallen into an error in considering *Melanconium* the same as *Coniothyrium*. They described material from Mauritius as *Coniothyrium sacchari* and illustrated their description with a plate. The illustration leaves little doubt that the material was *Melanconium*, and the description answers fully as well for *Darlucina*. Apparently these are all one and the same fungus.

In summing up it is seen that—

*Strumella sacchari* is generally admitted to be identical with *Melanconium sacchari*.

*Darlucella melaspora* is said to be a *Diplodia*, but really appears to be *Melanconium sacchari*.

*Trullula sacchari* is said to be identical with the macroconidial stage of *Trichosphaeria* but appears to be the same as *Melanconium sacchari*.

*Melanconium sacchari* is the generally accepted and proper name for the rind fungus of sugar cane.

*Coniothyrium melasporum*, same as *Darlucella melaspora*, is probably *Melanconium sacchari*.

### LIFE HISTORY OF THE FUNGUS.

In the foregoing paragraphs there has been given brief mention of various references to the so-called rind fungus as it has been understood by various investigators. In the main *Melanconium sacchari* and its various possible forms are considered the cause of the disease and will be treated as such.

*Melanconium sacchari*, the ordinary form of the rind disease, consists of dark septate hyphae running within the stalk of the cane. Immediately below the epidermis the hyphae often forms a layer of pseudo tissue from which arise the short conidiophores bearing the terminal conidia. These are produced in large numbers and if their formation is close to the surface of the epidermis, the mass breaks through and oozes out either forming a black conical heap or a long slender thread entirely made up of the spores. The variation in this formation apparently depends upon the rapidity of the formation of the spore mass, which in turn depends upon the moisture conditions in the atmosphere. These spores germinate and are supposed to grow into the cane and after increasing vegetatively to repeat the spore formation. The method of entrance through the rind of the cane is not positively known. It may be through the stomata, or through such wounds as those caused by the stalk-weevil, the moth borer or the ambrosia beetle, or there is the bare possibility that the hyphae can penetrate the cells of the epidermis itself.

There has been much discussion as to whether this fungus does not produce more than one kind of spore—that is to say, have more than one stage of growth. It is common for some fungi to have various stages of growth, and it is of the utmost importance to know them all in order to work out control measures for the disease. As

already mentioned the first description of *Strumella sacchari*, which has been identified with *Melanconium sacchari*, describes only the *Melanconium* form. Masee was the first to claim that he had found more than one stage, *i. e.*, a macroconidial and a microconidial stage in addition to the *Melanconium* stage. In his paper on the subject he attempted to prove the genetic connection between the forms. Masee placed four conidia (*Melanconium* [?] spores) in each of three flasks containing equal quantities of sugar-cane solution, and then placed the cultures for incubation in a temperature of about 75° F. At the end of five days the liquid in each of the flasks presented an opalescent appearance which examination showed to be due to very delicate, much branched hyphae. Examination of the contents of a second flask after eight days' growth showed numerous filaments of mycelium measuring up to 8 microns in diameter and full of brilliant, fine-grained, homogeneous protoplasm. These thick hyphae originated as lateral branches from the delicate hyphae first produced by the conidia.

A third flask after twelve days' growth assumed a dark olive color and the entire surface of the mycelium at the level of the solution presented an appearance of an olive-colored, dense, velvety mass. The velvety appearance proved to be due to the presence of closely packed, erect, dark olive conidiophores growing out into the air, each bearing at its apex a single chain of reddish-brown conidia—called by Masee microconidia. The dark olive color of the mass of mycelium immersed in the fluid was found to be due to immense numbers of large conidia arranged in chains and springing from the tips of the thick hyphae previously described. These latter forms Masee called macroconidia.

It must be observed that Masee's method of procedure is not sufficiently described in detail to demonstrate clearly the origin of these various spores. He starts with four of the *Melanconium* spores placed in each of three flasks, but nothing is indicated to show that there might not have been some contamination. The first two flasks were treated after examination so that their contents were killed. As a result he found the microspore and the macrospores only in the third flask.

After the above experiment in which he is assumed to have produced from *Melanconium* spores two other forms in flasks, Masee took small portions of cane containing hyphae of *Melanconium* and placed them in a nutrient solution. The characters which distinguish *Melanconium* hyphae from others are not given, nor is it stated that there were no other hyphae present, nor is the operation stated

to have been done under sterile conditions. After twelve days the nutrient solution was crowded with mycelium bearing both forms of conidia, that is, the micro- and the macrospores. Further Masee took internal portions of diseased cane near the apex and placed them in a nutrient solution, care being taken to prevent the accidental introduction of other fungi. There resulted rapid growth of the hyphae and eventual formation of macroconidia.

An inoculation experiment was next carried out by introducing *Melanconium* conidia upon the base of an old leaf-sheath of cane six feet high. After twenty days *Melanconium* spores were produced. At the same time a small portion of diseased cane containing hyphae of the *Melanconium* stage were introduced into a slit made into a cane stalk. Mature fruit burst out of the cane after twenty-two days. Eight days later this cane was split open and it was found that at the joint where inoculation was performed by wounding the cane, the mycelium had produced the large macroconidia in the decaying tissue. No macroconidia were present at the point where infection took place through a dead-leaf base.

