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The Parasitism of *Rhizoctonia bataticola* (Taub.) Butler and other Fungi.

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THE writer's work on the fungus causes of root disease of woody plants in Uganda and Ceylon has led to two conclusions, (1) that *Rhizoctonia bataticola*, a soil-inhabiting sclerotial fungus, is a cause of root disease, that is to say, that the fungus is able to attack and kill plants exposed to it in the soil and is therefore a parasite, and (2) that, when it is found in the company of another fungus (or fungi) in cases of root disease, it precedes the other form (or forms) in time of attack and is therefore primarily responsible for disease. Those views were published in 1927 (1), and the facts which supported them and the circumstances which led up to them were duly discussed. They have been criticised from two points of view, (1) that *Rhizoctonia* is a saprophytic form and is entirely incapable of parasitism, and (2) that the parasitism of *Rhizoctonia* is dependent to such a degree upon the presence of preliminary or contributory conditions which affect the host plant adversely before attack takes place that the fungus may be regarded as a weak parasite or one that is harmless in the absence of the contributory conditions.

The second view which, be it noted, does not deny the parasitism of *Rhizoctonia* but makes it conditional on circumstances unfavourable to the host plant is held in the West Indies and will be answered in another place to the effect that contributory conditions are not apparent in the field in Ceylon and have not been found to be essential in successful *Rhizoctonia* infection experiments. The first view is held in Ceylon by Gadd and Petch who deny that *Rhizoctonia* can be parasitic under any circumstances and assert that it is only and always a common soil saprophyte. They make no mention of, and presumably do not

admit, the possibility of facultative parasitism on the part of *Rhizoctonia*. In other words, their view of *Rhizoctonia* means that they consider that the fungus lives upon or obtains its food materials from dead matter only and that it cannot and never does live on or in living tissues. The writer's point of view is opposed to that of Gadd and Petch; it regards *Rhizoctonia* as a parasite in its relationship to living plants and as having none of the attributes of a true saprophyte. The present note deals with the views of Gadd and Petch only, and in particular is a reply to the remarks made by the latter at the Agricultural Conference held at Peradeniya in May, 1928 (2). It shows that there is reason why the views of Gadd and Petch may be rejected.

Gadd (3) put forward the saprophytic view in 1927, and, in reply to his criticism, the writer (4) drew attention to the sole association of *Rhizoctonia* with numerous cases of root disease of woody plants and to the circumstances of its occurrence in nature which pointed strongly to parasitism. With reference to the writer's doubt concerning the parasitism of other root fungi like *Poria* and *Fomes*, Gadd held that their parasitism was proved by the supposed successful control of their activities by trenching and stumping. It had to be pointed out (4), therefore, that there was no proved cause-and-effect connection between treatment of root disease by trenching and stumping and a supposed diminution in the amount of root disease in Ceylon, that the success claimed for trenching and stumping might be doubted and that the supposed diminution of root disease might be questioned. Gadd ignored *Rhizoctonia* infections of woody seedlings obtained by the writer in Uganda (5), and he has not yet offered proof of the complete saprophytism he claims for the fungus in nature. It may be added that *Rhizoctonia* does not behave as a saprophyte in the field in the sense that it may be found on any medium convenient for its growth, for example, woody debris or the dying or dead roots of trees that have been cut down in areas of soil known to contain *Rhizoctonia*, nor is it by any means confined to the dead matter or substrata affected by the true saprophyte.

It may be of interest to consider the points brought forward by Petch (2) against the parasitism of *Rhizoctonia*. In saying that there is no evidence that *Rhizoctonia bataticola* can be parasitic on woody plants, he also ignores the results reported by the writer (5) in 1926 and the later statement (6) that results had been attained at Peradeniya. It has been shown that *Rhizoctonia* can attack and kill seedlings of tea, rubber, cacao, lime and dadap, and other infections have been obtained on plantains and young coconuts. An account of the experiments and the results will be published elsewhere. Further, Petch follows Gadd in ignoring the significance of cases of sole asso-

