THE IMPORTANCE OF SOIL AIR FOR TEA ROOT GROWTH

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The importance of soil air for satisfactory root growth of tea plants has been investigated in experiments carried out both in the nursery and in the field. It has been found that roots of young vegetatively propagated plants tend to grow in between the polythene sleeve and the soil, if the latter is clayey and ill-aerated. Root penetration of such soils can be improved by breaking up the soil by pressing in the sides of the bags or by stabbing the soil from above with a rod. The use of better soil mixtures is suggested.

In poor clayey soils, there were distinct advantages in digging larger planting holes. The growth of the plants was much better with larger planting holes than with smaller ones. These differences diminished in good well-aerated soils. The Deeprooter machine was used for digging planting holes, and this machine has been critically evaluated. The significance of the experimental results are discussed and suggestions have been made for improving soil in areas to be planted where tea has died as a result of drought conditions.

Many instances of poor root and shoot growth of tea plants, both mature and young, of seedling origin as well as vegetatively propagated, have been reported from time to time, but have become more common in recent years. It was reported earlier that mature tea plants in certain areas where tea had been growing on clayey soils showed characteristic symptoms of the lack of soil air (de Silva 1967). It has also been pointed out that nursery plants exhibit poor root growth as a result of soil compaction in polythene sleeves in the nursery (Tolhurst 1966). This article discusses the underlying cause—the lack of sufficient soil aeration—and provides suggestions for minimizing the damage.

Nursery plants

It has been emphasized that suitable soil structure (Tolhurst 1966; Richards 1966) and 'good drainage' (Visser & Kehl 1958; Richards 1966) are required for good growth of vegetatively-propagated tea plants growing in polythene bags in nurseries. There is some evidence to indicate that young plants respond adversely to the lack of sufficient soil air. This response takes the form of poor root growth as well as unsatisfactory shoot growth. Roots tend to avoid penetrating the soil, and grow in between the soil and the polythene sleeve where there is greater aeration (see Figures 1 & 2). The few roots which do penetrate the soil tend to be more translucent than healthy roots, a symptom which has already been noticed in the feeder roots of mature tea (de Silva 1967).

In one experiment using subsoil mixed with coarse sand in the proportions of 1 : 1, 2 : 1, 3 : 1 and 4 : 1 with the pH of all mixtures corrected to 4.8, it was found that there was greater root growth where the highest proportion of coarse sand was present. Further, the tendency of roots to grow into the body of the soil was more pronounced when the proportion of coarse sand was greater. Similar and better results were obtained when compost was used instead of sand in the treatments.

In another experiment where plants were grown in clayey soil for eight months, it was found that both root and shoot growth became retarded. Defoliation occurred and the few roots that were present, grew in between the polythene sleeve and the soil. The plants were then treated in three different ways :

FIGURE 1 — *Left-A healthy plant growing in well-aerated soil*
Right-A plant growing in poorly-aerated soil

FIGURE 2— *Left-A healthy plant with a well developed root system growing in well-aerated soil*
Right-A weak plant with a poorly-developed root system as a result of poorly-aerated soil

1—Bags were picked up and pressed in from the sides in order to break up the clay and improve the soil aeration,

2—Using a round iron rod, 7 mm in diameter and pointed at one end, the soil in each bag was stabbed six times from above so that the rod penetrated to the bottom of the soil, thereby improving the drainage of water from the soil.

3—The plants were untreated.

Fertilizer and water application were common to all treatments.

It was found that treatments 1 and 2 resulted in greatly enhanced root growth whereas the growth in the untreated controls continued to remain poor.

Field plants

Soil variation in tea fields is infinite, and depends on many factors historical, topographical and climatological. Two aspects of soil are relevant to this article: the thickness of the topsoil, and the nature of the subsoil. Top soils on tea estates which have supported tea for many years may vary with location but it may be generally stated that in order to support the tea for many years the topsoil could not possibly have been too detrimental to the tea plant. If it had, it could not have supported the crop. On the contrary it must be assumed that topsoil is a product of the interaction of the tea plant and the environment and is the mainstay of the sustenance of the plant. The more topsoil there is, the better will the tea plant grow. Difficulties arise when there is insufficient top soil. The causes of depletion of topsoil are many, and will not be considered in this article. It would be sufficient to mention that topsoil is usually rich in organic matter and beneficial soil microflora, and that its structure and air content are satisfactory for the sustenance of feeder roots of tea which are found in abundance in this type of soil.

