ORGANIC MATTER IN CEYLON TEA SOILS

J. A. H. Tolhurst

You will see from the papers to be presented this morning that discussions about organic matter are to be taken up from different aspects, and you may wonder if the phrase "organic matter" refers to one substance or to several. It does, in fact, refer to a series of products. When plant or animal material dies, whether it is above or below the soil surface, it immediately begins to decompose and the microbes active in this work are capable of transforming the raw organic matter into chemical compounds bearing little obvious relation to the original material. These compounds are often referred to as "humus", but I prefer to retain the term "organic matter" asking you to bear in mind that this paper deals with well-decomposed organic matter which has been incorporated into the very structure of the soil.

This organic matter plays an essential part in the life of the soil but, although fairly stable, it is not entirely free from still further decomposition by microbes. It is possible for it to be transformed to mineral products which do not have the same value in the soil. Bringing a virgin soil into agricultural use tends to destroy much of its original organic matter, and if we can measure the extent of this loss we can evaluate the effect of past cultivation and can try to predict what may happen in the future. Therefore, when I undertook a broad survey of Ceylon tea soils, I paid particular attention to the relation between the organic matter in those soils and in the forest from which most of the tea areas had come. It was far from easy to find undisturbed forest soils in some of the main concentrations of tea, but the analyses which I shall be quoting were done on soils which I believe are representative of the virgin forest in all the regions which concern us.

Let us look at Figure 1 showing the level of organic carbon in the top six-inch layer of forest soil. I will say more about the analytical method in a moment, but here is the percentage of organic carbon plotted against elevation of the site. It is clear enough that the organic carbon, which excludes roots as far as possible, increases steadily with a rise in elevation. The increase is not quite uniform, and there is often a wide variation between soils at similar elevations.

Now let us turn to Figure 2 for the tea soils, plotted from 200 samples, and compare it with the 60 forest samples plotted in Figure 1, each of which has a complementary point in Figure 2. Two features are prominent. There is less variation in organic carbon at most elevations and there is a slight but definite fall in the curve, from sea level to about 2,500 feet, before the organic carbon begins to increase rapidly with the rise in elevation. In the 2,500 foot region there is the least variation of all between the samples.

The "organic carbon" to which I have been referring was actually only the more readily analysable portion of the carbon in those samples. Some of the carbon in the organic matter was resistant and we took a representative selection of the soils for the tedious analysis of the *total* organic carbon. In addition, we analysed all the soils for total nitrogen, an essential constituent of organic matter. Finally, each of the top soils illustrated had a corresponding sample from six to twelve inches depth and some samplings were continued in regular layers to depths

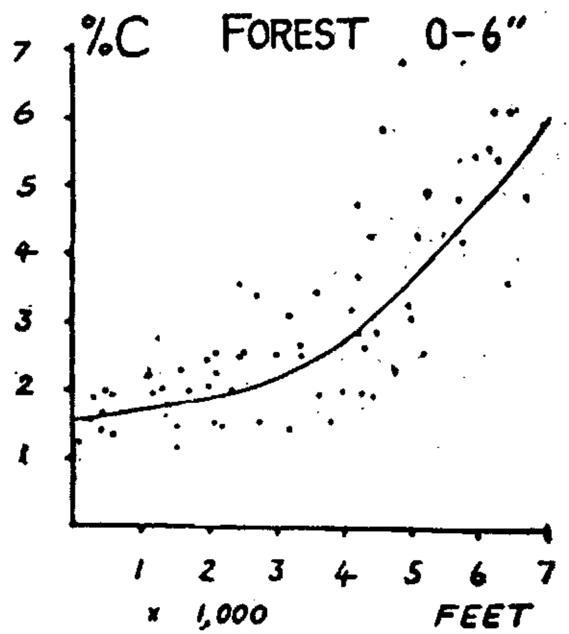

Fig. 1. The relation between organic carbon (Walkley and Black) and elevation in forest soils; 0-6".

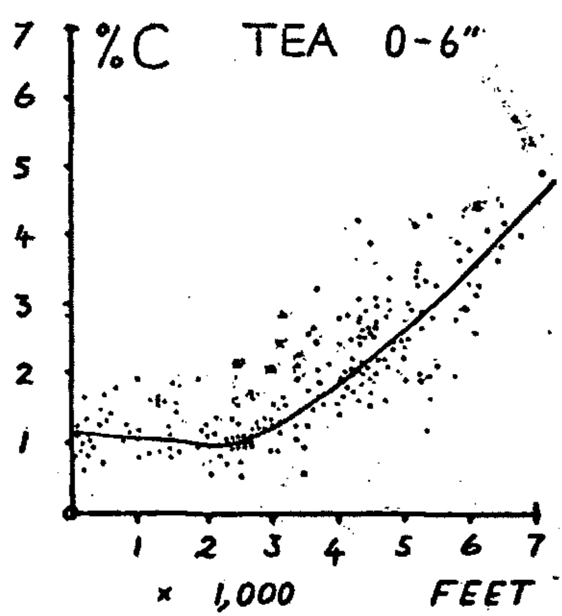

Fig. 2. The relation between organic carbon (Walkley and Black) and elevation in tea soils; 0-6".