ciation of *Rhizoctonia* with root disease. It would be interesting to know how he would explain occurrences of *Rhizoctonia* on tea in which no other root disease fungus is present and in which penetration by *Rhizoctonia* from the smallest roots through the larger roots and even into the stem is distinctly set forth and is followed by death of the plant. In such cases, and they are not uncommon, the death of the plant may be attributed to *Rhizoctonia* with reason and certainly with as much reason as Petch attributes pathogenicity to *Poria* and *Diplodia*. If not, Petch would apply to *Rhizoctonia* tests or citeria of pathogenicity which he has not applied to certain fungi which he lists as causes of root disease of tea, a proceeding that is somewhat one-sided. The conclusion seems unavoidable that, if he had detected its association with, for example, root disease of tea, Petch would have included *Rhizoctonia* among the fungi to which he attributes root disease of tea without having tested in experiment their ability to cause root disease. Gadd (7), again, has said that "there is no obvious "reason why the mere presence of the fungus should suggest a "parasitic habit," a remark which shows that he also judges *Rhizoctonia* by standards which he does not apply to other supposed parasitic fungi.

Two further points are contained in the following sentence: "If a root attacked by *Fomes* is buried in contact with the roots "of a rubber tree, it is more than even chance that the tree "will be attacked by *Fomes* and die. That cannot be done with "*Rhizoctonia bataticola.*" The first point is that the claim cannot be admitted because experiments conducted at Peradeniya within the last two years have failed to show that *Fomes* will spread to and attack rubber roots alongside which it is buried, and the second is that the words "That cannot be done with *Rhizoctonia* "*bataticola*" are meaningless because *Rhizoctonia* does not and has never been asserted to spread by contact or attack woody roots through the bark. In saying, therefore, that the chances of parasitism in fungi like *Fomes* and *Poria* are mathematically greater than those of *Rhizoctonia* he ignores the fact that the number of possible points of entry for *Rhizoctonia*, that is, the feeding roots, is at least as great as, if not much greater than, the points open to the attack of *Fomes* or *Poria*, that is, the surfaces of the larger roots. A calculation regarding a method of infection which is not adopted by the fungus in question is of no value. Besides, it takes no note of the possibility that a fungus may be more strongly parasitic than another with which it is compared. It may be added that the simple demonstration of the parasitism of *Poria* recommended by Petch has not been found to succeed in recent trials with healthy tea bushes. *Poria*, like *Fomes*, cannot therefore be regarded by the writer as a primarily parasitic fungus.

Petch's arguments for the saprophytism of *Rhizoctonia* do not bear scrutiny. The first, that the fungus has not been made to attack woody plants, has already been answered. The second is that it is found in dead roots of plants of all kinds. It may have been forgotten that a supposed root disease fungus, that of brown root, has been recorded in Ceylon as a cause of disease of over twenty plants. The argument may therefore be applied equally to *Fomes lamaoensis*. If emphasis is meant to be laid upon the words "of all kinds," it can be said that there is no reason why the fact that a certain fungus may be found on the roots of many different plants should not mean that it is capable of attacking and killing monocotyledons as well as dicotyledons and gymnosperms. Further, Petch does not take into account the most significant fact of all, that *Rhizoctonia* can be found in *living*, apparently healthy, large roots as well as in those it has killed, although the fact was brought to his notice (6). Another argument for its saprophytism is that *Rhizoctonia* grows rapidly in culture. Petch appears to be unaware of the fact that all isolations of *Rhizoctonia* do not grow rapidly in culture, and he implies that all fungi which grow rapidly in culture are to be regarded as saprophytes, a view that only requires to be put forward to be rejected. It cannot be applied to *Rhizoctonia* and withheld from other parasitic fungi. It is well known that many parasitic fungi are capable of vigorous growth in artificial culture. These criticisms show that Petch's arguments for the saprophytism and against the parasitism of *Rhizoctonia* cannot be accepted.