In steep areas, however, especially after pruning, the topsoil on tea estates tends to be eroded particularly by the rains, and to a lesser extent by wind. Wind erosion can take place even on areas which are not steep. Whatever agencies cause the layer of topsoil to diminish it is recognized that this process is detrimental to the estate and must be minimized; but often, the topsoil happens to erode away and the tea plant's survival in such areas would depend on the nature of the subsoil which becomes a critical factor in all areas where the topsoil is shallow.

Subsoil is characteristic in that it has little or no organic matter, and does not support a wealth of soil microflora. It may further, be clayey, rocky or gravelly. Whatever its composition it is characterized by the fact that it has not supported plant growth in the past, perhaps for a multiplicity of reasons. In tea areas where the topsoil is thin, it may be just as well to envisage how we can make tea grow on subsoil.

The first method that seems to be obvious is that subsoil might be mixed with topsoil. In order to investigate this a series of experiments were conducted with a machine known as the Deeprooter* using which it was possible to dig two sizes of planting holes depending on the size of the penetrating augers that were used. The larger holes were approximately 20.5 cm in diameter and 60 cm deep and the smaller ones were approximately 15 cm in diameter and 57.5 cm deep. As a third treatment, holes were dug manually using a curved spade, the holes being approximately 10 cm in diameter and 20 cm deep. In one experiment an area of land

*Manufactured by Dolmar Maschinen-Fabrik GmbH, of Hamburg, W. Germany,

approximately one acre in extent which had been under Guatemala Grass for two years was blocked out into two, and in one area, holes were dug manually while in the other, they were dug using the smaller auger of the deeprooter, *ie* the holes were approximately 15 cm in diameter and 57.5 cm deep. The area was planted with a single clone (TRI 2025). After three months the plants were observed and their growth assessed visually. There was a striking difference in the growth of the plants, those growing in the larger planting holes being appreciably larger than those growing in the holes that were dug manually. It must be mentioned that the soil was rather clayey over most of the area on which this experiment was conducted. The enhanced growth of the plants in the larger holes was visible even 24 months after planting.

In the next two experiments, three different sizes of planting holes were dug, two of them with the Deeprooter, and the third manually. The dimensions of the holes are mentioned above. The planting holes were spaced 1½ ft within each row, and 4 ft between rows. The experimental layout is shown in Figure 3.