of 3 to 7 feet. I do not intend to illustrate all these analyses, but I mention them to show you that we have checked and cross-checked before I could say that the analyses do in fact show that tea soils around 2,500 feet elevation have suffered more severely than others by a loss of organic matter resulting from their cultivation under tea, possibly following other crops. The tough, residual, organic matter analyses also reflect this feature, but a greater effect is shown by the softer fraction of the organic matter. The simplified graph in Figure 3 shows the relation between tea soils and forest soils in this respect.

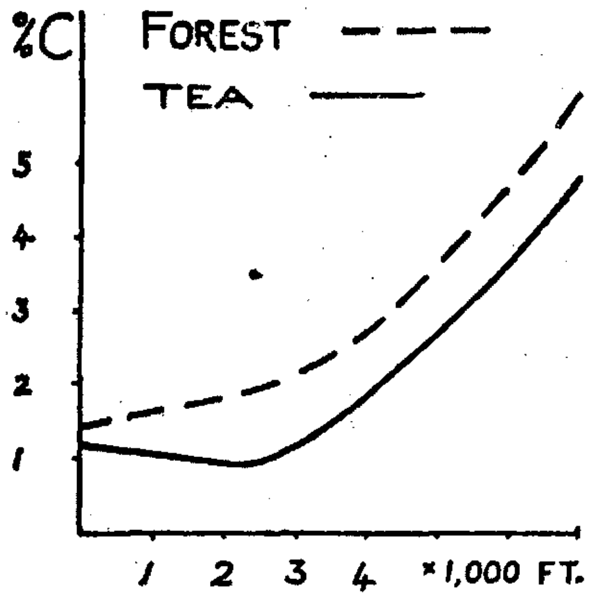

Fig 3. Comparison between the organic carbon in forest and tea soils; 0-6".

The obvious question arising is: "Why do tea soils at 2,500 feet suffer in this way?". The soils in question are as widely scattered as they could be in the tea areas, and include regions as different as Deniyaya and Hunnasgiriya, Ginigathena and Badulla. The past history of tea plantations is not always easy to obtain, but I have no reason to believe that these widely separated regions underwent more intensive cultivation than some others, either before or after tea was planted. The graphs show that the effects of the many variables in tea plantations, pruning cycles, shade, slope, aspect, etc., were decidedly subordinate to the influence of elevation. From visual and from analytical evidence I am not led to suspect that erosion of the top soil was so much more severe in these regions than in many others. A survey of some of the more fundamental chemical properties of the same soils has shown that they are remarkably uniform, and we can hardly look to the mineral composition of the soil to explain the pattern of the organic matter distribution. We do not have sufficient evidence to be able to answer this particular question, and indeed at this stage we can more profitably discuss the practical implications of a loss of organic matter, at all elevations.

In other contexts, I and my colleagues attach great importance to raw and partially decomposed plant material on or in the soil. What importance has the virtually invisible organic matter that is incorporated in the soil structure? It is true that it contains some plant foods, which it may release as it is decomposed, but undecomposed it has the properties of cementing the soil particles into fertile crumbs, of maintaining a more uniform moisture status, and above all of holding manurial nutrients in such a way that they are less readily washed out by rain but are still available to plant roots. Some soils, in Ceylon and elsewhere, contain clay minerals which are also very efficient in holding nutrients. Unfortunately none of the tea soils which I have had examined contained any minerals of this type. Our clay mineral is of a highly degenerate and rather inactive nature, and the only component in the tea soils which we could hope to alter, in order to increase the efficiency of manuring, is the organic matter. Thus we have arrived at a highly practical point. We are starting more and more field experiments to find the most efficient way of using inorganic manure, and the interpretation of those trials will depend largely on a knowledge of the influence of the organic matter at each experimental site. The translation of the results into practical advice will in turn be influenced by the soil organic matter in each region. The extent of the influence of organic matter on manurial efficiency will not be known until much more work has been done, and for this reason I have avoided saying whether the analyses shown in Fig. 2 reflect enough organic matter or too little at certain elevations.

I have, and I think justifiably, assumed that the marked fall in organic matter over the last 60 or 80 years in the middle ranges of elevation is bad and must be checked. Perhaps recent changes in agricultural practices have already started a slow build-up of organic matter again. Only repeated surveys could answer that. The very wide variations in the region around 3,000 to 3,500 feet may be an indication that the restoration has already begun, probably under the influence of a more complete cover of the soil by the tea, and, not to be forgotten, with the assistance of vigorous root systems.