A further point is that quick action on the part of *Rhizoctonia* when inoculated into wounded jute stems proves it to be a rapid grower, an argument that ignores the fact that any fungus will prove to be a rapid grower on a medium to its liking. Growing *Rhizoctonia* on the wounded stems of jute, a plant part that is susceptible to *Rhizoctonia*, is almost comparable to growing it in a culture medium or on blocks of wood. A truer and fairer comparison would have considered the rate of growth in healthy roots, not in wounded stems, and it would show that the rate of advance is slow. The latter fact, however, is no argument in favour of saprophytism or against parasitism. Petch requires *Rhizoctonia* to be a rapid grower in order that it may be fitted into the hypothesis which regards *Rhizoctonia* as able to enter and advance in the roots only after they have been presumed to be killed by the attack of fungi like *Fomes* and *Poria* at a higher point or by some other agency. He takes no account of the many cases in which *Fomes* or *Poria* or an outside agent is absent and *Rhizoctonia* nevertheless has penetrated the roots with thoroughness, or of the numerous cases in which attack of *Fomes* or *Poria* on larger parts of roots is only in its initial stages while *Rhizoctonia* attack has killed the smallest roots extensively and often

also the larger roots, that is, cases in which there is no question of the advance of *Rhizoctonia* in roots killed or injured by another fungus even though the other fungus be present. Petch would have difficulty in explaining the presence of *Rhizoctonia* in such cases and also the fact that the attack of *Fomes* and *Poria* is confined to roots or parts affected at lower points by *Rhizoctonia* and the further fact that *Fomes* and *Poria* may not appear at all whereas *Rhizoctonia* is always present. In other words, it is to be noted that *Rhizoctonia* attack takes place in the absence of the conditions which are said to be necessary for it. This point brings the argument back to the denial by Gadd and Petch that any meaning may be attached to the sole association of *Rhizoctonia* with cases of root disease and shows how illogical and unreasonable their attitude is.

Gadd (7) has postulated the ability of *Rhizoctonia* to invade dead plant tissues with rapidity, an ability which he requires in order to explain the presence of *Rhizoctonia* at points well-removed from its point of entry, that is, its presence in larger roots into which it has advanced from the smaller parts. As there is no proof or evidence that *Rhizoctonia* can or does enter dead roots and grow in them rapidly or otherwise under natural conditions, Gadd's postulate is founded entirely upon supposition. The only dead roots in which *Rhizoctonia* is found are those killed by itself which remain attached to the plant until natural decay sets in, and there is no doubt that the growth of *Rhizoctonia* under natural conditions is dependent on living root tissues as far as its relation to plants is concerned. At the same time, attention may be drawn again to the fact that *Rhizoctonia* can be found in and isolated from *living*, apparently healthy roots of tea and rubber, which fact is strong evidence against its supposed saprophytism and in favour of its parasitism. The fungus can also be isolated with ease from its advancing edge in roots that are sickly but not moribund or dead. Further evidence for parasitism can be obtained from infection experiments with woody seedlings which will show the entrance of *Rhizoctonia* by the feeding rootlets and the slow advance of the fungus in the roots (or a portion of them) leading to sickness and eventual death of the invaded plant.

The position of Gadd and Petch with regard to their view of *Rhizoctonia* is unsound because it is founded entirely on supposition which can be criticised and swept aside and is backed by their refusal to face the significance of the sole association of *Rhizoctonia* with cases of root disease. They claim saprophytism where none of the conditions of saprophytism are fulfilled, where, on the contrary, it can be shown that the supposed saprophytic fungus cannot possibly be a saprophyte. Their other supposed

strong point, that *Rhizoctonia* has not been proved to be parasitic in experiment, is tenable no longer. The facts point conclusively to the parasitic nature of *Rhizoctonia*.