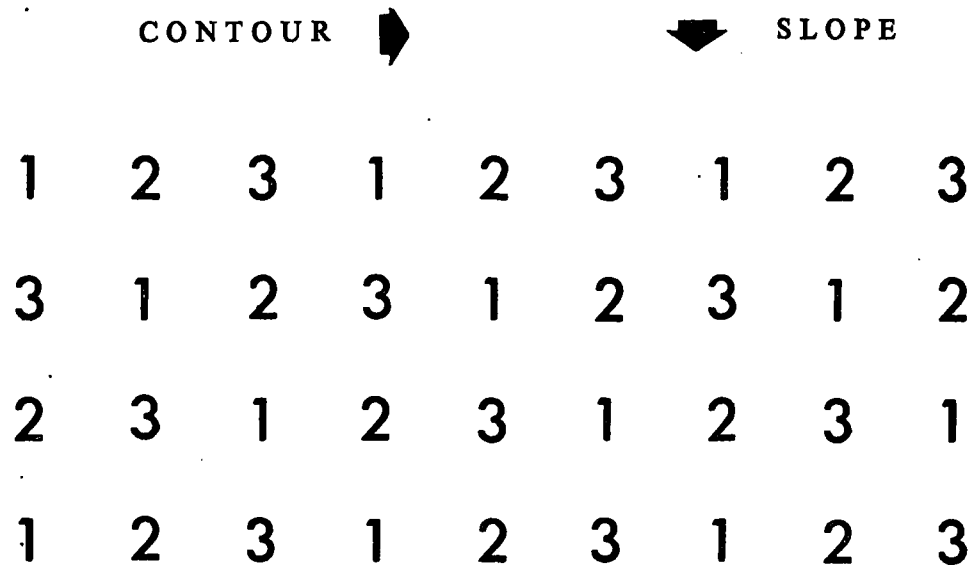

FIGURE 3 — *Experimental layout for testing the effect of the dimensions of planting holes on subsequent growth — 1 Holes dug with the large auger of the Deeprooter — 2 Holes dug with the smaller auger of the Deeprooter — 3 Holes dug manually*

In one experiment, plants of clone CY 9 were planted out in June 1966, whereas in the other, the clone used was TC 9 and the plants were put out in July 1967. The CY 9 experiment covered about ¼ acre and the TC 9 experiment covered about ½ acre. The growth of the plants was assessed visually. It was found that in the CY 9 experiment where the soil was poorer than in the TC 9 experiment there were striking differences in the growth of the plants about 6 months after planting, the plants put into the larger holes showing better growth than those in the smaller holes. In the TC 9 experiment, which was situated in a gently-sloping area where the soil seemed to be better, there was hardly any difference in the growth of the plants, between the various sizes of planting holes. It would appear, therefore, that some degree of variation is possible in the response of plants to the dimensions of the planting hole, but that there seems to be a distinct advantage in using larger and deeper planting holes in areas which have poor clayey soil, but that the advantages seem to be less in good soil.

Deeprooter Machine

The performance of the Deeprooter machine was quite commendable. It is powered by a 2-stroke engine which uses an oil-pertol mixture, and can be worked by two operatives. Two more operatives should be present as standbys because the vibration of the machine is such that two operatives by themselves cannot work on the machine all day, but four could do so working in turns. One of the four is required to remove clay adhering to the auger. The machine is robust and stood up well to exhaustive and continued use. The starter cord, however, gave way several times, and is clearly unsatisfactory. The machine is capable of digging 200 to 250 holes per hour, as compared with about 100 to 150 holes per day dug manually by a labourer. A point of criticism of the machine is that if large tea roots are present they can stop the rotation of the auger. On occasions the machine tended to swing round when a tea root was wedged into the auger, and this constituted a danger to the operatives who are caught unware that this was going to happen. This, of course, should be no difficulty if the area is free from large roots. Smaller roots either get broken up or are sufficiently pliable and give, when they come in contact with the auger screw. With a full fuel tank, the machine can work for half an hour.

Discussion & conclusions

The importance of soil aeration for the satisfactory growth of tea plants is clear. It would seem that treatments designed merely to increase soil aeration in nursery plants resulted in better root growth, and therefore, better shoot growth as well. Often, nursery plants which have poor root systems because of poor soil do not respond well to fertilizer applications because there are insufficient roots to take up the fertilizer. Symptoms of leaf scorch and defoliation may occur following fertilizer application in plants with poor root systems. Of course, even healthy plants growing in good soil can show symptoms of scorch if fertilizer is incorrectly applied, indeed the plants may even die, but in the case of healthy plants they would have healthy well-developed root systems. Instances of fertilizer-induced leaf scorch or defoliation can, therefore, be distinguished from instances of poor root growth caused by the lack of proper soil aeration. As has been pointed out earlier (Visser & Kehl 1958; Richards 1966) excess water is unsatisfactory for good growth of nursery plants. The water will tend to displace the air in the soil, and will result in the tea roots being subject to asphyxiation.

When the tea replanting scheme in Ceylon began over ten years ago estates were advised to use jungle soil which is rich in nutrients and is also well-aerated. Estates could easily obtain jungle soil for nurseries supplying plants for one or two acres of tea land which were being replanted. At present, however, with the greatly accelerated pace of the replanting scheme where the better estates replant anything from 15 to 100 acres a year, it may not be possible to obtain jungle soil for nurseries in such large quantities. Most estates use soil from land under Guatemala Grass as an alternative. This soil is often, but not always very satisfactory. It is sometimes clayey, in which case it must be mixed up with compost or well-rotted refuse tea to improve its organic matter content, and therefore its air content. If sand is being used, care must be taken to see that the soil pH does not arise above 5.0, at the time cuttings are planted. There is evidence that some clones show a more marked response to the lack of soil air than others. TRI 2024 and TC 9 are clones which do poorly in ill-aerated soils.

