DROUGHT CONDITIONS IN RELATION TO TEA CULTURE.

I.—WATER AND THE PLANT.

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Of all the substances essential for plant life, water occupies a pre-eminent position. It constitutes a very large part of the fresh weight of plants; it is the medium by which all substances enter into the body of the plant, and it forms the means of transport by which food materials and foods are transported from one region to another. Yet the bulk of the water is not a permanent constituent of the plant — it comes and goes, entering by the roots and emerging as vapour from the leaves. It is part of the environment which permeates the whole plant, yet in this water take place the complex chemical and physical processes which we call life.

In many of the tea districts of Ceylon our problem has been, not the conservation of this very important liquid but the ridding of the soil of an excess of it without losing an undue proportion of our hillsides. Agriculturists in general are reputed to blame the weather, and it is not unusual to attribute failure to harvest an estimated tea crop to adverse climatic conditions. The drought of last year, however, was of a severity unprecedented in the experience of even our oldest planters and it brought in its train, particularly on the Eastern side, problems and experiences not usually encountered in tea culture in Ceylon. These problems cannot be put aside as having no bearing on normal practice.

At the end of last year, Mr. Eden and I were enabled to visit a number of estates in the Balangoda district where the effects of the drought were most severe. What we saw provided plenty of food for thought. Why, for instance, were small-holdings much less affected than adjacent, better-cultivated estates ? Those of you who have worked in the stricken areas have seen far more of the effects of drought than we could in the limited time at our disposal, and no doubt have many such problems requiring solution. The best method of solving them is to pool our observations and conclusions at a conference such as this. For that reason the subject "drought" has been included in our agenda today. As much that will be said will have a direct bearing on normal estate practice, it is hoped that the subject will not be without interest to those who were more fortunate and did not see large numbers of their tea bushes die for lack of water.

It is my privilege to open this discussion and I shall confine my remarks mainly to the water relationships of the plant. Mr. Eden will follow on the soil aspect of the problem. That division of the subject, however, is somewhat artificial, as obviously our respective subjects are not watertight, plant growth being very closely related to soil conditions.

We may regard a healthy, growing tea bush, for the time being, as a channel through which water is constantly flowing. It enters in liquid form by the roots and is discharged as vapour from the leaves. The amount of water got rid of in this way, although invisible, is very considerable in quality. Balls has estimated that the water given off by an Egyptian cotton crop amounts to about 50 tons per acre per day, or 3 pints per plant. An acre of tea in full leaf, I estimate from experiments at St. Coombs, will lose on a normal fine day somewhere in the region of 10 tons of water, the equivalent of 1/10th inch of rain. The corresponding figures for a rainless month are 300 tons or 3 inches of rain.

During July, August and September last year (1934), one estate in the Balangoda district recorded in all 1·96 inches or an average of 0·65 inch. per month; another recorded only 1·65 inches for the 3 months or 0·55 inch. per month. The mean monthly rainfall for the same months during the preceding five years on these estates was 3·20 and 3·04 inches, respectively. It is not surprising therefore that these estates felt the full effect of the drought in 1934.

The flow of water through the tea bush is not maintained at a uniform rate. The rate of flow depends upon the rate of discharge from the leaves, and this is controlled by external factors. The quantity within the channel (the bush itself) remains constant and this water I would term '*vital water*', as a loss of even a small quantity of it will seriously affect the vitality of the plant. If the rate of discharge from the leaves is diminished, the rate of intake at the roots is automatically reduced. Conversely, an increased rate of discharge calls for an increased intake. If the latter is not forthcoming, some of the vital water is lost, and wilting occurs.

The discharge of water as vapour from the leaves is known to botanists as the process of Transpiration, but for present purposes we may regard it simply as Evaporation to which it is closely akin. From an acquaintance with withering loft conditions, or the more homely washing day, we know that the rate of evaporation — the withering of the leaf or the drying of the clothes — is determined by such conditions as the humidity of the atmosphere. temperature, and movement of air or wind. These are the conditions which largely control the rate of loss of water from the leaves of a living bush and, consequently, the rate of flow of water through the tea bush.

If all the bushes in a field have an equal supply of water, we should expect those which lost water most rapidly to wilt first. As wind is a factor which increases the rate of evaporation, it might be expected that bushes in sheltered hollows and protected from the wind would resist drought conditions longest. But this was not observed to be the general rule. More frequently, the bushes on the hillside, exposed to sun and wind, and those well away from a sheltering windbreak were unaffected, while the bushes in the hollows and nearer the windbreaks had wilted. An explanation of this observation is not easy to find. The fact that air movement increases the rate of evaporation is beyond question, so we are forced to look for our solution below ground. I would suggest that the bushes growing in the more exposed position have either a larger root range so that they draw water from a greater volume of soil, or that they receive supplies from some obscure source. The question of root range I will deal with later, but the discussion of obscure water supplies I must leave to Mr. Eden.