An inoculation experiment was made by placing the macroconidia on the basal part of the upper surface of a very young leaf; in five days the infected area became a deep red, and in fourteen days a dense pile of conidiophores appeared on the surface bearing microconidia. Internal macroconidia were not found. Nothing was said by Masee about the presence of *Melanconium* spores.

Another inoculation was made by placing macroconidia on the broken surface of a lateral shoot which had been broken off close to the stem. In fourteen days microconidia were formed, but no macroconidia, and no mention is made of *Melanconium* spores.

Two more experiments showed practically the same results, the macroconidia, however, being found in one case.

An inoculation made with microconidia produced both the micro- and macroconidia but no *Melanconium* spores.

Neither Masee's flask cultures nor his inoculation experiments can be taken as any proof that the *Melanconium* spores are in any way connected with either the micro- or macrospore forms.

Masee found two mature perithecia on a much decayed portion of a cane received from Barbados; they sprang from a point that had previously borne a crop of microconidia and were surrounded by old collapsed conidiophores, the conidia having disappeared. Masee says "although the evidence in favor of a genetic connection between the perithecia found on the cane and the microconidia with which they were associated, was strong, yet it could not be accepted

as conclusive; and it was not until similar perithecia were accidentally discovered on the surface of the material contained in one of the flask cultures, that this supposition was proved to be correct." The flask referred to was one filled with a mass of hyphae produced from a macroconidium. The submerged portion was black from a copious development of macroconidia, while the surface was covered with a dense pile of conidiophores bearing microconidia. This flask was accidentally broken and out of curiosity Masee examined a portion of the contents bearing microconidia. Two young perithecia were found which were almost colorless and without spores but bearing the long characteristic bristle-like, septate hyphae as did the mature perithecia found on the decayed cane. Two examples of the initial stage of a perithecium were found. The culture was placed under favorable conditions for the further growth of the perithecia, but unfortunately soon became covered with *Penicillium* and other growth, and gave no further results. However, from these results Masee concluded that he had the perfect stage of the fungus which he named *Trichosphaeria sacchari*; and as has already been stated he concluded this stage to be derived from the macrospore stage, which in turn arose from the Melanconium stage. The microspore formation was considered somewhat in the light of a variation of the macrospore formation, and like it to be derived from the Melanconium spores. It has already been shown that the genetic connection between the Melanconium stage and the macrospore and the microspore stages has not been demonstrated by Masee. It is equally clear that the finding of perithecia amidst macro- and microconidia on diseased cane and finding immature forms of some perithecia (possibly the same) on a culture of macro- and microconidia which are not demonstrated pure cultures does not prove or any more in the slightest degree suggest a genetic connection between the macro- and the microspores and these perithecia. Thus Masee has constructed the life history of the Melanconium fungus largely out of assumption.

It has been claimed in reference already quoted that *Melanconium* has a fourth stage in the life history, that of *Colletotrichum falcatum*. No work, however, was published to prove this assumption.

Went (39) in 1896 took up the matter of the relationship of the *Melanconium* with the macro- and microconidia. These two latter forms appeared to him to be identical with what he called *Thielaviopsis ethacetica* and especially for that reason he wished to determine if there was any relationship between the various forms. Unfortunately the fungus with which Went worked does not correspond

to the West Indian *Melanconium*, so that the results cannot be taken as for or against Masee's claims.

In 1900 Howard (20) published a rather elaborate paper on his researches on this subject. He had already stated in another paper (21) that he had infected unsterilized pieces of cane with *Melanconium* spores and five days afterwards macro- and microconidia had developed. He found later, however, that a repetition of the experiment gave the macro- and the microspore forms as frequently on control canes as on inoculated canes. He thus concluded that the genetic connection between the various forms was *not* demonstrated. Howard further made many inoculation experiments both with the *Melanconium* form and with the macro-spores; he cultivated the macroconidial stages for over two years; and he had flask cultures under observation for 18 months, but in no case did he find *Melanconium* spores give rise to macroconidia or vice versa. He states that several thousand rotten canes were examined, but in no case did he find perithecia corresponding to Masee's *Trichosphaeria sacchari*.

From these various discussions it will be seen that no form other than the one originally described under the name of *Strumella* by Cooke has been proven for the *Melanconium*. There is the minor possible exception of chlamydospores found by Went with his questionable *Melanconium sacchari* but corroborated by Howard in flask cultures. So far as has been shown they have little bearing on the reproduction of the fungus as it actually occurs in the fields. Thus, so far as is known to-day, the life history of *Melanconium sacchari* is very simple, consisting only of the vegetative part producing stylospores, which in turn reproduce the plant.

#### ASSOCIATED FUNGI.

As has already been seen several fungi have been found associated with *Melanconium sacchari*, some of them so closely that they have been assumed to be stages of the same fungus.

