The Relationship Between Manuring and Callus Formation in Tea.

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THIS question of the healing of pruning cuts and wounds in the tea bush which is to be discussed this afternoon is one of considerable interest and, I think, importance, for the tea bush is pruned more often and more drastically I suppose, than any other plant of economic importance except, possibly, cinnamon, and many of the troubles from which the tea bush suffers are the result, either direct or indirect, of the exposure of cut surfaces by pruning.

In the normal course of events, when a branch is pruned off a tree, the cut end protects itself by growing a layer of callus tissue from the edges of the cut towards the centre, and this callus growth eventually covers the entire cut surface so completely that in time almost all external evidence of the injury disappears. This is not peculiar to trees growing in temperate climates, but occurs also in Ceylon, and can be seen taking place on almost any roadside tree from which branches have been trimmed. It can generally be easily seen on rubber trees also, which seem to be particularly active in growing callus tissue. It does not, however, readily take place in the case of tea, or at least it was very uncommon a matter of ten years ago, or less, although it is not such an unusual phenomenon nowadays.

Observations many years ago led me to suspect that this inability of the tea bush to grow callus over wounds was due to gradual weakening of the bush by continued plucking and pruning, which had resulted in a condition of carbohydrate starvation. It seemed to me that the continued recovery from pruning which the bush is called upon to make must involve a heavy drain on the reserve manufactured materials (starches, etc.) which are made in the leaves and stored in the older tissues of the wood, and that the replacement of these must be much interfered with by continual plucking.

It is during recovery from pruning, when the new buds and shoots are being put out, that the greatest drain on these starch (or carbohydrate) reserves takes place, and no replacement of them is possible until the new leaves begin to function, for they are made in the leaves; and obviously no large replacement can

take place without a large number of leaves. As soon as the bushes put on a moderate number of leaves, however, they are tipped, and most of the young and active leaves are removed. This process of leaf removal goes on constantly as plucking proceeds, and it seems obvious that the process of carbohydrate formation is greatly interfered with. The act of plucking causes many new leaf-buds to appear and these new leaves are also put out and developed largely at the expense of reserve food material, so that a constant drain on this reserve goes on from one pruning to the next. This constant depletion of starch reserves must, it seems to me, make the recovery from pruning more difficult each time and make also the new wood which is put out less and less good, and this I think is what has actually been happening in the case of most tea in Ceylon during the last 20 years or more.

As callus growth is closely connected with wood growth, and is in fact a modified type of wood growth, it seemed to me likely that poorer wood after pruning meant less ability to grow callus tissue over pruning cuts, and explained why such callus growth was so exceptional.

The result of this line of thought was the idea that anything which could be done to increase active growth in the tea bush during the only time when it is not plucked, namely between pruning and tipping, would help the replacement of carbohydrate reserves and so promote better wood growth and better healing, and this led me finally to advocate the application of nitrogenous manuring at pruning time.

I may say that it was many years before these ideas made any headway, and it was not until comparatively recently that continued trials on an estate scale were possible. These trials soon indicated that this type of manuring did induce the growth of callus on pruning cuts, and even on extensive wounds in the condition commonly known as cankered, and I was encouraged to continue the treatment.

Among other observations, I noticed that where a cut surface became encircled by a ring of actively growing callus, the central wood did not decay. This occurrence was evident even on large cut surfaces, although as had frequently been pointed out to me they take many years before the surface is completely covered. So long, however, as the ring of callus remains alive and healthy, the central wood does not appear to decay. The surface layer may, and in fact does, die and become disintegrated by ordinary weathering agencies, but there is not the same tendency to decay downwards and form a deep cavity as so often happens when no callus growth occurs. The explanation of this was not clear to me at the time, except that it seemed that the activity of the cambium was a factor in determining whether decay would take place or not.