The importance of soil air for mature tea has already been considered in a previous article (de Silva 1967). In this discussion we wish to re-emphasize the fact that a shallow topsoil coupled with an unsuitable subsoil can be very critical to the plant particularly during a drought. It is not uncommon to see tea plants wilting

defoliating or dying in patches during a drought. It is significant that the damage is confined to *patches* whereas the drought covers not only the whole field or new clearing where the patches are located, but also the whole estate. The reason is, of course, that in the affected patches the topsoil is shallow and the subsoil is poor and unsatisfactory for root growth. This is why the plants have produced all their feeder roots in the topsoil, which is the first layer to dry out during a drought. It is a clear indication that all is not well below the ground. It can, therefore, be readily understood why plants growing in shallow topsoil will become weak in drought periods, and that their susceptibility to attack by diseases, will therefore, increase. There appears to be circumstantial evidence that susceptibility to *Phomopsis theae* increases as the plants become weak. It would seem that plants growing in soils considered in this article would be particularly prone to infection with *P.theae*. After the dead tea in areas affected by the drought is removed and new tea is planted, it is almost certain that the new tea too, will succumb during the next drought unless adequate precautions are taken. These preceautions can be grouped into two categories:

1—Thickening the layer of topsoil

2—Improving the subsoil so that it could support the growth of tea roots.

A brief summary of how this could be achieved will prove useful at this point.

In order to thicken the layer of topsoil we must first ensure that whatever topsoil there is, must be retained and protected from erosion. In very steep areas terraces are an absolute necessity, while even in less steep areas, a terrace may sometimes be useful. It would be best if the terraces were built to a height of one foot *above* the soil surface. Soil erosion will not only be minimized, but also, it would then be possible to add compost, mulch and thatch over the soil and thicken the layer of top soil.

Improving the subsoil can only be done if the subsoil is clay, which can be dug up by forking. Mulch and compost can be mixed into the subsoil before it is covered up with topsoil. Where the subsoil layer is stony or gravelly or even if it consists of slab rock, we shall have to be satisfied with thickening the layer of topsoil. Only after soil amendment measures have been completed, should the new tea plants be supplied. Of course, we need hardly emphasize that planting must be done in the best weather in poor areas so that we can protect the plant to some extent from the disadvantage it has to encounter of being planted in relatively poor soil. Clones known to tolerate drought conditions are obviously preferable.

Summary

Experiments with nursery plants show that tea roots require satisfactorily-aerated soils. If the soil is too clayey it is ill drained and is not conducive for luxuriant root growth. If this problem is encountered in nurseries, it can be overcome by pressing in the sides of the polythene bags to break up and aerate the soil or by stabbing the soil from the top with a rod. The problem can be avoided by using better soil mixtures incorporating compost, well-rotted tea refuse or sand in the polythene sleeves.

In the field, it was found that in poorly-aerated clayey soils the use of large planting holes was advantageous but that this advantage did not seem to be present in rich, well-aerated soils. The larger planting holes dug in poor soils resulted in enhanced plant growth, and increase in the rate of growth was visible even 24 months after planting.

The merits and demerits of the Deeprooter Machine have been evaluated and discussed.

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References

DE SILVA, R. L. (1967). Asphyxiation of tea roots in clayey soils. *Tea Q.* **38,** 340-343.

RICHARDS, A. V. (1966). Vegetative Propagation of tea. *Tea Res. Inst. Ceylon, Advisory Pamphlet* **8/66,** 17 pp.

TOLHURST, J. A. H. (1966). Good structure in nursery soil mixtures. *Tea Res. Inst. Ceylon, Advisory Pamphlet* **7/66,** 3 pp.

VISSER, T. & KEHL, F. H. (1958). Selection and vegetative propagation of tea. *Tea. Q.* **29,** 76-86.

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