Correspondence.

ROOT DISEASES OF ECONOMIC CROPS.

A Reply to Dr. W. Small.

BY

C. H. GADD, D.Sc. (Birm.),

Mycologist, Tea Research Institute of Ceylon.

THE view expressed by Dr. Small in his paper "A review of recent work on root diseases of economic crops," read at the last Agricultural Conference at Peradeniya, is both novel and alarming. It is novel in that certain fungi, which in Ceylon and elsewhere have been regarded by experienced mycologists as the primary causes of definite serious diseases, are now to be regarded as harmless or relatively so, and that diseases with very different and distinct symptoms are now all to be considered as the results of the parasitic activities of one fungus--viz. *Rhizoctonia bataticola*. It is alarming because this omnivorous fungus is everywhere present, it is only a matter of time before its presence becomes more notably evident, and because no satisfactory remedy is likely to be discovered in the immediate future.

Concerning this sinister fungus, *Rhizoctonia bataticola*, Dr. Small states :--

(1) "My interpretation of the meaning of the presence of the Rhizoctonia involves a complete change from the accepted view of the causation of root disease in the tropics." "I conceive of *Rhizoctonia bataticola* as the basic cause of root disease in Ceylon. It is, as it were, the foundation on which other fungi build."

(2) "The complete list of victims (host plants) is now about thirty in number. It includes tea, rubber, cacao, coffee, beans, dadap, *Albizzia*, *Acacia*, *Grevillea*, *Tephrosia*, *Clitoria*, soursop, custard apple, chillies, tomato, lime, orange, plantains and several ornamental and useful trees and plants." "It is conceivable that the 'Diplodia' dieback (of rubber) is nothing more than a symptom of the presence of root disease underground . . . . . Similarly the common dieback and gumming of lime trees may be attributed to Rhizoctonia root disease, and so also may the gumming of Acacia, Grevillea and other stems. Dieback of the aerial parts of a tree is to be regarded on the whole, as a symptom of other trouble, most probably of root disease, and I am not prepared to believe in an independent fungus cause of dieback of local woody plants unless I am convinced that root disease is not present, especially *Rhizoctonia bataticola* root disease."

(3) "There is no doubt that Rhizoctonia root disease will always occur when the fungus is present in the soil."

(4) "It has been found that *Rhizoctonia bataticola* occurs in the soil of all the planting districts of Ceylon. It does not seem to be confined to certain types of soils or be more common in certain soils than in others, and elevation has no influence on its distribution."

(5) "It possesses a pycnidial stage which grows upon the aerial parts of plants, for example, the stems of jute in India. This pycnidial stage produces spores and when the spores fall to the ground and germinate they give rise to the Rhizoctonia stage of the fungus. It is therefore conceivable that the distribution of the pycnidial spores by natural agencies like wind and rain, and their germination in the soil when conditions are favourable account for the wide distribution of the Rhizoctonia. If this theory proves to be sound it will follow and will be proved, I hope, that the pycnidial stage of the Rhizoctonia is fairly common in Ceylon."

(6) "It is not a practicable measure to attempt to eradicate the fungus from the soil."

(7) "The only measure that can be recommended to the practical planter is that he should promote the health of his plants by all means in his power. Unfortunately, success in avoiding Rhizoctonia root disease cannot be guaranteed to follow that measure, for it is clear that the healthy well-grown trees and bushes fall victims to the fungus and it is to be feared that they will continue to do so."

This short summary presents a somewhat gloomy picture. When it is remembered that the action of this fungus on woody plants is slow, that deaths do not take place, as a rule, until the trees are old and large enough to fulfil their purposes, and that all our Ceylon soils contain this pernicious fungus, *Rhizoctonia bataticola*, the fact that fresh infections are continually occurring owing to the distribution of spores from at present unknown sources, is somewhat disturbing. It must be evident, if Dr. Small's view is correct, that the prospects of our main agricultural industries in Ceylon are anything but bright.