A possible explanation has since been offered by the work recently done by Swarbrick at the Research Station, Long Ashton, Bristol, and a short account of his investigations will, I think, be of interest. The work started with an investigation into the best time of year at which to prune trees at Home from the point of view of their recovery from the injury, and for this purpose trees were pruned every month of the year, and a pruned end from each monthly pruning was examined at monthly intervals.

It was found that at some stage after pruning, varying with the season, the starch in the wood below the pruning cut disappeared and was replaced by a substance to which the name of " wound gum " has been given. Swarbrick as a matter of fact mentions two substances, but for the purpose of this discussion it will be sufficient to deal only with what he describes as wound gum. This material is of unknown chemical nature, and does not react as a true gum or a true resin. It is extremely resistent to chemical action, and the name wound gum is quite a convenient one.

I should like to emphasise here that this material must not be confused with the gum or resin which exudes from many trees when they are wounded. Its formation has nothing whatever to do with the external appearance of gum or resin, and takes place in cases of trees which have no tendency to resin exudation. It is called wound gum meantime merely for the sake of calling it something.

This substance forms in the cells which were previously filled with starch, and it seems probable that it is formed from the starch, and it gradually forms a series of plugs which eventually completely block the cross section and forms a barrier from one edge to the other. This barrier is only visible under a microscope.

During this series of observation it was found that this blocking by wound gum took place very slowly and incompletely when the growth of the trees was dormant, as in Winter, but that when branches were pruned in the Spring and Summer months, when growth was active the exposed ends became plugged in about 10 days and completely blocked in about four or five weeks.

It was also found that in no cases were the hyphae of fungi seem to penetrate the blocked region, they always stopped just short of it, and this seems to me a matter of great importance with reference to the decay of the wood in our tea bushes.

Subsequent to the formation of wound gum, the growth of callus at the edges of the cut surface begins and, in the normal course of events, eventually covers the cut. It is, however, in

these cases more in the nature of external evidence that internal blocking has taken place than the only protection which the wounds can produce.

The blocking is found to take place just below the cut surface and to follow a curved line which is deepest in the pith in the centre and closest to the surface at the edges, and it has been found that the cells immediately below the cut surface, although damaged by the act of pruning, remain full of starch indefinitely, and are not active in the formation of wound gum.

This is briefly the story of Swarbrick's investigation published in March, 1926, and its practical application amounts to this, that when growth is vigorous after pruning, the pruned cut is blocked by wound gum in such a way that micro-organisms and disease germs in general are prevented from penetrating below the blocked layer, but that when growth after pruning is slow, the blocking is slow and incomplete and the pruned end is open to infection at least until vigorous growth begins. It is also indicated that an abundant supply of starch is necessary for the blocking by wound gum to take place. These conclusions, if true in the case of tea, seem to me to justify the application of such manures at pruning time as are best calculated to promote vigorous growth immediately thereafter and that the maintenance of a good supply of starch is necessary. It is also clear, if we assume these physiological changes to take place in tea, why the continued depletion of starch reserves resulting in poorer wood after each pruning also lessens the chance of the cut being sealed by wound gum and leaves the exposed surface open to decay, while an explanation is also given why a cut surface once encircled by a callus tissue, does not decay although still exposed in the centre. It has been presumably blocked by wound gum before the callus growth appears.

I propose now to give you a very short account of my endeavours to find whether a similar series of happenings take place when the tea bush is pruned.

I might say, to begin with, that there is no inherent improbability that the healing process in tea or in any similar bush or tree in the tropics should not be the same as in temperate climates. I do not say that it necessarily is the same, but I see no reason why it should necessarily be assumed to be different. The various stages of the healing process described by Swarbrick are physiological changes which are affected in degree only, but not in type, by the seasonal changes which occur at Home, and it seems to me more likely than not that they follow the same course in Ceylon, at least in the case of Dicotyledenous trees, although they are doubtless equally influenced by seasonal changes, especially as it is a fact of common observance that such trees in all parts of the Island do form a callus covering over pruning cuts.