Gadd (7) has also discussed the significance of the mycorrhizal form of *Rhizoctonia bataticola* found on tea and described by Park (8). His remark that "a mycorrhizal fungus normally plays "no part in causing the death of the plant it inhabits" will not meet with general acceptance for certain authorities hold that the mycorrhizal condition is one of parasitism of the fungus on the plant root, and, when he says that the mycorrhizal theory fits the observed facts "and accounts for the presence of *Rhizoctonia* "in dead roots, particularly the finer roots," he supposes the roots to have been killed by another agent than *Rhizoctonia*, a supposition to which objections have been raised. He makes no allowance, of course, for the possibility that *Rhizoctonia* may have advanced from the mycorrhizal form and killed the roots, and he also fails to account for its presence in large roots well-removed from the original mycorrhizal site, large roots which, be it noted need not be dead. The mycorrhizal theory, therefore, does not fit, as he asserts, the observed facts and is not "entirely opposed "to the parasitic theory." His attempt to explain the advance of *Rhizoctonia* from the mycorrhizal condition to the parasitic on the ground that conditions upset the equilibrium between plant and fungus depends upon proof of the existence and action of conditions unfavourable to the plant. At the moment he merely supposes them to be in action because it is convenient to do so. It may be hoped that the conditions exist; they are not apparent in the field or necessary for the parasitism of *Rhizoctonia* in experiment. In any case, with or without conditions, *Rhizoctonia* would still have to be regarded as a parasitic fungus. The suggestion that *Rhizoctonia* may be enabled to pass from the endophytic or mycorrhizal form to that found in larger roots, particularly larger dead or diseased roots, when the plant is attacked at a higher point by another fungus, for example, *Poria* or is upset physiologically by external conditions was made by Park (8). He was careful to point out, however, that he had little evidence in support of it. The following points militate against the suggestion. It fails to account for the advance of *Rhizoctonia* in the absence of attack by another fungus or in the case of attack which is in an early stage while *Rhizoctonia* has advanced a long way or in the case of attack at a certain point which cannot influence the advance of *Rhizoctonia* at other points. It is not proved that the other fungus can attack independently, or that *Rhizoctonia* is unable to make progress until the other fungus has attacked, and, as pointed out above, adverse external conditions are not clearly in evidence. In any case, *Rhizoctonia* entry into the roots is still prior to the supposed attack of a fungus like *Poria*.

Speculations of this nature, however, have little value in the present state of our knowledge. Before they can be of real help, investigation will have to show if the mycorrhiza is obligate and lasting, that is to say, whether it is a true mycorrhiza. In other words, synthesis of the mycorrhiza should be attempted. A true mycorrhiza need not be of benefit to the plant, and it must therefore be shown whether *Rhizoctonia* is harmful in the mycorrhizal stage. The percentage of roots which harbour the endophytic form and the possibility of the presence of other fungi must also be investigated, and the conditions, not necessarily conditions of external origin, under which *Rhizoctonia* passes from the mycorrhizal stage to that of advance in the roots must be studied.

In bringing forward the question of the *Rhizoctonia* endophyte of tea roots, the writer (6) merely wished to draw attention to the possible significance of the identity of the endophytic or mycorrhizal fungus with that which causes root disease and death and to point out that the present balance of evidence is in favour of the view that the fungus is, as it were, intent on parasitism *ab initio*. It is possible that the mycorrhizal and parasitic forms of *Rhizoctonia* are unrelated as far as subsequent root disease is concerned; it is equally possible that the mycorrhizal condition is a phase, perhaps obligatory perhaps fortuitous, in the causation of root disease by *Rhizoctonia bataticola*. However that may be, the lines upon which investigation of root disease is proceeding seem more likely to lead to a true understanding of the causation of root disease than past investigation which ceased at the point where it first found a possible cause, that is, the larger parts of roots, and was unaware of the necessity for examination of the smaller roots and the feeding rootlets. It thus made the mistake of regarding the agents of root disease which attack at higher points as symptomatic of a first or primary phase of root disease whereas they are more likely to belong to a secondary phase.

Two recent publications which have a bearing on the subject under discussion may be mentioned here. The first is an account by O'Brien and M'Naughton (9) of an investigation into the widespread strawberry disease known as Lanarkshire disease. They describe the invasion of strawberry roots by a mycorrhizal or endophytic fungus which resembles the mycorrhizal *Rhizoctonia* of tea isolated by Park and shown to be *Rhizoctonia bataticola*, and their observations lead them to conclude that the fungus is parasitic and responsible for the disease. It is noteworthy that the disease is reported to be slow-acting and chronic in nature and that the fungus is capable of causing death. It is said that "the ultimate damage "is greater or less as mycorrhizal attack is severe or slight

"and as conditions are unfavourable or favourable for plant "growth." The case differs from that of *Rhizoctonia* on woody plants in Ceylon inasmuch as very large areas are affected whereas *Rhizoctonia* root disease affects scattered plants or small areas, and the difference points to the probability that the action of external conditions over large areas, the manner in which they may be expected to act, has an influence on the amount of disease. It should be noted, however, that external conditions have not been proved to be of primary importance in relation to the root *Rhizoctonia* of strawberry. In fact, O'Brien and M'Naughton remark that "there was abundant evidence to show that the "disease might be serious even on good soils, liberally manured "and well-drained."