*Thielaviopsis ethacetica*.—The micro- and macrospores of *Melanconium* as described by Masee were believed to be identical with the spores of *Thielaviopsis ethacetica* by Went. Howard was also of the same opinion. *Thielaviopsis* is not commonly found in standing cane, but is common in cut cane that has been left standing about or particularly in seed in the soil. *Melanconium* is characteristically found in standing cane. However, when affected seed is used the fruiting bodies of *Melanconium* may be found on seed in the soil.

*Colletotrichum falcatum*.—This was originally described by Went in Java as the cause of the red-rot or red smut. It is supposed to

gain entrance through borer holes or wounds in the cane, but does not usually fruit until the cane has dried out considerably. The fruiting bodies appear in velvety black patches on the dry part of the cane. Under a lens small black bristles are found to be abundant, and from among these arise the single-celled, colorless, more or less falcate spores. There is no evidence of pustule formation nor of any formation to mistake the *Colletotrichum* for the *Melanconium*.

*Diplodia cacaoicola*.—This fungus has been found on cane in India by Butler (3), in Barbados by Howard (22), and in Porto Rico by the author. A fungus was sent to Kew in 1878 from Porto Rico and was described in manuscript as *Darluka melaspora*. This was referred to by Cooke in Nuovo Giornale Bot., Vol. X, p. 26, 1878, who according to Masee (l. c.) incorrectly gave the locality as Australia. Saccardo changed the name to *Coniothyrium melasporum*, quoting Cooke's diagnosis incorrectly in Syll. Fung., Vol. III, No. 1799. Prilleux and Delacroix (31) in their paper on sugar-cane diseases have, according to Masee, wrongly considered *Melanconium sacchari* as synonymous with *Coniothyrium*. Examination of Berkeley's type specimen by Masee revealed the fact that it was a *Diplodia*. As already shown, however, on previous pages, Prilleux and Delacroix's description answers to that of *Melanconium* and not to *Diplodia*. When Masee examined the material he must either have seen another fungus or examined the wrong specimen. A fungus answering to the description of *Diplodia cacaoicola* occurs at present in Porto Rico on cane. This fungus forms pycnidia, which break through the rind in conical projections, thus resembling to some extent the eruptions of *Melanconium*. This fungus, however, has not been reported as common in any country, so that there is little danger of confusing it with *Melanconium*.

*Cytospora sacchari*.—This fungus has been reported by Butler (3), who states that it might be confused with *Melanconium*. It forms similar black eruptions on the surface of the rind. It has so far been reported only from India and from Porto Rico.

*Melanconium saccharinum*.—This fungus was originally reported from Java, but is common in Porto Rico, Santo Domingo and the Southern United States. Under certain conditions it might be mistaken for *M. sacchari*. This latter, besides occurring on the stalk, is abundant on the leaf sheaths and on that part of the leaf blades immediately adjoining the sheath proper. In these locations it seldom sends out the long threads, but usually appears as conical eruptions. Much the same appearance is presented by *M. saccharinum* and in the same part of the leaf. The two fungi may be present

at the same time. So far as is known *M. saccharinum* does not occur on the cane stalks, with the exception of the flowering stalk, and is not as yet known to cause serious damage.

*Gnomonia iliaii*.—This fungus occurs in Hawaii and in Louisiana. The perfect or *Gnomonia* stage might at a casual glance be mistaken for *Melanconium sacchari*, but the necks of the perithecia are slender and hard and do not spread out as do the black spore masses of the rind fungus. The imperfect stage of *Gnomonia iliaii* is called *Melanconium iliaii* and to the writer does not present satisfactory means of identification to the naked eye, so closely does it resemble *M. sacchari*. Under a lens, or more especially under a compound microscope, the differences are readily apparent.

#### GEOGRAPHICAL DISTRIBUTION OF THE DISEASE.

*United States*.—The rind fungus (*Melanconium sacchari*) was reported by Dr. Stubbs in the Louisiana Planter for May 21, 1910. Edgerton (11) reported it as occurring only on seed cane. H. R. Fulton, formerly of the Louisiana Agricultural Experiment Station, sent to Washington specimens of *Melanconium sacchari* on cane. This was sent from New Orleans on October 19, 1907. About 1905 Dr. Erwin F. Smith was growing cane in the greenhouses in Washington, D. C., for studies on the gumming disease. On much of this cane *Melanconium sacchari* appeared. In the summers of 1911 and 1913 more cane was grown in other greenhouses in Washington, and on this cane appeared much of this disease. Further than these notes there are no records of the occurrence of this disease in the States, with the exception of the author's notes. These notes report its occurrence in Florida, Georgia, Louisiana, and Texas.

*Cuba*.—The fungus was reported as common on dead canes, leaf-sheaths and dead leaves that had been kept in a moist place and also as frequent on dead or injured parts of living canes, by Horne and Cooke (10). The writer has also seen this disease on standing cane at Nipe Bay, Cuba.

*Jamaica*.—As already mentioned, *Trullula sacchari* E&E identical with *Melanconium sacchari* was sent from Westmoreland County, Jamaica, and reported on by Cockerell (7) in 1891-93. Fawcett (15) in 1895 reported the rind disease due to *Melanconium sacchari* to be common on certain estates, especially in cane tops affected by the moth-borer.

*Santo Domingo*.—The author reported the rind fungus common in most of the cane districts of this Island in 1913.