A convenient preliminary method of showing whether any obstruction such as that produced by wound gum forms in a cut branch is to remove a few inches of the cut end and to endeavour by means of a suction pump to draw a coloured solution through the specimen. I have applied this method to a great many such pruned branches in tea, and I have found clear evidence that in certain cases something occurs just below the cut end which prevents the solution of dye being drawn through. I have not had time to investigate a complete series such as was done at Home, but I have examined a large number of specimens at different stages from pruning and have found that more or less blocking takes place in a manner similar to Swarbrick's description. The specimens have been from various estates, some of them highly cultivated and some of them not, and I propose to hand round a few of them for your inspection. These specimens refer only to the preliminary investigation of the penetration of colour solutions, and while, partly through lack of time and partly through lack of the necessary section-cutting apparatus, I have not been able to make anything approaching a complete microscopic examination, I have with the help of my assistant, Mr. T. K. Anderson, to whom I am indebted for much of this microscopic work, examined a great number of sections, and I have found changes in the cell contents which appear to be precisely as described by Swarbrick.

To begin with, in every specimen examined, the cells immediately below the cut are full of starch. It remains as a thin layer below the cut to a depth varying from 1 c.m. to 2 c.m. but gradually disappears, and its place is taken by what is at first a pale yellow substance but which darkens gradually to a dark brown or black. This is the description of the beginning of the formation of wound gum by Swarbrick. These blocked cells increase in number as the time from pruning lengthens, and there is reason to suppose that they eventually extend across the whole of the tissue. Owing to the difficulty of getting a complete longitudinal section without a suitable microtome, I have not been able to obtain a specimen showing complete blocking, but it seems to me unlikely that blocking should begin, and proceed exactly as described by Swarbrick, and not go to completion, while there is also the evidence of the suction method that it does go to completion.

In one series of observations, a tea bush was pruned after a run of about 18 months, and specimens of the pruned wood were examined at different intervals. The following are some of the observations made.

1st day.—Starch abundant in all tissues.

4th day.—No trace of starch to a depth of $1\frac{1}{4}$ inches except in a thin band immediately below the cut. Cells turning yellowish brown.

5th day.—Starch immediately below pruned surface in a thin band not more than 2 mm. thick. No starch in any tissue except the pith up to a depth of 1 inch where it occurs in the pith, medullary rays and zylem, in this order. Starch less than 4th day, taken all over. Cells on edge of pruning cut turning yellow.

7th day.—Starch present in all tissues immediately below pruning cut. Present in pith in fair amount to about 2 c.m. depth. Absent in phloem and just present in the medullary rays and zylem. Cells darkening and filling up irregularly to a depth of not more than 1 c.m., the maximum depth being at the pith.

9th day.—Starch immediately below cut in all tissues for 1 m.m., absent below this in all tissues up to almost 1 inch. Blocking distinct in the medullary rays and pith in order mentioned.

12th day.—Starch immediately below cut. None in any tissue up to 1 inch depth below that. Blocking very distinct, specially in the medullary rays.

24th day.—Starch immediately below cut surface to a depth of 1 m.m. Absent from all tissue below that to $1\frac{1}{4}$ inches except a trace in pith here and there up to $\frac{3}{4}$ inch. Blocking distinct in medullary rays, and wood vessels, and cells are fairly dark. Cell contents very resistent to boiling with alcoholic potash and subsequent treatment with hot oil of cloves.

31st day.—The same, but no starch at all up to about 1 inch.

To anyone reading Swarbrick's paper, these observations will be found closely in accordance with what he describes, and without suggesting that my investigations have been in any way complete, I offer these experiences as affording a certain amount of evidence that the tea bush does not differ in the physiology of its response to wounds from trees of temperate climates. I might venture the opinion that the evidence, though incomplete, is fairly strong.

Coming to the more practical question of the influence of manuring on this process of healing, my contention for many years has been that the time of application of the manure with reference to pruning has a very great influence on its effect.