The second concerns endophytic fungi of the roots of sugar-cane. Ciferri (10) reports from the Dominican Republic that the endophytes lead to retardation and death of rootlets, that is to say, that the endophytes are parasitic. A species of *Rhizoctonia* is regularly present and is more aggressive and penetrative than a second form which is also found. The evidence for the parasitism of *Rhizoctonia* is considerable. It may be added that the rootlets of tea seedlings infected by *Rhizoctonia bataticola* in the writer's experiments do not show the persistence of a mycorrhizal condition of *Rhizoctonia* in the roots. If it formed a stage in the process of infection, it has been left behind, as it were, by the advance of the fungus; there is morphological evidence of its presence. It should be noted that it is not assumed that the Rhizoctonias of tea, of strawberry and of sugar-cane are the same species. Attention is merely drawn to the trend of investigation, to the recognition of the parasitism of the genus *Rhizoctonia* in small roots without the aid of contributory conditions, and to the fact that the findings of other workers tend to support the writer's conclusions regarding the parasitism of, and the method of attack adopted by, *Rhizoctonia bataticola* in Ceylon.

Up to this point the arguments for and against the parasitism of *Rhizoctonia* have been surveyed and the mycorrhizal condition of the fungus has been discussed. It remains to make a few remarks concerning the position of the fungi which have been regarded in the past as causes of root disease. Their parasitic status has been questioned by the writer on the grounds that they do not occur in nature without *Rhizoctonia* and that *Rhizoctonia* attack takes place prior to the appearance of the other fungus (or fungi) and therefore leads to it. The questioning of their status has led to experimental work on their parasitism and also to the bringing forward of evidence in favour of their supposed parasitism. That the evidence cannot be accepted is apparent from the notes which follow.

Petch (11) has collected the experimental evidence in favour of the parasitism of the old-established and well-known root fungi and Gadd (12) has reported successful inoculations with and infection of tea seedlings by a species of *Rosellinia*. The nature of Petch's evidence for the parasitism of *Poria* and the fungus of brown root disease cannot be regarded as satisfactory. Other cases quoted by Petch seem perfectly good until it is remembered that *Rhizoctonia* is found to be present so consistently in cases of supposed *Poria* and other root disease that suspicion of its undetected presence in the cases quoted is justified and well-founded. In the past *Rhizoctonia* was not looked for or suspected to be present because investigation had not disclosed its presence. It is therefore possible, even likely, that the cases quoted by Petch are not as reliable as they seem. Further, Petch omits to mention in his invitation to planters to experiment with certain root fungi the probability of the presence and influence of *Rhizoctonia* and the necessity for making certain that *Rhizoctonia* is not concerned vitally in what are supposed and meant to be simple one-fungus experiments with *Fomes* and *Poria*. Again, *Fomes*, *Poria* and other root fungi have been used in experiment at Peradeniya in the manner suggested by Petch. The promised results have not been obtained; in fact, it has been shown that *Fomes lignosus* and *Poria* are parasitic only in the presence of *Rhizoctonia*, the former on rubber seedlings and the latter on tea bushes. It may be added that field experiments with the brown root fungus (*Fomes lamaoensis*), *Ustulina* and *Diplodia* have given negative results.