*Porto Rico*.—Cane diseased by *Melanconium sacchari* was sent from Porto Rico to the United States Department of Agriculture in Washington in 1906 (?) and was identified by the writer. Tower (36) reported the fungus present especially on the south side of the Island. Fawcett (16) the following year reported it, stating that it was very common on the east end of the Island. In the report of the writer (23) for 1910–1911 the fungus is said to be prevalent all over the Island.

*Barbados*.—Bovell (2) reported in 1895 in regard to the rind fungus that “in many instances so badly has the disease attacked the canes that instead of an acre giving from two to three hogsheads of sugar it will require many acres to give one hogshead.”

South (33) in 1909–1910 reported this fungus as always present on dead canes which are dry.

*British Guiana*.—Harrison and Jenman (18) stated that until early in 1894 the canes in British Guiana appeared to be quite free from fungoid disease, although the fungus *Trichosphaeria sacchari* could be found in greater or less abundance on dead canes and on the dead parts of dying canes in probably every field in the colony, but in February, 1894, they noticed that several varieties of seedlings were affected with rind fungus. Specimens of this fungus on cane were received from both Demerara and Essequibo.

*Other English Colonies, in the West Indies*.—Prof. Harrison (l. c.) visited Trinidad, St. Vincent, Barbados, Antigua, Grenada, and Carriacou and found the rind fungus present in all of them. South (l. c.) reported as follows:—

*St. Vincent*.—The rind fungus occurred to a considerable extent, but chiefly in fields of the Bourbon variety of cane.

*Antigua*.—The fungus was not prevalent, but cases were somewhat more frequent than formerly. It was often noticed in fields badly attacked by root disease.

*St. Kitts*.—It was not observed to any extent.

*Nevis*.—It was observed on some estates. Seedling cane B147 was always more subject to attacks than any other variety.

*Argentine*.—Engler and Prantl (13) record *Melanconium sacchari* Masee on cane in Argentine.

*Mauritius*.—Prillieux and Delacroix (31) record the fungus in Mauritius. In an article entitled *La Maladie de la Canne* in *La Sucrierie Indigénie et Coloniale*, pp. 361–363, Vol. VII, 2d semester, 1894, is correspondence between Thistle-Dyer, of Kew, and M. W. Scott, of Mauritius, and discussion of the rind disease caused by

*Melanconium sacchari*. The *Melanconium* form was found to be very abundant. Masee records it from Mauritius in 1894.

*British India*.—*Melanconium sacchari* is stated by Butler (3) to be rare in British India. It is also reported from India by Masee (29). Barber (1) also records the fungus from India.

*Tonquin*.—The fungus was reported in this part of Indo-China by Prilleux and Delacroix (l. c.).

*Java*.—Went (38) describes its appearance in Java. His description in the *Annals of Botany* (39) is such, however, to lead one to suspect that he did not have the West Indian *Melanconium sacchari*. Thistleton-Dyer (35), in discussing the subject, thinks he had a very different fungus. Went describes black spherical conidia as being connected with the *Melanconium* with which he was working, and no one else has as yet published a description of such a form. He mentions chlamydospores, so that it cannot be certain just what Went had, although these were also found by Howard (20).

*Natal*.—Fuller (17) reported in this colony a fungus on sugar cane supposed by him to be *Strumella sacchari*, which, as we have seen, is identical with *Melanconium sacchari*.

*Queensland*.—The first description of *Strumella sacchari* was by Cooke (9) from a specimen received from Queensland. Tryon (37) also also records the occurrence of the rind disease in this country.

*New South Wales*.—Cobb (4) reported *Strumella sacchari* as occurring there.

*Hawaii*.—Perkins (30) in 1904 stated that "nearly a year ago, \* \* \* an unusual outbreak of some parasitic leaf-fungi was noticed, and this was shortly followed by a similar spread of fungous diseases affecting other parts of the cane. It must not be supposed that these fungi are new to this country; they have been known to us for at least some years sporadically, but are now epidemic. The present epidemic is clearly due to the abundance of the leaf-hopper.

"At present by far the most widespread and injurious of these diseases is the so-called Rind Disease. \* \* \*. On examining the stripped stem of young cane, I find that the fungus has already attacked this severely. \* \* \*. Whole fields of cane are simply saturated with the spores of the fungus."

Cobb (5) in 1906 stated that he had "noted the presence of rind disease in sufficient quantity to call for remedial action." Lewton-Brain (24) described the rind disease and the loss caused by it in 1907. Cobb (6), writing again in 1909, said that in many fields, especially ratoon fields of Lahaina cane, it was common to find the sheaths of the "lalas" (shoots from the top of the cane) attacked

by rind disease. "I have seen fields of this kind in which nearly every *lala* showed the spores of rind disease issuing from the sheaths of its lowest leaves, and when the higher leaves were pulled away it was evident that these, too, were attacked and in the first stages of the disease."

### PARASITISM OF THE FUNGUS.

The fact that *Melanconium sacchari* has attracted such widespread notice would lead one to assume that it was without question a parasite. Still careful workers cannot accept the prevalence alone of an organism to indicate its parasitism. Though it may not in this case be an active parasite it is necessary at least to know its degree of parasitism before recommending methods of treatment.