Without going deeply into the history of Ceylon tea manuring, I should like to point out that until comparatively recent times all manuring, with the exception of a dressing of slag and potash or lime at the time of pruning, was done while the tea was being plucked. Tea makes a wonderful recovery from pruning

as regards its leaf growth, and it is not altogether to be wondered at that in the early days of its cultivation it was not considered necessary to manure it until plucking began. The act of pruning was, indeed, looked upon in the old day as a kind of manuring, for it brought the tea on with apparently renewed vigour. The tea bush is cultivated for its leaf and the production of leaf was all that was sought for by manure applications.

That this type of manuring did not do all that was required is, I think, very evident to anyone who has had the opportunity of seeing pruned tea in all parts of the Island during the last 15 or 20 years, and I do not think that anyone seeing the average pruned field to-day would consider it a proof that its treatment has been correct. Decay of the wood is everywhere to be seen, and an important point to remember is that this decay began and has continued to get worse during those years when manuring was done in the manner described. If this manuring system had provided the tea bush with its real needs, it would surely not have reached the stage of poor wood, to say nothing of decay, in which we now find it. If, on the other hand, a change in the system of manuring can bring about a change in the diseased conditions of the bushes, it is perhaps not too much to conclude that it was the system of manuring that was at fault and not that manure have no effect in preventing decay.

While I am anxious to make no statement which may appear to claim what has not been proved, I can definitely state that I have seen extensive development in the healing of pruning cuts and even of old cankered wound in Ceylon tea since the proper manure was applied at the time the tea was pruned, and that these estates where this healing is now to be noticed did not produce this type of growth under the old system of manuring only during the flushing period.

Some of you may be prepared to state that tea which to your knowledge has not been manured at pruning time is showing healing, and I would not dispute that statement. I know certain cases of it myself, and I am familiar with tea which has never been manured at all and yet which shows quite good healing going on to-day. These instances do not, however, seem to me to affect my main argument, in fact they rather confirm it. My contention is that if tea is sufficiently vigorous, and especially if it shows vigorous growth during its recovery from pruning, it will heal its pruning cuts in the way I have described. Whether this vigour is conferred on it by the natural fertility of the soil or by manure does not matter, and the fact remains that by far the larger proportion of the tea in Ceylon is unable to carry on the natural healing process without the help of manure, and that it has not done so until this manure was applied at the time of pruning.

The application of pruning mixtures is now becoming comparatively common and so is healing, and anyone who has only had the opportunity of examining tea in the field on an extensive scale during the last year or two might easily assume that the healing which is now found has always been going on, but I can assure you that this is not the case. I saw so little of it at one time that I nearly came to the conclusion that tea did differ from the trees of temperate climates, and even from the trees one finds in the jungle and on roadsides in Ceylon, in being unable to produe callus tissue, and it was not until I made trials with the type of manure which I have since found so useful that callus formation began on anything like an extensive scale. When Ceylon tea was young it doubtless healed most, if not all, its pruning cuts and where one finds specimens of the old high centred bushes which have not since been cut down, one generally finds that the original centring cut has healed completely and that there is evidence of healing of old pruning cuts also; but that took place many years ago and before starch depletion and carbohydrate starvation became acute. To-day it does not take place, in the vast majority of cases at least, unless special measures are taken to encourage it.

I have here some specimens from an estate which has been manured at pruning time for about 10 years, although very moderately so at first. Its wood was formerly in the same state of decay as the majority of Ceylon tea, and it had continued in that condition for a good many years although manured liberally under the old well known system. If the altered treatment at pruning time has had no effect on callus formation why should this tea now exhibit the excellent growth of callus and woody tissue which these specimens show ? I can assure you that the actual amount of plantfood applied under the present system was less, when healing first began, than was applied on the old system, the only change being that part was applied at pruning time. The total is now practically the same as in the old days.