Gadd (13) has said that "the majority of the fungi which "cause root diseases of mature tea appear to be incapable of "attacking seedlings," and he suggests that tea seedlings "are "immune to these fungi (*Poria*, *Ustulina* and *Fomes lamaoensis*) "until they have reached a suitable stage of development." The fungi in question have still to be proved capable of causing of their own efforts root disease of mature tea, and it may be suggested that they do not attack seedlings in nurseries because they may be absent from the carefully-prepared soil of nursery beds or because they are incapable of attacking as primary parasites. It is to be noted that *Poria* and *Fomes lamaoensis* can be found on young tea and other plants attacked by *Rhizoctonia* in the field very soon after planting out. If Gadd has conducted experiments with *Fomes* and *Poria* on seedlings, it would be of interest to have an account of his results. Successful inoculations of tea seedlings with *Rosellinia arcuata*, a fungus which is, on the whole, uncommon, have led Gadd to conclude that "a "pathogenic soil fungus can easily gain entrance into its host by "other ways than viâ the fine rootlets." If this statement is meant to include soil fungi like *Poria* and others, the pathogenicity of

which has not been proved, it is more sweeping than justifiable; it may not be applicable, in any case, to adult bushes since Gadd would make a distinction between the susceptibility of seedlings and that of adult plants. *Rosellinia arcuata* may be the virulent parasite that Gadd reports, but it is uncommon enough to be of very little account. So far as the writer's hypothesis of the secondry nature of *Fomes*, *Poria*, *Ustulina*, *Diplodia* and *Rosellinia* is concerned, it may be necessary to withdraw the relationship of *Rosellinia arcuata* to tea from the list, but, on the other hand, it is important to note that the few cases of *Rosellinia arcuata* on tea that have come into the writer's hands have also shown the presence of *Rhizoctonia*. Further, the writer's experiments with *Rosellinia arcuata* in the field have given negative results. In any case, absolute truth of the hypothesis regarding the secondary nature of *Fomes*, *Poria*, *Ustulina*, *Diplodia* and *Rosellinia* is perhaps too much to expect. The hypothesis, however, is shown by experimental results to be tenable as a whole, and the fact that a small part of it appears to be contradictory to the general conclusion need not invalidate the whole hypothesis.

A few notes on *Armillaria*, *Fomes lamaoensis* and *Diplodia* may be of interest. With reference to *Armillaria* root disease of tea, Gadd (13) who has lately recorded the fungus remarks that "the parasitism of *Armillaria mellea* has been well proved else-"where." This statement is open to doubt for there seems to be a lack of clear experimental evidence for an aggressive parasitism on the part of *Armillaria* under natural conditions. W. R. Day (14), a recent worker with *Armillaria mellea* (which is probably the same species as that found on tea), says that "the conclusion "to be drawn from the evidence put forward is that *Armillaria* "*mellea* is able to penetrate an uninjured and apparently healthy "host. Accordingly it might appear that the fungus is a virulent "parasite and a primary cause of disease. This is by no means "certain, however, if for one reason only, and that because it is "possible sometimes to find trees that are attacked by the fungus "and yet do not die, or that, belonging to a species reckoned to be "susceptible, are in close proximity to the parasite and yet show "no signs of successful attack." Day's general conclusion is that "other and external factors often, and perhaps always, have a "much greater influence in determining the intensity of infection "and the general susceptibility of species." These words are significant. Although out of place, the suggestion may be made that an examination of the smaller and the feeding roots of trees attacked by *Armillaria* might shed light on the question of the factors that lead to *Armillaria* attack.

Hansford (15) who has been studying root disease in Uganda makes the following remarks on the subject of the brown root disease fungus and *Armillaria* which he found to accompany *Rhizoctonia* in cases of root disease of robusta coffee. "In most "of these instances, but by no means in every case, the original "*Rhizoctonia* has been followed by other fungi among which the "characteristic rhizomorphs of *Armillaria mellea* and the mycelium "of *Fomes lamaoensis* have been noted. The latter fungus, des- "cribed in the East as the cause of brown root disease of various "trees, was definitely a secondary parasite in the case of diseased "coffee in the Sesse Islands. In one native plot of *Coffea robusta*, "every stage in the disease was found, commencing with the "original attack of *Rhizoctonia* on the small rootlets, afterwards "passing along to some of the main roots nearest the surface of "the soil, and finally marked by rapid development of the brown "mycelium of the *Fomes* with its adhering soil and gravel over the "whole of the larger roots of the trees. In other cases the rhizo- "morphs of *Armillaria* were noted as starting on the smaller roots "attacked by *Rhizoctonia* and finally progressing beyond the limits "of invasion of this fungus to the main roots of the tree. In no "case was *Fomes lamaoensis* or *Armillaria mellea* found on coffee "roots in the absence of *Rhizoctonia*, whereas in over seventy-five "per cent. of all cases of root disease *Rhizoctonia bataticola* was "alone present in the attacked roots. This evidence is all in "favour of the contentions of Small that *Rhizoctonia* is the primary "invader in most, if not all, cases of brown root disease and similar "diseases formerly ascribed to fungi of the *Fomes* group." Hansford's evidence supports strongly the writer's contention that the presence of certain fungi is indicative of a secondary phase of root disease, the primary phase of which is caused by *Rhizoctonia*, and it shows that *Armillaria* need not be a primary parasite.