That, then, is the basic picture of the organic matter status of our tea soils in the late 1950's. I have outlined very briefly one of my reasons for treating this incorporated organic matter with respect, and one which is especially pertinent in view of our present increasing use of fertilisers. That aspect is not an isolated one, of course, but is part of the over-all scheme of work which we are all doing, namely striving to increase the vigour of the cover of tea.

Question No. 13.—Mr T. M. Fernando, Enselwatte Group, Deniyaya.

Will the application of high doses of nitrogen, using ammonium sulphate as the basis of nitrogen, create a deficiency of potash, magnesium and calcium in the tea bush? If the answer to the question is in the affirmative, what type of nitrogenous manure will the T.R.I. recommend?

Question No. 62.—Superintendent, New Peacock Group, Pussellawa.

(*a*) In view of the very high yields obtained from new and re-planted tea, manure dosages have been correspondingly increased at the recommended ratio of 8 to 10 lb nitrogen to every 100 lb of made tea. Is not the T.R.I. of the opinion that adverse factors are liable to emerge at high dosages? What upper limit of nitrogen does the T.R.I. recommend, so as to be fairly certain that the excessive dosages will not be harmful and also pay for itself in relation to crop?

(*b*) Is the T.R.I. of the opinion that a totally inorganic manure can safely be used without generous quantities of compost or some form of mulch?

Mr Tolhurst: I do think that the continued use of sulphate of ammonia at high levels will cause trouble, and I do think that in fact some instances of trouble have already been seen. The reason I say this is that on two of our manurial experiments—one in the low country, and one in the driest part of Uva—in spite of what we consider high dressings of potash, the tea is nevertheless showing definite symptoms of potash deficiency. I must add that a third experiment, also in the low country, has as yet shown no potash deficiency. I have also found, within recent months, potash deficiency symptoms on some of the highest-yielding estates in Ceylon.

Now, why is this deficiency appearing on tea which appears to be receiving plenty of potash? The main reason, I think, is a very complex nutritional one. All the tea referred to has been highly manured with sulphate of ammonia, which has the effect of releasing manganese reserves from the soil. (Please do not confuse manganese with magnesium). From quite a lot of leaf analyses it does seem that tea can accumulate too much manganese in its foliage. On St Coombs I have, simply by manuring bushes with manganese sulphate, induced them to show potash deficiency symtoms. There may, then, be an indirect competition between sulphate of ammonia and potash in the soil, as well as a direct competition.

Quite a lot of tea in Ceylon, particularly high yielding tea, is being manured generously, to say the least of it. Ratios of 12 or even 15 lb. nitrogen per 100 lb. made tea are not uncommon. I strongly advise you to examine your yield records very carefully, as Dr Joachim has just suggested, to decide whether your tea really does need such generous manuring. I would remind you that the TRI still holds to an 8 lb. ratio as a maintenance level of manuring, with a 10 lb. ratio to allow for expansion of cropping capacity. Some of you have gone one better, but the deciding factor is, surely, whether or not the tea is capable of increasing its frame and its capacity to yield more highly. If so, be generous with manure at a 10 lb. ratio. If not, restrict your nitrogen until you find a maintenance ratio to suit your particular conditions.

Therefore I will not state any particular upper limit for nitrogen manuring, as I was asked to do, as there is no one answer to that query.

If you do restrict the nitrogen, I suggest you restrict phosphate as well, but leave the potash level as it was; or even increase the rate of potash per acre. The problem I have mentioned can not be solved simply by increasing the potash manuring if sulphate of ammonia continues to be used excessively. It is a nasty problem, but I can suggest that we shall be moving towards richer potash manures in the next few years, and I would encourage you to experiment with mixtures which are at least 50% higher in potash than our present recommendations. This is particularly necessary for low country, where T.521 is already commonly used, for the mid-country, and for the lower elevations in Uva.

If you do use more potash, do not forget the need to use magnesium. This is, of course, part of our standard manurial recommendations.

Looking further to the future, we may find a more attractive way of tackling this problem. Rather than reduce the level of nitrogen we may be able to alter the form of nitrogen and avoid much of the damage resulting from sulphate of ammonia itself. Animal meals might replace some of the sulphate of ammonia for high yielding tea, but they are expensive and the fact that they are organic is, in my opinion, not important. Urea could be an alternative source of nitrogen, being less damaging than sulphate of ammonia, but introducing problems of its own. If urea is used, you must avoid applying the manure in the wettest months. But, better still, is the "compound granulated" type of manure, quite new to the Ceylon market and as yet unadvertised. This type of manure has NPK and calcium compounded in fixed proportions in granules the size of rice, and, as long as it does not pick up moisture too readily the granules would doubtless be easy to distribute in the field. In general they are more concentrated than the usual mixtures. From my point of view I think the main advantage may be that half of their nitrogen is in the nitrate form. Nitrate would not be expected to bring manganese into solution in the same way that ammonium does, and thus we could expect less damage from such manures.