I do not say that we should strive to grow great rolls of callus tissue such as the first of these specimens exhibits. In fact I should describe this growth as tending to freakishness, but I exhibit this specimen as an illustration of what can be done in the way of inducing callus growth by manuring in a particular way. You will see that besides the big lump of callus tissue, all the pruning cuts of two years ago show callus growth, and many of them have completely healed. I can assure you that no such effect as this was seen on the estate in the old days.

It may perhaps not be considered of great importance that the bush should be able to cover the surface of a clean pruning cut with callus tissue. No great harm apparently comes to the tea if it does not, but apart from the fact that it seems to me

important to close all these possible points of entry for decay or for the attacks of insects, it is I think obvious that if branches and stems which have been rotting away for years can be healed up, something very tangible has been gained. I have here two specimens of such healing from the same estate, and I think you will agree that the present condition of this wood is better than the old and that it is in a fair way to get rid of the decay altogether.

The difficulty of healing irregular and decayed cavities such as these last two specimens exhibit is obviously greater than the case of a clean pruning cut, but I think it probable that the process is essentially the same. If it is, and if the wood below the cavity is sealed by wound gum then it is probable that the process of decay is arrested by this barrier and the growth of callus is enabled to take place beneath the dead tissue and above the sealed layer. If these ideas are correct, the fact that decay has gone deeply into the wood may make the healing process slower and more difficult, but should not make it impossible, for there must be living tissue at some depth below the decay and it is here the blocking of the wood should take place whether the cavity is big or small.

It seems that when callus tissue begins to grow along the edges of a wound such as this specimen shows it becomes sometimes infected presumably by a fungus, which causes its death and decay, and this re-infection may continue with successive layers of callus which subsequently form. This condition has occurred, although in my experience not very often, but when it does it looks as though the natural process of healing were insufficient to get rid of the trouble, and the removal of the source of infection seems necessary. Whether this should be done by the removal of the diseased tissue or by the application of a fungicide, or by both, I do not know, but if a fungicide is produced that will kill the fungus responsible for the infection and subsequent decay I would certainly be inclined to use it in such cases. I would use it, however, in conjunction with suitable manuring, for fungicides do not of themselves induce callus growth. My experience with the dressings commonly advocated, of which tar is the most common, has been that they do not prevent decay. I believe others have different experiences, but that is mine.

I have seen a great many heavily pruned fields in which the cuts have been tarred, often after very expensive cleaning out of decayed tissue, and with the best will in the world I have not been able to convince myself that anything has been gained by the tarring. Decay appears to go on beneath the tarred surfaces in quite as many cases as beneath the untarred, and it certainly does not seem to me that tar gives the protection required. A point often brought up in favour of tar and similar preparations,

is that it is waterproof, and that decay is brought about by the infected surface being wet. Decay may be hastened by wet, but I do not think callus formation is retarded by it. I have found good healing on cut surfaces covered with moss, and which were thereby kept pretty constantly damp, while investigations at Long Ashton in 1922 indicate that coverings which keep the tissue moist promote the formation of callus. I do not object to tar because it may delay callus formation.

A little delay is unimportant if freedom from infection can be assured, but I should like to see it more convincingly demonstrated than the field trials I have seen have done, that tar has the necessary fungicidal properties. The trouble with these external dressings seems to be that the more effective they are as fungicides the more destructive they are on the plant tissues, and it has been suggested that any wound dressing which adversely affects the exposed zylem, phloem and cambial tissues—the last in particular—loses thereby any value it may have because it lowers the powers of the plant to heal its wounds. This may be wholly or partly true, but it does not exclude the possibility that a substance may yet be found which will fulfil the required conditions.

Meantime I confess I am much more hopeful of improving the condition of the wood on our tea bushes, both as regards resistance to and recovery from disease and decay, by a rational system of manuring than by the application of such fungicides as we have at present at our disposal.

Discussion.