Briton-Jones (16) has reported from the West Indies that "*Fomes lignosus* is not a primary parasite and, if it contributes "at all towards the killing of the plant, it is in the capacity of a "very weak parasite. It is of no consequence whatsoever "from the practical standpoint." He says further that *Fomes lignosus* is one of the commonest fungi to be found in Trinidad, that it is not recorded as a cause of disease in the West Indies, and that, though conditions in Trinidad seem ideal for *Fomes* infection of cacao, it does not occur. Petch (17), however, asserts that the supposed West Indian *Fomes lignosus* is a different fungus from the *Fomes lignosus* of the East. Further comment must be withheld until the question of the identity of the West Indian form is settled.

Experiments at Peradeniya have failed to show that *Diplodia* is the virulent parasite of tea roots described by Petch (18). Gadd (13) may have had a similar experience with the fungus for he now wishes to attribute the association of *Diplodia* with tea root disease and failure to recover from pruning to a weak or secondary parasitism which follows upon and is encouraged by a shortage of food reserves in the affected roots. *Diplodia* may therefore be ignored as a primary cause of tea root disease or failure to recover from pruning, and the true cause of the loss of bushes is to be sought elsewhere, that is, in an inherent or induced inability on the part of the bush to recover from the effects of pruning and plucking. Failure to recover from pruning is regarded by the writer as identical with root disease because it is found that cases of failure to recover from pruning are in reality cases of root disease, and, further, that attack of the fungus *Rhizoctonia bataticola* upon the roots is associated with them. It may be pleaded that *Rhizoctonia* follows the shortage of food reserve in the roots, as *Diplodia* probably does, but it is equally possible that the shortage is caused directly by *Rhizoctonia* attack and advance. It is apparent from the recovery of tea in the field from pruning and from plucking that the effects of these operations alone are unlikely to be the sole cause of a degeneration which results eventually in the loss of the bush and that the presence and operation of another harmful factor are required. The possibility of the action of another harmful agent being aided by the effects of pruning and plucking is always present, but there is no evidence for it, as far as the most likely factor, *Rhizoctonia bataticola*, is concerned. It seems that efforts are being made to treat failure to recover from pruning as a so-called physiological disease before the possibilities of parasitism on the part of a consistently-present fungus are exhausted or even considered, a step that is indefensible when there is evidence of the presence and for the parasitism of the fungus in question.

The matters discussed in the preceding pages may be summarised as follows. It is held by those who oppose the writer's views that the plant in the roots of which *Rhizoctonia* is found must be upset or disturbed by the attack of another fungus (for example, *Fomes* or *Poria*) or by the operation of adverse conditions of growth before *Rhizoctonia* is enabled to attack at all, that the disturbance is complete enough to cause the death of the roots, and that *Rhizoctonia* can enter and occupy only roots killed by such disturbance; in other words, that *Rhizoctonia* can behave only as a saprophyte and never as a parasite. It has been pointed out that these views are founded on supposition and are unsupported by either proof or field evidence. The writer holds,

on the contrary, that the supposed disturbing conditions, physiological or fungus, are neither apparent nor essential for *Rhizoctonia* attack in the field and in experiment, that they have not been shown in operation and are only supposed to be present, that, in general, the other fungi which are said to attack before *Rhizoctonia* have not been proved capable of doing so, that *Rhizoctonia* is found in such positions (for example, living roots) and under such circumstances (for example, sole association) that it cannot be a saprophyte and must be a parasite, and that *Rhizoctonia* has been proved capable of parasitism in experiment.

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