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* THE MAINTENANCE OF FERTILITY IN TEA SOILS.

By

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Most of the lectures or talks I give to Planters' Association meetings are on highly specialised aspects of tea planting or tea manufacture. On this occasion, more especially because it is your Annual General Meeting, I have prepared a formal lecture of a more general and fundamental nature than usual. I feel it is desirable every now and again to take a broad view of tea planting as a branch of agriculture in general rather than to persist with nothing but myopic glimpses of tea in particular.

Man's ability to mechanise and to increase agricultural production per man hour has far exceeded his ability to increase the yield of agricultural produce per acre. The manufacture and mining of concentrated plant nutrients has enabled mankind to overcome some of the initial difficulties of maintaining the productiveness of agricultural land, but our efforts to increase the fertility of our soils are not keeping pace with the fertility of man himself. William Vogt, in his provoking book, "The Road to Survival", maintains that the human race has been living on a capital of fertility stored on the surface of the earth and that we are exploiting this capital at a rate which threatens to reduce the scale of living to which we have been accustomed in the last century, since mechanisation increased our ability to exploit. This thesis cannot be lightly dismissed and I propose to discuss it in some detail.

The sun is the fundamental source of energy in all forms of life on the earth. Plants absorb this energy and, with it, transform carbon dioxide, water and minerals into vegetable matter. Animals are entirely dependent on plants for their nutrition, since they cannot synthesise their food directly from mineral elements. Lower forms of plants, such as bacteria and moulds, reduce dead tissues to forms in which they can either be used again as plant food or stored for future use in the form of humus. Specialised bacteria and moulds also help to control plant and animal populations by causing premature death when overcrowding occurs. The most elementary speculations on biology immediately lead us to the question of balance. The expression "The balance of nature" is no idle fancy; none but fools will scorn it. To understand the balance in all the subtleties is, however, a task which is beyond the wisest of us.

Carbon dioxide is freely available all over the earth, but the amount of sunshine and water available to plants varies widely, and has led to the evolution of an enormously wide range of plants, ranging from those which have adapted themselves to the minimum amount of light and warmth, such as arctic plants, to the cacti and the euphorbias which can survive in burning sunshine with the minimum of rainfall. In Ceylon, we have all the light, warmth and rain we need; in fact we have an excess. The amount of heat available at the surface of the earth in tropical regions causes a rapid decomposition of rock but, in the monsoon areas where rainfall is heavy, the products

* *Lecture delivered to Dimbula, Dickoya and Uva District Planters' Associations.*

of decomposition tend to get washed away. Nature's own solution to these conditions is the tropical rain forest, which breaks the fall of rain and protects the soil from excessive light and heat. Humus and surface mulch then form which, in turn, help to store nutrients, especially water, and also to regulate the flow of excess water into natural drainage channels at a rate which does not carry away the soil as it weathers from the parent rock formations.

Storms of sufficient violence to wash away soil in natural rain forest areas do occasionally occur and the purpose of these I cannot pretend to explain. Neither can I explain fires which sometimes destroy the tropical rain forests but the process of regeneration appears to be fairly obvious. Grasses quickly become established in fired and eroded areas and maintain or even establish conditions in which trees can once again take over. The patnas are undoubtedly part of a natural succession and become temporarily established when fire, or fire plus erosion, destroys the natural forest. Forests cannot, of course, become established until there is an adequate depth of soil, and grasses will be found where the depth of soil is not sufficient for trees. Geologically, Ceylon soils are old, so I have omitted mention of the earlier stages of soil formation, but we can still see these initial stages on slab rock where mosses and lichens are the advanced guard of the grasses.

Tea was planted in place of the rain forests or patna where the depth of soil was already adequate for the growth of trees. Tea is in itself a forest plant and grows in mixed tropical rain forests with a high cover—often, I believe, of *Albizzia* species. It is therefore a suitable crop for the soil with which we are concerned and we will now consider the factors which are involved in the fertility of the soil so hardly won from granite rocks, and so carefully preserved by natural successions of plant growth. They are :—

1. Light and temperature.
2. Water supply.
3. Air supply.
4. Supply of plant nutrient.
5. Various injurious factors.

I will deal with each factor in brief outline and at the same time attempt to assess the importance of each in planting practice.