Fomes, Poria and other fungi, which in the past we have looked upon as the causes of our more serious diseases, are not peculiar to Ceylon. They occur in India, Java, Malaya and other tropical countries where the scientists who advise our planting rivals, also regard them as primary causes of disease. If it proved in Ceylon that those root diseases which we have previously attributed to the activities of Fomes, Poria, etc., are in fact due to *Rhizoctonia bataticola*, it must follow that Fomes, Poria, etc., are not the real causes in Java and Malaya also. That Dr. Small shares this view is evident from his statement:— "There are many countries in which I personally have no doubt *Rhizoctonia bataticola* is present and undetected on such crops as tea, rubber, cacao, and citrus, and I think it is only a question of time and investigation until the fungus is run to earth, so to speak, and until its suspected great economic importance is realised in full." For those who like companions in distress it may be some consolation to realise that their rivals outside Ceylon will be in the same boat.

It is of more importance for a practical planter to know how to treat specific diseases than to know full details concerning their causes. But efficient treatment is dependent, to a great extent, upon the nature of the cause. When the cause of a disease is a living organism, a full knowledge of its habits and life history has to be acquired, in order that the best method of limiting and stopping its activities may be devised. The present methods of treatment for our more serious root diseases have been based upon studies of the life history, method of dispersal or spread of those fungi known as Fomes, Poria and Rosellinia. It must follow that

unless *Rhizoctonia bataticola* is similar in habit to these fungi, the treatment practised will not be suitable if the real cause of the trouble is *Rhizoctonia bataticola*.

The present treatment of those diseases known as Fomes, Poria and Rosellinia consists essentially of (1) starving the fungus out of the soil by the removal of all roots upon which it may feed and from which it may grow out to reach other bushes or trees suitable for attack, and (2) the construction of a barrier in the form of a trench in front of the fungus to prevent it reaching other bushes or trees *via* the soil. If I understand Dr. Small aright, *Rhizoctonia bataticola* does not spread by contact. I quote from the Transactions of the British Mycological Society, Vol. X. p. 290. " But careful search has not revealed a single instance of infection by contact. It was supposed that a young tea plant and an arnatto affected by the Sclerotium (now *Rhizoctonia bataticola)* had acquired the root disease through their proximity to diseased *Grevillea robusta*, but an examination of numerous examples of the new hosts of the fungus has not produced any evidence of its spread by contact. It seemed, therefore, that independent infection was the rule rather than the exception, and that the incidence of infection of woody plants was governed more by the degree of susceptibility of the host plant and the presence of the fungus than by such external conditions as control the health of the plants." That view appears still to be maintained by Dr. Small, as the only remedial measure he can recommend to the practical planter is that he should promote the health of his plants by all the means in his power. It must follow that, if the cause of all our root diseases is the fungus *Rhizoctonia bataticola* the present methods of treatment are waste of energy and money. We are merely throwing good money after bad.

Such a view must be strongly resisted. I am informed, accurately I believe. that the incidence of root disease in both tea and rubber at the present time is markedly less than in the past, say between 1906 and 1912. The improvement in the position regarding root diseases synchronised with the adoption by estates of the present methods of control, together with the systematic removal of old stumps. The success achieved by these methods has certainly justified their adoption. I also find it difficult to conceive that the Ceylon Planter would have continued these methods of treatment, as they are expensive, if he had not been satisfied with the improvement resulting therefrom. If the success of the treatment is admitted, the correctness of the principles on which it was founded is tacitly implied.

As there appears to be some evidence indicating the accuracy of the old ideas, viz. that Fomes, Poria etc., are the active parasites, it behoves us to look closely into the reasons for discarding those ideas and for accepting the new hypothesis that all root disease is due to the activities of one fungus *Rh. bataticola*, before we abandon methods of treatment which have been found satisfactory and substitute another, the success of which its author cannot guarantee.

Dr. Small rather summarily dismisses the old ideas with the following statement. " Fomes and Poria, not to mention others, are presumed to be truly parasitic because of their supposed sole association with frequent cases of root disease, but, as already indicated, recent investigation has shown that they are never in sole association with cases of root disease, and that in fact, they have been accompanied by *Rhizoctonia bataticola* in every case examined of late." I cannot call to mind any scientist who has ever based any claim for the parasitism of Fomes or Poria on the supposed or proved *sole* association of the fungus with its host. It is the common experience of mycologists and pathologists in general that as soon as the tissue has been killed by one organism, other organisms appear and sometimes so

crowd out the original invader that the latter is difficult, almost impossible, to find. I would go still further than Dr. Small and state that every diseased root bearing Fomes or Poria is accompanied by *numerous* other fungi besides *Rhizoctonia bataticola*. Most mycologists, I think, will agree with this statement. If, then, the presence of another fungus on the diseased roots is sufficient to disprove the parasitism of Fomes, the same argument is sufficient to upset any similar claim made for *Rhizoctonia bataticola*. But, as no claim has ever been made or is likely to be made by an experienced mycologist that Fomes, Poria or other parasitic fungus occurs in *sole* association with frequent cases of root disease, Dr. Small's statement quoted above does not afford any reason for displacing those fungi from their established position.