A misleading idea given in many articles on fungus diseases is that the very presence of an organism to the apparent exclusion of others, or the preponderance of one organism over another indicates that it is the cause of whatever disease may be in the host plant. Thus the presence of *Melanconium* has been assumed by many to indicate that it was the cause of the diseased condition of whatever cane it might be found in.

Massee (27) was the first to publish the results of inoculation experiments with this fungus. His experiments were as follows:

*Experiment I.*—A sugar cane, 6 feet high and  $1\frac{1}{2}$  inch in diameter at the base, was inoculated by placing *Melanconium* conidia upon the base of an old leaf sheath, the leaf having fallen away. After twenty days the *Melanconium* fruit was fully developed, the long black filaments of conidia oozing out through minute cracks in the cuticle about half an inch above the node, and from the point of inoculation. At the same time as this experiment was made a small portion of diseased cane containing hyphae of the *Melanconium* stage was introduced into a slit made in the cane; this experiment resulted in the appearance of mature fruit bursting out from the cane after twenty-two days. The cane was cut down ten days after the last-mentioned experiment, and on being split open it was found that at the point where the inoculation was performed by wounding the cane the mycelium had produced the large macroconidia in the decaying tissue.

*Experiment II.*—*Melanconium* conidia were placed on moistened patches of young living leaves of sugar cane, some of the patches being first carefully washed to remove the bloom on the surface of the leaf, others not being so treated. After twelve days there were no signs of infection on the unbroken surfaces of young leaves and

stems, hence Masee concluded that while *Melanconium* was a parasite it was only a wound parasite. In his own words he demonstrated conclusively that the fungus called *Trichosphaeria sacchari* (the *Melanconium* stage) can effect an entrance into healthy tissue quite independently of the agency of "shot-borer" or "moth-borer."

"Although a true parasite, in the sense of destroying perfectly healthy tissues, the fungus almost invariably commences as a saprophyte."

Besides Masee, Went made inoculation experiments to demonstrate the parasitism of this fungus. As before remarked, however, we cannot be certain that the *Melanconium* with which he worked is identical with that of the West Indies. With the fungus with which he was dealing he made inoculations into slits made into sound canes; the mycelium developed in the cells surrounding the slits, but in no case (9 experiments) did it attack the healthy tissue of the cane. Later he sterilized pieces of sugar cane by keeping them in a flame for some time; he then divided them longitudinally with a sterilized knife and placed them in a sterilized glass box. On the cut surface he placed some of his *Melanconium* spores, but out of ten experiments only three finally showed pycnidia, and this was on dying cane. Thus Went does not consider *Melanconium*, or whatever fungus he was working with, to be parasitic.

So far as publications show Howard has been the only other one to test the parasitism of the rind fungus. He published a report (21) of his experiments in 1900, in which he split open healthy unsterilized canes and inoculated them with *Melanconium* spores, and with mycelium developed from a pure culture. Five days afterwards both micro- and macroconidia developed. Later, however, Howard (20) decided that these micro- and macroconidia had no genetic connection with the *Melanconium* spores, as they appeared as frequently on control canes as on the inoculated ones. In his early experiments he had concluded that *Melanconium* was parasitic as some infection had resulted. As the infection did not spread, however, more than three inches above and below in three months' time, and as the canes showed none of the typical appearance of the disease he concluded to repeat the experiment. The results are set forth in the last publication cited.

*Experiment I.*—On November 27 eighteen healthy Bourbon canes were selected, of which six were used as controls and twelve for inoculation at wounds, six with *Melanconium* spores from a pure culture and six with similar spores and food material. The places where the wounds were made were cleaned with alcohol and flamed with a spirit

lamp. The holes were cut with a sterile knife, and after being inoculated were bound up with sterilized tape which had been soaked in parafin. The control canes were treated in a similar manner, but in this case no spores were introduced. On December 28 these canes were examined. In no instance had the mycelium spread to any extent, except immediately above and below the wound where it had reached the nearest nodes. The affected tissues were a bright red, but the cane exhibited no traces of the rind disease. The controls showed no infection, although the cells around the wound were bright red and the bundles cut through showed gumming in the large vessels.

*Experiment II.*—On December 10 four healthy White Transparent canes were inoculated with *Melanconium* spores from a pure culture at wounds made with a sterile knife as before. Four other canes from the same stool were used as controls. Thirty days afterwards the canes were examined. In all cases the tissues were brownish red above and below the wounds, but no difference was evident between the inoculated canes and the controls in this respect. On examining the inoculated canes it was found that the mycelium of the fungus had in all cases spread in the tissues immediately above and below the wounds as far as the nearest nodes, but it could not be traced beyond the vertical column of tissue containing the wound and bounded by the nodes above and below this aperture.

*Experiment III.*—On December 19 four healthy White Transparent canes were doubly inoculated—at wounds in an upper and a lower internode—with actively growing mycelium of the fungus from pure cultures. Four other canes were used as controls. On January 22 the results were almost identical with those obtained above.