MR. STOCKDALE.—Before the discussion takes place, I would like to say that many of us know the improvements that have taken place on a number of estates in Ceylon by the adoption of a system of manuring which has been outlined by Mr. Keiller. I have received a letter from Mr. J. A. M. Bond in which he says that he regrets that he is unable to be here to-day, but he gives some details of one estate over which he has charge. They are as follows :—

"In particular Mr. Keiller's advice has been followed and his methods practised for the past five years on an estate in Matale.

"Five years ago the tea on that estate was riddled by shot-hole borer and was yielding just over 300 lb. of made tea per acre. The bushes were contracted and a mass of old pruning wounds and diseased tissue.

"Yields have steadily risen to 625 lb. per acre all over and are still rising and what is even more important the bushes have grown practically new frames while the formation of 'callus' or healing has been rapid and most marked.

"These results have been achieved by the application of a pruning mixture applied at pruning time, followed 12 months later (in a two-year pruning cycle) by the application of a 'General' manure mixture. Prunings have been consistently buried and all available forms of 'green manures' have been regularly mulched in with the fork at the time manure has been applied.

"In view of the discussions which sometimes arise as to the effect of manuring on the quality of made tea it is interesting to record the fact that the teas have well maintained their relative position in the market and that the prices obtained for these teas compare very favourably with neighbouring Estates.

"Adequate treatment at pruning time by means of quiet acting soluole nitrogenous fertilisers combined with heavy 'green manuring' forms the basis of this programme of tea cultivation and I have found that programme uniformly successful under varying conditions of soil and climate all over the island."

There is one other point I would like to make brief reference and that is the importance of this question in regard to the termite problem. As you all know termites are one of the most serious problems the tea industry is faced with at the present time and is the subject of special investigation. Mr. Jepson has the investigations in hand and he has been recently to America studying the question there. The conclusions which have been arrived at so far, though not final, are that termites find their entry into tea bushes through die-backs, and if any system can be adopted by which one can secure good callus formation, the termite is in a fair way of being defeated in its operations, and Mr. Jepson is making investigations along that line as well as on other lines indicated by his visit to America. I do not wish to discuss the matter further as I am perfectly certain that there are a number in this Hall who would like to address Mr. Keiller on certain points in this interesting paper which we have had placed before us this afternoon.

His Excellency the Governor said that he was sure before they proceeded to the discussion they would wish him to express in their name to Mr. Keiller their very sincere thanks for the valuable and interesting paper he had read to them. He hoped that anybody who had questions to ask and observations to make, would ask their questions and make their observations forthwith.

Mr. Petch.—I understand that Mr. Keiller's views on the healing of wounds are based on a series of experiments carried out for several years. It would be of interest if Mr. Keiller would give an account of his experiments in detail, stating whether they are comparative, *i.e.*, done at the same time, what manures were used, and how the results were estimated.

It is often possible, in a field without special manuring, to find a few bushes which show a very much better callus development than others. What is wanted, in judging the results of an experiment, is some estimate of the relative results over the whole of the experimental blocks. It is, of course, difficult to do that with mathematical accuracy. But the bushes might be classified, as regards healing, into, say, three groups—good, fair, and poor. If a whole field has been treated, a number of consecutive bushes, say 25, in a row should be examined. Then another 25 should be taken in another row at a predetermined distance from the first. And this should be repeated until 100 or 200 bushes have been judged. In that way, an idea of the general effect would be obtained, and it would be possible to estimate whether the effect could be attributed to the treatment, or was merely accidental. To pick out, here and there, bushes which show good healing, cannot prove anything.

An interesting point which requires investigation is the difference between the results claimed at this elevation, and the results obtained at higher elevations. Mr. Keiller admits (p.10.) that the results are more rapid at low and medium elevations than at high. But I have examined an up-country estate where the result was nil. In this connection, it must be remembered that callus growth is most rapid when it first begins: afterwards it slows down. If there is no particular callus growth within six months of manuring, one must count that manuring a failure from that standpoint.