Dr. Small offers a number of reasons for considering *Rhizoctonia bataticola* to be a parasitic fungus which causes all the root diseases of our economic crops. We will now proceed to examine those reasons in detail.

1. "First, there is the evidence of cases of root disease in which there are no complications, that is, cases in which the Rhizoctonia occurs alone and must therefore take all the blame for the disease caused." On first reading this statement one wonders whether Dr. Small really intended the words "occurs alone" to be interpreted literally. The frequent repetition of such statements as "occurs alone," "sole association" and "it was determined by a careful examination that no other fungus was present" leads one to infer that these terms convey exactly what Dr. Small meant. I have already stated that the occurrence of a single fungus on dead tissues is almost, if not quite, unique. I would ask Dr. Small whether he really means that no fungus other than *Rhizoctonia bataticola* can be cultured out of the dead roots, including the cortex and the wood, of the specimens he refers to. If other fungi can be cultured out of the material then *Rhizoctonia bataticola* evidently does not occur alone, and without further definite evidence *Rhizoctonia bataticola* has no greater claim to parasitism than have the other fungi present. If, however, we allow for the sake of argument that *Rhizoctonia bataticola* does occur alone, I still maintain that it constitutes no proof of parasitism.

It has frequently been stated, probably with very good reasons, that some of the roots of a tea bush die back at every pruning as the result of pruning. It is admitted that *Rhizoctonia bataticola* is common in the soil and appears to prefer woody matter as a source of food supply. Then, is it surprising that this fungus should be found in these dead roots? It is more surprising to be informed that this fungus killed the roots. Is it not probable that some of the finer roots of any tree die off periodically as they are replaced by new roots, particularly when the trees are growing in an unsuitable environment or in infertile soil, such as is usually the case when rubber trees are affected by dieback such as Dr. Small describes in one of his examples? The presence of *Rhizoctonia bataticola* in such roots is satisfactorily explained on the simple basis of saprophytism, i. e., the fungus will live only on dead tissues. I would suggest, then, that the cases in which Dr. Small states there are no complications, are too frequently complicated by environmental conditions.

2. When "more than one fungus is present it is to be noted particularly that *Rhizoctonia bataticola* has been found to be present in every case." Here again the presence of Rhizoctonia may be explained as a saprophyte. The dead roots resulting from the attack by one of the established parasites form an excellent medium in which this common soil fungus can grow.

3. "The Rhizoctonia precedes in time of attack the other fungus Fomes or Poria or Ustulina which may occur with it." Dr. Small lays great emphasis on this question of priority in time of attack but I submit

that it is a most difficult matter to prove. We need consider only one case which Dr. Small describes in detail. "In the case of a rubber root disease, a group of dying trees was found on the roots on which only *Rhizoctonia bataticola* was present..... It was determined by a careful examination that no other fungus was present." This latter is rather a bold statement to make after an examination, apparently *in situ* in the field, of such a large root system as that of a rubber tree. If Fomes had been present in an advanced stage it would have been easy to recognise, but might it not have been overlooked in its incipient stage in all that mass of roots? Without suggesting that Fomes or other parasitic fungus was the cause of the trouble, is it not possible that Rhizoctonia was the first saprophyte to establish itself in the dead roots present as the trees were moribund? "After the lapse of five months it was found that the Rhizoctonia had been followed by *Fomes lignosus*, *Fomes lamaoensis*, Ustulina and diplodia, and all these four fungi were found together on more than one tree along with the original attacker, the Rhizoctonia." Dr. Small omits to state whether the trees were dead. It would be very surprising if any of them survived the necessarily thorough preliminary examination from which it was determined that "no other fungus was present." After such treatment the presence of any soil fungus on the roots merits no comment. My point is that if any great importance can be attached to priority in time of occurrence, priority itself is most difficult, if not impossible, to prove concerning fungi on roots in the field. Certainly Dr. Small's evidence is not convincing.