*Experiment IV.*—The same experiment was made using only spores from a pure culture instead of the mycelium. The same results were obtained.

Howard concluded as a result of his studies that *Melanconium* cannot be considered as the cause of the "rind" disease. He appears to have shown that *Melanconium* is not an active parasite, but it is not clear that he has demonstrated this fungus to be only a saprophyte. In fact his inoculations rather point to *Melanconium* being a wound parasite. Howard appears to be assuming that the rind disease is caused by an active parasite, for the proof of which he presents no facts whatever.

### CAUSE OF THE RIND DISEASE.

In discussing the cause of the rind disease it will be well to review briefly the symptoms of this trouble first. As mentioned in

an early part of this paper the rind fungus is one causing numerous tiny black eruptions from the rind or epidermis of the cane stalk. From first to last there has been only one fungus found in these typical eruptions. It was first called *Strumella sacchari* and later *Melanconium sacchari*, the name under which the fungus is known at present. As to the secondary symptoms it is very difficult to judge for the reason that usually insects, other fungi or unsatisfactory growth conditions are present to complicate the matter. In cane affected with the rind disease the leaves begin to wither and dry up. Often a rotten top is found. Frequently there is a reddening of the stem. Now as to which of these symptoms are connected with the rind disease no one has as yet attempted to make an analysis. That being the case we have only the eruptions of the rind for a certain characteristic of this disease. From these only *Melanconium* has been isolated, absolutely no other fungus. How then can we conceive of some other fungus as the cause of these symptoms? It is manifestly impossible. That Howard failed to obtain successful inoculations is not to the point. There has been no work done to show that *Melanconium sacchari* was not the cause of the eruptions of the rind of the cane.

Now Howard has approached the subject from an entirely different point of view. He has selected certain symptoms of disease in the plant, isolated fungi from the diseased parts, inoculated pure cultures of the fungus into healthy tissues and obtained the same symptoms of disease, and has then concluded that the fungus he is dealing with is the cause of the rind disease, disregarding the fact that neither the symptoms nor the fungus have much to do with the rind and have nothing whatever to do with the eruptions on the rind. The symptoms of the rind disease as he gave them are the drying of the leaves, which commences at the margins of the older ones and gradually spreads to the center of the bunch in from four to six weeks. As soon as this drying of the leaves is well marked, the stem of the cane shows a brown discoloration in one or more places, after which the rind shrivels up and the discoloration rapidly extends in all directions. On splitting such canes the tissues are seen to be of a general reddish color, in which darker red areas can be seen. Very frequently these darker regions contain definite white centers elliptical in vertical section. He states that the appearance is exactly like that figured by Went for the Red Smut due to *Colletotrichum falcatum*. Howard isolated this fungus and made successful inoculations and thus concluded that the rind disease was due to *Colletotrichum falcatum*.

It is unfortunate, to say the least, that the matter of the cause of the rind disease should be further involved by confusing the symptoms. Howard is here dealing with an entirely different fungus and entirely different symptoms from those which characterize the rind disease.

As has been shown neither Howard nor Masseur nor any other worker succeeded in getting good pure culture inoculations of *Melanconium sacchari*. On the other hand, no one has found any other fungus than *Melanconium sacchari* associated with the typical conditions of the disease, *i. e.*, the eruptions of the rind. Until more is done, therefore, to prove the contrary, *Melanconium sacchari* should be considered as the cause of the rind disease.

### NATURAL INFECTION OF STALK, LEAVES AND CUTTINGS.

Whatever question there may be about the active parasitism of the rind fungus, there can be no question as to the actual occurrence of the fungus on the cane in the field. The following is in part a repetition of what has gone before, but taken altogether it will serve to summarize the conditions.

#### OCCURRENCE ON THE STALKS.

*Melanconium sacchari* commonly occurs on green cane stalks at such points of injury as those caused by the weevil borer, near the base of the stalk. These injuries are not sufficient to kill the stalk and it remains green until infected by the rind fungus, and even then the infection progresses only according to the vigor of the cane. The fungus occurs at similar points of injury caused by the moth stalk-borer which may occur any where along the stalk, perhaps more commonly near the top. The moth borer or some bud moth often gets into the top of the cane and kills the heart. This injury is usually succeeded by an infection of the rind fungus which progresses downward. Occasionally the top is rotted and a *Melanconium* infection is present without any sign of insect injury. The extent of all this damage depends largely upon the vigor of the cane as discussed elsewhere.

#### OCCURRENCE ON LEAVES.

A point that apparently has not been considered of great importance is the occurrence of this fungus at the base of leaf-sheaths and occasionally near the joint of the sheath and blade. This occurrence is very common in cane over 8 or 10 months old. It has not been proven to be the same as the stalk fungus, but it cannot be

separated from it morphologically. It would seem to the writer that this point is of considerable value, for it may be assumed that so long as the fungus is present in the field anywhere, either on the leaf-sheaths or elsewhere, that there is a possibility of some damage whenever the right conditions for it occur. There is some variation in the different varieties of cane so far as apparent susceptibility is concerned, and observations have been made on over 50 varieties. However, the occurrence of the fungus does not seem to be constant so that up to the present it is not possible to state definitely that certain varieties are more immune than others. In general the softer varieties such as T77 are more commonly infected on the leaves than such as D116.