(1) **Light and Temperature.** The species of tea plants grown in commerce have become adapted to a wide range of temperature condition and withstand both moderately high and moderately low temperatures but cannot survive long periods of frost. So long as tea gives sufficient cover to the soil and maintains the conditions found on the forest floor, no particular harm is done by high temperatures. However, forest soils exposed to direct sun rapidly lose their cover of mulch and, when the soil temperature rises unduly, organic matter in the soil is rapidly destroyed. A great deal of work has been done in Malaya on these aspects of tropical soils and when I was in Trinidad I assisted in some experiments in which belts of natural rain forest were felled every year in order to determine the rate of oxidation of organic matter in exposed soils. During my time, the oldest felled belt was only 3 to 4 years old and the organic matter was already showing a very marked fall according to the method of analysis I employed. It is a very complicated subject and much remains to be done, but I hope that Dr. Haworth will be able to devote the greater part of his time to soil problems. One of the reasons for the experiment I have just mentioned was that the Forest Department in Trinidad were finding great difficulty in re-establishing teak in areas which had been clear-felled during the 1914—18 war, and I am frankly alarmed by the possible difficulties in replanting tea in areas of exposed soils. We already have an experiment under way to determine the effect of grasses on reconditioning and

replanting. From the practical point of view we must keep our soils covered by encouraging the maximum spread of our bushes, by high shade, and by growing green manures after pruning until they are crowded out by the tea again. Ground covers and selective weeding can be employed where considerable exposure has already occurred, but they must be regarded as temporary and rather extreme measures.

The tea plant does not need full exposure to sunshine to obtain its requirements of light. Plants grown in shade normally carry large amounts of foliage to increase their light absorbing power, which, in turn, increases soil cover and the ability to absorb nutrients. The removal of shade from tea, although it may temporarily increase the rate of growth due to light stimulus will tend to upset the balance between the amount of maintenance foliage, soil cover and nutrient absorption. The long term effects of such a change of agricultural policy are unknown and involve unwarranted risks.

2. **Water supply**

3. **Air supply.**

4. **Nutrient supply.**

These three factors are taken together because I must limit this lecture to the more important points. The main aspect I wish to stress is the importance of organic matter in the soil and its effect in maintaining the conditions essential for the growth of a plant such as tea. First and foremost I wish to mention the effect of organic matter on the physical condition of the soil — primarily the maintenance of what is known as "crumb structure".

It is difficult to define crumb structure, especially in tropical soils. Most good agriculturists know, by experience, when a soil is in good heart. Sir James Scott Watson says of temperate conditions "A soil with a good crumb structure is friable and handles well. It does not go sticky when squeezed, nor does it disintegrate into small pieces like sand. It holds water without becoming water-logged or sad, and works well with implements. To produce this good crumb structure it is essential to have organic matter of some sort."

Certainly even with tropical soils, a soil in good heart holds water well and does not dry out as quickly as a structureless soil. Soil structure enables free drainage, whereas a poor soil tends to pack when wet. With good structure goes free aeration and the minimum of cultivation is then necessary to provide an adequate air supply. A sticky soil compacts and impedes the supply of air to roots and to micro-organisms. Cultivation tends to destroy structure, so at all costs avoid plain forking. The best advice I can give you is, if possible, only to fork when there is organic matter and manure to fork in. When forking is carried out, fork deeply but avoid any lifting action which will break the larger roots of the tea bush.

Dr. Haworth is finding many indications that our Ceylon soils have a comparatively poor ability to hold nutrients. The technical expression is that they have a low base exchange capacity. The clay fractions in which this vital function is centred, is in any case apparently low, apart from which the kaolinitic types of clay formed from granite rocks do not hold ammonium and potash ions as well as many other types of clay. The preservation of organic matter, which also has the ability to hold nutrients, is therefore, in the case of our tea soils, of paramount importance.