4. "It adopts a most natural means of entry into its host, namely *via* the smallest feeding roots, and after establishing itself, so to speak, it grows inwards and upwards always getting nearer the larger roots killing or poisoning as it goes." In my opinion, the statements made in this sentence, if they could be substantiated, would form the best reasons for considering *Rhizoctonia bataticola* as a parasite. Possibly Dr. Small does not agree as he has offered less evidence on this point than on any other. The claims made here require very careful consideration. It must first be recognised that penetration through the smallest feeding roots as a most natural means for a fungus to enter its host is mere opinion. Does it also imply that the most natural means of entry for an aerial fungus is *via* the finer twigs? If so, all our major stem diseases like cacao and rubber canker, pink disease, and so on are exceptional. So are the soil fungi, like *Pythium Debaryanum* and *Rhizoctonia solani* which attack seedlings at the collar and cause serious losses in seed beds. I know of no very sound reasons for believing that the finer roots are easier of penetration by fungi than are other parts. The easiest way is the most natural way, and if any fungus finds it easier to penetrate older roots or the collar, then that fungus, in the majority of cases, will enter the older roots or collar in preference to the finer roots.

Admitting as an actual fact that Rhizoctonia enters the finer roots first, as Dr. Small's evidence is conclusive on that point, we have to consider evidence in support of the statement that, after establishing itself, the fungus grows inwards and upwards getting nearer the larger roots, killing as it goes. This is a far more important point than priority in time of attack and is usually more easy to prove. Here we can visualise an advance, a parasitic fungus ahead, killing as it goes and all the numerous saprophytes following it and feeding on the dead tissues. But note that the parasite is ahead, doing the killing. The leading fungus in this advance is always the one to which first attention is paid by mycologists, as a rule. When investigating an unknown disease, the cause of which is suspected to be a fungus, the mycologist usually attempts to isolate the fungus from the advancing edge of the diseased tissues. He takes tissue under sterile conditions from the apparently healthy margin, hoping to obtain cells in

which the parasite is in the act of killing, and which are not sufficiently moribund to allow the entry of pure saprophytes. If successful, he obtains a pure culture of the advancing fungus free from the saprophytes which normally follow. There is no means of determining whether an unknown fungus is a saprophyte or parasite by merely looking at it. The fact that a fungus is in the very van of the attack makes it worthy of further study and it will be found by experiment in nine cases out of ten that this fungus has a parasite habit.

The presence of *Rhizoctonia bataticola* at the head of the advancing disease, killing as it goes, and followed by Fomes and a host of saprophytes would afford some evidence of the parasitic nature of the Rhizoctonia. But Dr. Small does not claim that Rhizoctonia leads the attack by position, in fact he admits that it does not. In short *Rhizoctonia bataticola* constitutes a " Storm battalion " which is always in the second or third line during the main attack.

It will be noticed, despite my incomplete quotation, that Dr Small says " killing *or poisoning* as it goes." The importance of the part " *or poisoning* " will now be evident. It affords a reason why Rhizoctonia is not to be found in the forefront of attack. The reason is that *Rhizoctonia bataticola* emits an unknown poison or toxin such that it kills the host tissues without this fungus having to penetrate them. He says " The Rhizoctonia has been noted to kill or poison well in advance of its actual penetration, its host or the part of its host that it has attacked, and it is likely that it is enabled to do so by the production of a toxin which is poisonous to the plant attacked."

"In this way it may be conceived as providing, by its lethal effects on the larger roots and eventually on the collar of the attacked tree an easy means of entry for secondary fungi in this country, which prove to be Fomes, Ustulina, Poria, etc. I have not been able to find in any of Dr. Small 's writing on this subject one tittle of direct evidence in support of the presence of this poison or toxin. It is evident, however, that this hypothetical toxin is necessary to explain the secondary position of the Rhizoctonia when the primary position is claimed for it. It must be admitted that such toxins are not unknown in plant pathology but the number of such toxins which have been definitely demonstrated is very small.