In 1905 or 1906 I had some excellent examples of healing of longitudinal cankers on tea branches about an inch in diameter. Dr. Mann, who saw those specimens, declared that they were the best thing he had seen during his visit to Ceylon. That result was attributed to manuring with an excess of potash. As far as I remember the specimens were from an up-country estate.

I think, however, that there is a possibility that those results were not due to potash, and similarly that the present results may not be due to nitrogen, but that there may be some factor common to both which has been overlooked. That is where a physiologist is required.

Mr. Keiller has stated (p. 3) that the belief that potash is the cause of wood growth is traceable to the statement so frequently found in text-books that carbohydrate formation ceases in the absence of potash, from which it was an obvious conclusion, as wood is largely made up of carbohydrate. But scientific work is not done in that way, without testing "obvious conclusions." There are experiments, more than twenty years old, which show that potash manuring does increase the proportion of wood. Parallel to that, there is the practical man's objection to excessive potash manuring, namely, that it increases the amount of woody fibre in the leaf.

Mr. Keiller refers to the statement so frequently found in "text-books", as though it were incorrect. It is fully established. He will find it in Russell's *Soil Conditions and Plant Growth,* which is usually considered reliable.

Mr. Keiller suggests that the advocates of potash are influenced by the propaganda of the German Potash Syndicate (p.8). I was rather under the impression that my reaction to propaganda is negative, and I think the Chilean Nitrate Committee agree with me in that view. But Mr. Keiller has overlooked the fact that his suggestion lays him open to a very obvious retort.

I would ask Mr. Keiller whether he still holds the opinion that potash is not necessary in tea manuring. I ask the question because I have seen several of Mr. Keiller's prescriptions, and they all contain potash. If Mr. Keiller has changed his opinion, does not that mean that he has discarded all the results of his experiments?

With regard to the application of preservatives to wounds on tea, I have pointed out elsewhere that Mr. Keiller has misapplied the results of the experiments he quotes. I cannot imagine how anyone acquainted with wood-rot on Ceylon tea can argue that no protectives or preservatives are necessary. Recently I was called in to examine a field of tea up-country which had been treated by tarring three years previously, because the Directors, influenced by published statements, thought the expenditure unnecessary. The exposed wood, three years after tarring, was quite hard and decay had evidently been arrested. On the same estate I was shown another field, two years from pruning, where the wounds had been treated with Bordeaux mixture, which is nearly equivalent to doing nothing. I had

been told that this second field was better than the tarred field, but there was no difficulty in demonstrating that the exposed wood in that field was soft and decaying.

The use of Bordeaux mixture for this purpose appears to be a waste of time. Bordeaux mixture cannot soak into wood. It is a suspension of a powder in water, and if the water soaks into the wood the powder is filtered out. Of course, during wet weather some soluble copper compounds will be regenerated from the Bordeaux mixture sediment, but the probable fate of those is that they are washed away by the rain.

Mr. Petch also raised other points of criticism. He referred to the question of wound-gum and quoted from a paper by Brookes in the Silver-leaf disease investigations. It was there urged that in fruit trees that in spite of wound-gum occurrence it was considered necessary to recommend the application of preservatives. The Tea Research Institute had not been able to discover any signs of wound-gum in tea. All tests for wound-gum had been negative and what Mr. Keiller described was certainly not wound gum. The Institute still recommended the application of washed tar to pruning cuts. He stated that Mr. Keiller's experiments were uncontrolled and related to bushes picked out here and there. Callus formation might be stimulated by manuring but it often died back.

MR. KEILLER said that Mr. Petch had contended that the fact that the coloured dye had not penetrated the piece of wood did not prove the existence of the wood-gum barrier. At any rate, it proved the existence of some barrier, and he could not think of any other explanation than that some obstruction had formed to prevent its penetrating the piece of wood. He did not say that wound-gum existed in the tropics in exactly the same way it existed at Home. He had merely put forward evidence to show that the process appeared to be the same here as it was at Home, and he had found this by microscopic examination. He had assumed, perhaps quite wrongly, that the process that had taken place in the series of observations made by him, was the same as the process described by Swarbrick at Home. He laid claim to no more than that. Mr. Petch stated that he had entirely failed to find any barrier. He, on the other hand, had found exactly what Swarbrick had described in his paper, namely the formation of a viscous substance right across the cut surface. He had also found starch exactly where the investigator at Home had found it.