Summing up, I can say that higher potash manuring is suggested for certain districts and for high yielding tea in general, with restriction of nitrogen to the lowest possible maintenance ratio. Do not forget magnesium. If you do use any of the new manures I would like to know your opinions of their behaviour in practice, because my experiments cannot answer such points. Given a sufficient market, we could no doubt persuade manufacturers to develop formulations to suit any of our requirements.

Mr Tolhurst: Answer to the question 62 (b): There is no reason to think that high levels of inorganic manure necessarily destroy organic matter in the soil. In fact, with good husbandry, the reverse has often been shown in other countries, and may be expected to hold good for tea in Ceylon.

Question No. 36—Anon.

Will the continued use of dolomite have an adverse affect on tea?

Is Epsom salts preferable to dolomite in curing or preventing magnesium deficiency?

Question No. 36(a)—Mr T. M. Fernando, Enselwatte Group, Deniyaya.

Will the ammonium in ammonium sulphate create magnesium deficiency in the same way that potassium does?

Question No. 37—Mr Williams, Glen Alpin (Uva)

Why does the T.R.I. recommend Epsom salts for young tea and dolomite for mature tea?

Mr Tolhurst: There seems to be quite a burst of interest in magnesium, and first of all I will answer the query—"will the ammonium in sulphate of ammonia create a magnesium deficiency in the same way that potassium does?"

Yes, it will, but probably not to the same extent. There is generally a competition between ammonium and magnesium ions around plant roots, but nitrate does not show this adverse effect. This can be borne in mind when thinking about the new types of manure which I mentioned earlier. I must emphasise, however, that the continued use of any form of NPK manure without magnesium would eventually run the tea into magnesium deficiency as soon as the soil reserves were exhausted.

In reply to the fear that continued use of dolomite might have an adverse effect on tea, I can say that as long as dolomite is used as we recommend, and with the NPK manuring which we do now or are likely to recommend, the answer is: No.

"Is Epsom salts preferable to dolomite in curing or preventing magnesium deficiency"? and a similar question—"why does the T.R.I. recommend Epsom salts for young tea and dolomite for mature tea?" First let me make it clear that, as given in the *Tea Quarterly*, we recommend kieserite, which contains 24% MgO and not epsom salts with only 17–18% MgO. Both sell at the same price per ton, and both are known by the broad term magnesium sulphate.

Our reason for recommending kieserite for young tea is that it is quite easily soluble, and as young tea is particularly susceptible to magnesium deficiency we want a source of magnesium which will dissolve and reach the small root systems quickly. For the same reason kieserite is preferable for a quick-acting soil dressing in cases of known magnesium deficiency either in young or in mature tea.

Dolomite is only slowly soluble, but for a long-term prophylactic manure for mature tea I think it is perfectly satisfactory. It is possible that in areas of high rainfall it may be superior to kieserite for this purpose, being resistant to washing out from the root zone.

Question No. 38—Mr W. J. Childerstone, Balangoda Group.
To fork or not to fork? That is the question!
Could Mr Tolhurst kindly elucidate?

Mr Tolhurst: One of my colleagues very aptly commented that my problem in answering this question is—to talk or not to talk. I will take the easy way out and be very brief.

I look upon forking as being an operation to help—I emphasise the word "help"– to keep the surface soil reasonably well aerated. When we eventually get really compact stands of tea with vigorous root systems and plenty of leaf-mulch, I think we shall be able to rely on the tea bush, together with the much disputed shade trees, to keep the soil in this desirable condition. These conditions are not yet universal and as a matter of prudence I do still recommend one deep forking per cycle, or at lower elevations, once every other cycle, after pruning. I know a tendency at the moment is to forget the fork altogether, but as a long-term practice I think it is dangerous to go to that extreme now.

I am afraid that some of the low-organic-matter soils, those which I pointed out in my paper, may be more troublesome in this respect, and perhaps for many years to come they may need very shallow forkings within the cycle, in addition to the deep forking. If you feel that the surface is packing to a smooth, hard, crust then you are in a position to decide when to break that crust. But do not be too vigorous. There is no point in stirring the soil about so much that you make a loose, dry, mulch of it. A few shallow cracks at intervals of a foot or two might be sufficient to allow plumps of rain to soak in without running off. Organic matter, both in and on the soil, is probably a better answer in these problem areas.

To summarise the problem of forking, I would say: If in doubt, don't.