#### OCCURRENCE ON CANE CUTTINGS.

Very commonly cuttings that have failed to germinate have been dug up and found infected with this fungus, apparently killed by it.

On one occasion several sacks of cuttings were kept for a period of five weeks. When they had been cut they were supposed to be free from disease, but examination at the end of the five weeks showed that out of 156 cuttings, 135 had the rind fungus, and of these 135, 71 had the rind fungus and no other.

#### LOSS DUE TO THE RIND FUNGUS.

In a disease of this kind it is impossible to state definitely the amount of loss caused. The injury is usually associated with that due to other causes, and it is impossible to consider them apart. One may say that a certain field of cane is entirely destroyed by the rind fungus, whereas the rind fungus might not have infected the cane in the first place if it had not suffered from root disease, drought, moth-borer injury or any one of several factors. It is also just as true that one may say that the same field was entirely destroyed by any one of these factors, where as a matter of fact the loss would not have been half so great without the rind fungus. In general terms I would state that the loss due directly to the rind fungus is often very heavy, involving a partial or complete loss of hundreds of acres of cane in some seasons.

#### TREATMENT OF THE DISEASE.

It is sometimes unsafe to make recommendations for the treatment of a certain disease when the cause or nature of the disease is not well understood. If the recommendations are restricted to general



improved methods of cultivating the cane or of handling it, however, they may be valuable. Such has usually been the type of advice given by various investigators when working on this disease.

In 1895 there was published in the Kew Bulletin an article on sugar-cane disease in Barbados and extracts were included from the report of the commissioners appointed by the Governor of Barbados to inquire into the pests and diseases of the cane. This commission made the following recommendations:

That all plants be soaked in Queensland solution<sup>1</sup> before planting.

That whenever deemed possible by the inspector the practice of spreading trash around young canes be given up; and that whenever it be resorted to, only trash from a field which had been inspected and declared healthy or as healthy as possible be employed.

That rotten canes on all fields diseased with rind disease should be burnt on the field, or crushed and burned as mentioned below.

That rotten canes on all fields be regularly burned during the crop. Juicy canes could be first crushed and the megass burned, the juice being boiled.

That the trash used as litter be taken from fields which are healthy or as healthy as can be got.

That each estate put such an area under the so-called hardy varieties of cane plants as will suffice to replant the whole of the estate in those varieties if necessary.

That the cane fields be periodically inspected, with a view to cutting out the canes infected with borer or fungus, which canes should be bagged upon the spot and taken away, crushed and burned.

Fawcett, writing in the same year (1895) in the Bulletin of the Botanical Department of Jamaica, adds to the foregoing recommendations the following:

Only healthy tops of strong canes should be used as seed canes.

To avoid any chance of the fungus existing unnoticed in the tops, they might be steeped in a solution of sulphate of iron (one ounce powdered in three gallons of water) for a few hours, especially if they are pierced by the borers.

Unfortunately no report of experiments is available to show the value of this latter suggestion. The idea of the sulphate of iron is purely as a disinfectant, which is well accomplished by the use of Bordeaux mixture. Moreover, it should be noted that the mycelium of the rind disease may be within the stalk as well as at the surface, and if there is any of the mycelium within, soaking in any mixture long enough to kill the fungus growth within will also injure the cane. Dipping seed in sterilizing mixtures is purely for the purpose of destroying external fungi and providing a protective covering to prevent the entrance of fungi.

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<sup>1</sup> Queensland solution equals one pint of carbolic acid to 100 gallons of water.

## ALLIED FUNGI.

This subject has already been discussed so far as other alleged stages of this fungus are concerned. The claim that *Trichosphaeria sacchari* is the perfect stage of *Melanconium sacchari* has been shown to be without sufficient proof. The so-called microconidia and macroconidia of *Melanconium* have been shown to be in all probability the same as *Thielaviopsis ethacetica*, apparently an entirely different fungus.

Other species of *Melanconium* have been described, among which are the following:

*Melanconium saccharinum* Penz et Sacc. in Malphigia, 1901, p. 238; Ic. Fung. Jav. t. LXV, f. 3.—Acervulis hypophyllis, gregariis, longitrosus seriatis oblongis, 1 mm. long., 0.5 lat., nigris, epidermide hysteriodes-rimosa velatis; conidiis majusculis globoso-compressis e fronte 24 microns latis, e latere 14 microne es., nigrescentibus, levibus, hyphulis filiformibus tenerrimis, hyalinis suffultis. Sacchari officinarum prope Buitenzorg, in insula Java.—affine *M. bambusino* et *M. hystericino*, sed satis diversum videtur. (from Saccardo.)

*Melanconium Iliani* Lyon described in a Study of Iliani by H. L. Lyon in Hawaiian Sugar Planters' Record and by Edgerton. This fungus is so described as to be in all grosser appearances exactly similar to *Melanconium sacchari*. Its method of fruiting is exactly the same, but the spores are very different. They are large and filled with spherical granules, measuring 7-10 x 15-28  $\mu$ .