To me it seems unnecessary to call in the aid of this unknown toxin to explain the observed facts. I submit that in occupying a secondary position in the attack *Rhizoctonia bataticola* is occupying its true position, the place where one always finds the saprophytes, including this particular fungus.

5. Experimental proof:—Positive results with his inoculation experiments have been few. Dr. Small claims that " the parasitism of *Rhizoctonia bataticola* has been proved by experiment with more reference to herbaceous plants like beans than to woody plants like tea, rubber and cacao." It is with the latter that we are more particularly interested. Since *Rhizoctonia bataticola* is said to cause various types of disease, most of which are fatal, under all sorts of conditions and in all types of soil, and since it is stated that healthy plants are attacked, there should be little difficulty in reproducing at least some of the types of disease, under laboratory conditions with pure cultures of the fungus. Dr. Small has experiments in progress but results are not yet available. These results together with full details of the conditions of the experiments will be awaited with interest. No criticism of these experiments can be made until the full details are published.

In the foregoing, I have attempted to show that the reasons advanced for the claim that *Rhizoctonia bataticola* is the only parasite of present importance in the causation of root disease and its secondary results, are not sufficient to establish the fact that this fungus is a parasite at all. I have

shown incidentally that the observed facts may be accounted for more simply on the basis that *Rhizoctonia bataticola* is nothing more than a common soil saprophyte. Before leaving the subject I would offer a few remarks concerning the occurrence of our root diseases in the field. I shall confine my remarks to Tea, as it is with that crop I am at present intimately associated.

We can divide our tea root diseases into three types. The first will be known to tea planters by the name of Poria or Rosellinia.

This type spreads through the fields very readily and many planters are only too well aware how difficult it is to control. The second may be known as Brown root. This disease does not spread to any extent; it is usually associated with old stumps and is normally easy to eradicate. The third type is that of the Diplodia root disease. This disease usually crops up after pruning and affects a whole area at once. When once the critical period is passed, it is unlikely that anything more will be noticed of this disease until next pruning. These three types can be readily distinguished without any reference to the fungi associated with them. If, as Dr. Small states, these three types are due to a single cause, viz., the attack of *Rhizoctonia bataticola*, it appears material to ask why the disease should sometimes occur as one type, sometimes as another, without any apparent rhyme or reason. The older explanation, viz,. that these types are due to distinct causes, appears to be much more reasonable.

I have already quoted a passage indicating that *Rhyzoctonia bataticola* does not spread by contact, but that independent infection is the rule. How then are we to interpret the spread of those diseases which in the past we have ascribed to Poria or Rosellinia, through an area of tea when we can see bush after bush succumb in regular succession? Is there some more subtle explanation of this apparently simple phenomenon, observed and recorded by so many planters and scientists? As the Poria disease spreads from bush to bush while Brown root disease does not, to any marked extent, and both are due to the attacks of fungi, it must be obvious that the fungi which cause these diseases have markedly different habits. The introduction of a third fungus, which admittedly does not spread by contact does not assist the explanation. Before *Rhizoctonia bataticola* can be accepted as the only parasite of present importance in the causation of root disease in Ceylon some very satisfactory explanation must be offered to account for the everyday observations in the field.

I have criticised at some length the views expressed by Dr. Small as to the primary cause of our Ceylon diseases for two reasons. Firstly, the view that *Rhizoctonia bataticola* is the primary cause of all root diseases is but a hypothesis. Before a hypothesis can be raised to the rank of a theory, all adverse criticism must be satisfactorily met and it must be shown that the hypothesis is the best and truest explanation of the observed facts. I have tried to advance legitimate criticism, and I have suggested a simpler and more feasible explanation of the observed facts than that given by Dr. Small's hypothesis. Secondly, emanating as they do from the Government mycologist, his views should carry some weight with the planting community; and if his views are accepted and acted upon, the present method of treatment of root diseases will have to be abandoned as useless and wasteful. I have tried to show that the conclusions he has drawn from observed facts are not convincing, and that he has failed, as yet, to afford sufficient reason for a reconsideration of the accepted and established causes of our known root diseases. Until some tangible proof to the opposite is afforded, the vigorous measures to prevent the spread of our soil parasites must be continued. The cessation of those methods in favour of the sole recommendation to promote the health of the plants by all means, judging from past experiences in Ceylon, would be utter folly.