The finer particles in our soils also tend to wash down to the limit of the depth of forking and to form a hard pan which the roots of the tea bush cannot penetrate. Since we cannot cultivate with sub-soiling tools the deep

rooting shade tree is an essential companion to the tea bush, apart from all other benefits it may confer in the form of mulch and reduction of insolation."

Just as a break in a wire of hair thickness in a sparking coil can immobilise a car, so absence of traces of minor elements can arrest the growth of a plant. Dr. Haworth is following Dr. Eden's work on nitrogen, phosphate and potash, by an investigation of minor element nutrition. All nutrients however, depend for their effect on the physical condition of the soil, which banks and holds them until the roots can absorb them, on water which conveys them, and on air which helps to convert them into the form in which they can be absorbed. Micro-organisms play an important part in all these processes and again their activity depends on organic matter and physical conditions. Although you may supply all or more than the requirements of nitrogen, phosphate and potash, they are useless to the bush unless the physical condition of the soil and the population of micro-organisms are able to make them available and supply them at the rate required by the bush.

The use of so-called organic manures is of little help because nitrogen has to be converted into nitrate and the bone meal to soluble phosphate before absorption can take place. Their contribution in the form of humus is negligible and does not justify their relatively very high costs. The cost of organic manure is high in terms of actual nutrients and the extra expenditure involved is far better devoted to green manuring.

5. **Various injurious factors.** Before I pass on to practical recommendations, I must warn you that soils in poor condition often liberate toxic amounts of minerals such as aluminium or encourage the development of parasites such as eelworms. We are particularly concerned about eelworms, and the only controls known to us at present are the predatory eelworms and parasitic fungi whose activities are encouraged by organic matter in the soil.

I hope I have advanced enough arguments to convince you of the vital necessity for maintaining the level of organic matter in our tea soils. In recent years we have rather tended to neglect green manures. Mr. Loos agrees with the rest of the staff that the only possible policy at present is to grow any green manures which will thrive, regardless of whether they are themselves hosts to eelworms. If *Tephrosia vogelii* will give you a good yield of organic matter, then grow it. When it becomes heavily infested and will not survive lopping, then grow the next best green manure. If you are fortunate and can grow Crotalarias equally well, by all means rotate crops of legumes but concentrate on growing as much organic matter as you can. Once there is a complete cover of tea, there is apparently little to worry about and, at the end of the first year of pruning, green manures should be crowded out. With the crowding out of green manures will go the crowding out of weed growth. Excessive weed growth is in many ways a measure of deterioration of cover. To my mind the most serious threat of blister blight is its effect on reducing cover and all efforts must be concentrated on keeping our soils covered and preventing the direct access of sun and heavy rain to them. The staff of the Tea Research Institute feel that every inch of spare ground of tea estates should be used for growing green manures of some description. In many cases uneconomic areas of tea could with advantage be used for growing grasses. If you wish to grow large quantities of grasses you must manure them heavily. We are laying down experiments on manuring both Gautemala and manna grass with a view to discovering the maximum economic responses. For the present a mixture of 6 parts sulphate of ammonia, 2 parts superphosphate, 1 part muriate of potash should be reasonably satisfactory.

The quantity to be applied depends of course on the rate of growth but when the grass is fully established and growing vigorously 2 cwt. per acre of

the given mixture should be applied about 10 days after each cut. These grasses should be allowed to grow at least 6 feet high before cutting.

The maximum benefit will be obtained where grasses can be thatched on to the soil, giving priority to areas where the tea is thin. Composting will help to reduce the eventual weight of materials to be carried to the field but wastes something approaching 70% of the potential humus forming material during the process of rotting. Nitrogen added to the compost will help to reduce this loss but, in all cases, the best results will be obtained by green manuring either with green stuffs grown *in situ* or green stuff carried on to the field. I must warn you, at this stage, not to attempt to grow grasses in the tea.

To sum up, therefore we recommend a maximum effort in producing green materials, the utilisation of road verges, ravines, unplanted patnas and even unproductive tea areas, in an all out effort to restore or maintain the organic matter in our soils, for the maintenance of organic matter means the maintenance of fertility.