As regards fungicides, he personally still doubted their necessity. In the case of badly cankered wounds which were liable to infection, he would use a fungicide if he were convinced it would stop the trouble, but his own experience in Ceylon had been that tar did not stop the trouble. That, however, did not exclude the possibility that something might be found which would fulfil the conditions required. Mr. Petch had said that he (the speaker) had never told anybody what manures he recommended to be used. He had told a great many people and had written the whole story in reports whose number was legion. He had not gone into that question that day because it was not called for. The basis of his arguments was that he would apply such manures calculated to take effect quickly; that is to say, that they would be absorbed largely in the period between pruning and tipping, and for that purpose, he used readily available nitrogenous manures. As regards potash, Mr. Petch had said that he had stated that it was of no use, but yet always used it. It had caused a great deal of amusement. . . . .

MR. PETCH.—I do not think it should amuse you. You say here, "I very soon discarded potash....."

MR. KEILLER.—I am not denying what I said. I am merely trying to explain perhaps. For instance, he (the speaker) had said that morning that

he did a great number of soil analyses, which he did not believe in, but merely because he had been asked to do it. In the case of potash, he believed that the average Ceylon soil contained sufficient potash to render the continuous use of potash unnecessary, and that is the point he very often had to emphasise. He did not think it necessary to do it that day. He had never said that potash was unnecessary for tea for any stage of pruning or any part of the tea bush, but that the continued application of fertilizer was, in his opinion, unnecessary. He confessed to putting in a little potash because it found its place in the original mixture. He was not in favour of putting it into every mixture as an absolute necessity. When he (the speaker) was in Java, he was given a book in which a large number of soil analyses were included. No figures were given for potash. The author stated that they had satisfied themselves so thoroughly that the average soils in Java and Sumatra had sufficient potash that they did not even determine the potash in the soil analyses. If any man insisted on having potash ascertained, they did it and charged an extra 50 guilders. He did not want to be mistaken. He had never declared that potash was not necessary for tea—it was one of the essentials but it was not necessary to apply it every year, for potash fertilizer did not conduce to the growth of the wood. Mr. Petch had accused him of picking out a bush here and a bush there to show callus formation, and that he knew cases where this occurred quite well without manure. The whole trend of his remarks would make it quite clear that he based his conclusions as to the efficacy of manure at pruning time on full results over a good many years on numbers of estates situated in many parts of the Island. Mr. Petch had asked whether his experiments were comparative. They were not comparative in the strictly scientific sense, and he admitted that they were open to all sorts of scientific objections on that account. All he claimed was that this formation of callus became common on estates all over the Island as soon as this type of manuring was started and that it had not been common before. He did not agree with the statement that if nothing happened within six months of manuring, nothing would ever happen. In this instance his critics had overlooked the cumulative effect of manures. He did not object to a little retardation of callus formation by the application of tar, if it ensured against infection, but his own experience with fungicides, was that they did not appear to do any good.

MR. WESTROP confirmed what Mr. Keiller had stated in regard to the effect of easily available manurial applications before pruning. He had himself observed on several occasions the excellent callus formation.

HIS EXCELLENCY THE GOVERNOR.—I am sure we are all thankful to those who have taken part in this very interesting discussion. There has been an interesting difference of opinion between two of our experts. This difference of opinion may or may not be soluble, but at any rate, it has added zest to our discussion, and we thank both protagonists for their contribution.

His Excellency then called upon Mr. A. W. R. Joachim to read his paper entitled "The results of drainage and leaching trials at Peradeniva during 1927."