## SUMMARY.

1. The symptoms of the rind disease are the eruptions on the rind of the cane from which protrude black masses of spores, together with a drying up of the leaves.
2. The disease has been studied for the last twenty years at least in various parts of the world.
3. The fungus causing the rind disease has only one known spore form in its life history.
4. The rind fungus occurs in the Southern United States, all through the West Indies and Demerara; in Natal, Mauritius, British India, Java (?), Australia, and Hawaii.
5. The fungus is what is known as a wound parasite, *i. e.*, capable of infecting cane only through wounds, or cane that is in an otherwise unhealthy condition. It may be classed as an active parasite on certain weak or soft canes such as Bourbon and D116.
6. The rind disease is caused by *Melanconium sacchari*, one of the fungi imperfecti.
7. Treatment of the disease is restricted to the use of hardy varieties, to adopting such methods as will reduce the moth borer, and to grinding the cane before it is overripe.

8. *Melanconium saccharinum* and *M. iliau* have also been described on cane, but are not to be considered as causes of the rind disease.
9. The rind disease is common in Porto Rico.

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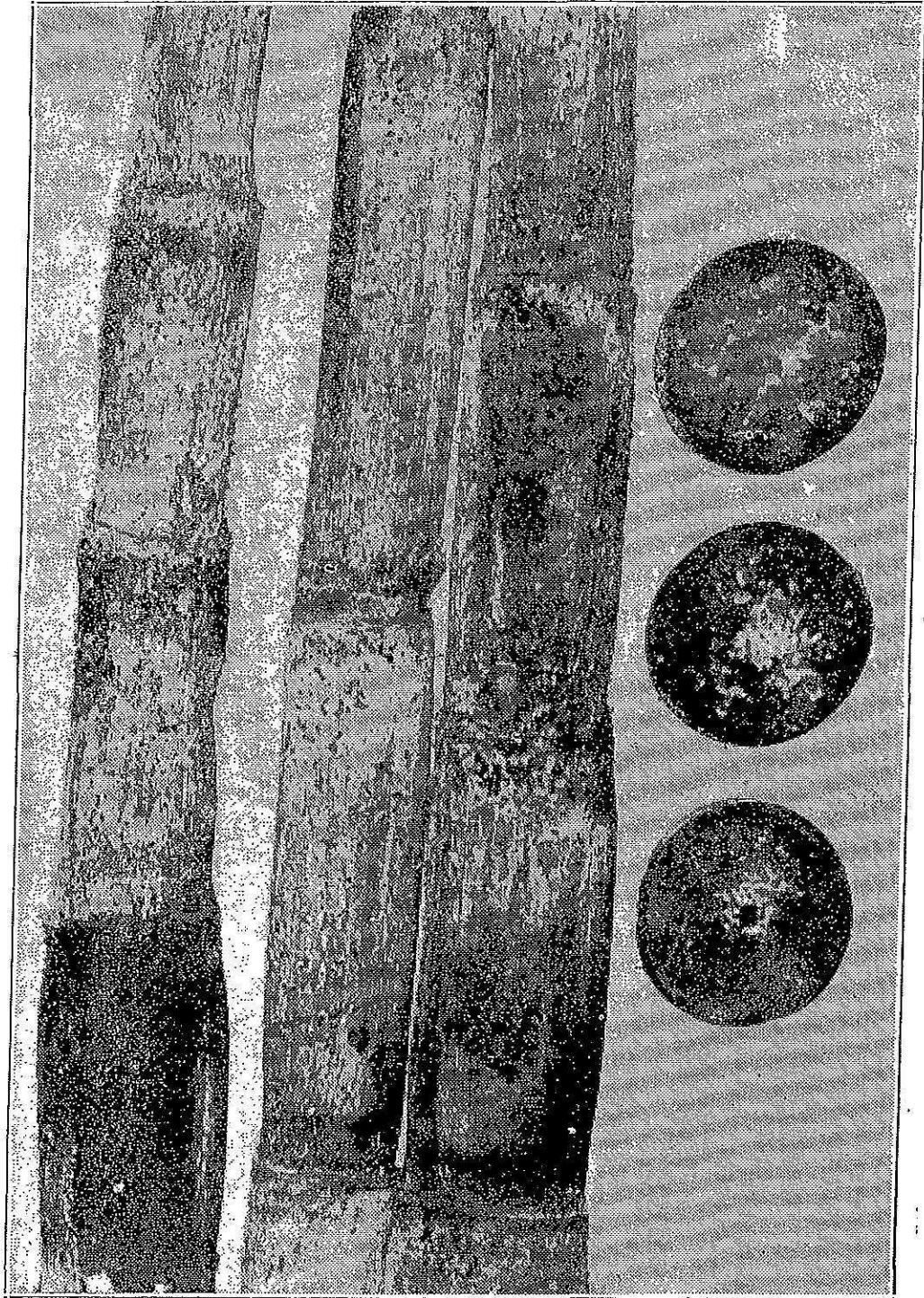


PLATE I.

Stalks of cane severely attacked by rind disease, showing the characteristic black fruiting pustules.