Another factor, and a most important one, which materially affects the amount of water lost by evaporation, is the area of the evaporating surface. The larger the area, the greater amount of water will be lost in a given time. For that reason, the dhoby spreads wide his sheets, and flush is spread thinly on the withering tats. The evaporating surface of the tea bush is its leaf surface; consequently, the more leaves the bush has, the larger the evaporating surface, and the greater is its discharge of water vapour.

It is pleasant to find that at least in this case observation supports theory. Speaking generally, the bushes which were oldest from pruning suffered most. Three-year-old fields suffered more than two-year-old areas and so on; the fields to suffer least were those recently pruned. For the same reason, viz. the larger evaporating surface high-yielding bushes suffered more than low-yielders — other conditions being equal. Undoubtedly the fields to suffer least were those recently pruned.

Here then is an apparently sound reason in support of dry weather pruning. That is true, if the object of pruning in dry weather is to enable the bushes to withstand drought conditions. On more than one occasion at these conferences, the pruning of tea has been fully discussed and the question of dry weather pruning has been referred to. At such times I have based my arguments on physiological grounds against dry weather pruning. I am still of of the opinion that in normal times, where severe drought does not enter into consideration, and when the recovery from the operation is the chief criterion, dry weather is not the best time to prune. But at the time when severe drought is experienced, pruning probably affords the best means of enabling the bushes to survive the shortage of water.

At such times, the pruning should be done before the bushes show visible signs of wilting, and the prunings should be left on the ground as a mulch. Pruning against drought is merely a method of rationing the water supply in the soil, the bush being forced to draw smaller supplies owing to the reduction of its evaporating surface. To be effective, rationing must be started before the supplies are exhausted. If the pruning is delayed until wilting has started, the operation may be too late. The first drooping of the leaves is indicative that the loss is exceeding the supply. That loss is made from the vital water of the bush, and it continues so long as the leaves remain attached. There is no system of water storage in the tea bush, and the loss of vital water results in the death of the small roots and stems. For this reason I consider that pruning after the leaves have dried is too late.

In the Uda-Pussellawa district I have seen bushes stripped of their leaves at the first sign of wilt, but before they have begun to dry out. The recovery of these bushes was extraordinary. New leaves were formed along the whole length of the stems even to the tip. There was practically no dieback such as is to be seen on normal, drought-affected bushes. Stripping then is very effective if it is done at the first sign of wilting and before there is any very serious loss of the vital water of the bush. The removal of leaves by stripping or pruning affords the best means I know of, of enabling the bush to survive during the severe drought conditions.

Leaving now the exit end of our water channel we will briefly consider conditions at the intake — the roots. The water is absorbed by the surface of the roots particularly in that region immediately behind the growing tip. Here again the question of surface area is of major importance. The large woody roots are of little importance from the point of view of water absorption. Their function is mainly that of anchorage; they also form the channel through which the water is passed to the stems, and they form a frame from which the more important finer roots are suspended. These fine roots, or feeding roots as they are often termed, have a very large surface area relative to their volume, and it is this large absorbing surface that renders them so important.

A wet soil can supply water to the absorbing surface of the root system at a rapid pace, in fact, faster than the root can absorb it. But as the soil dries out, the films of water round the soil particles become thinner, the resistance to capillary movement increases and the delivery of water to the absorbing surface becomes slower until at last the soil refuses to part with any more of its water. The intake of a plant's water system, however, is not stationary, as by growth the roots penetrate into new soil regions where the water content and water supplying power has been less depleted. Low water content of the soil, within certain limits, stimulates root development which results in an increased absorbing surface, but when the soil is very dry, root development is greatly retarded and even ceases.

The ability of a plant to withstand drought depends to a large extent upon the distribution of its root system within the soil. The first bushes to be affected by drought are those growing on a thin soil overlying slab rock, as their root systems are near the surface and the volume of soil to be explored is limited. A similar effect may be produced where the bushes are growing near water. If the subsoil is water-logged and thus unaerated, deeper roots will not develop and the main roots are consequently very superficially placed. A lowering of the water table during drought, particularly if the soil is coarse, renders these shallow rooted plants liable to water shortage. Thus bushes growing on sites which are normally wet may show signs of drought-effect quite early.

In actual fact our knowledge of the root system of tea is very limited, largely owing to the difficulties of research. We know that a large mass of fine feeding roots are to be found in the upper nine inches of the soil, but we know little about the number and distribution of the more deeply situated roots. It is a common experience when digging out bushes attacked by the *Poria* root disease, to find that although there is no visible above-ground symptom, a great part of the root system is dead. That means that under normal climatic conditions, an infected bush can carry on with only a small fraction of its normal root system. Infected bushes appear to die suddenly, and when that happens the majority of the larger roots are in a much rotted condition. I estimate that in many cases death does not occur for at least a year after first infection. During that time the extent of the root system is gradually being diminished owing to the progress of the disease. During drought, the shortage of water in the soil, together with the reduced means of obtaining it as a consequence of much of the root system being dead, causes the early death of *Poria* infected bushes. That, I think, explains the larger number of *Poria* deaths which occur during dry seasons. It is not that dry conditions favour the disease but that they add yet another handicap to the bush. From these observations I suggest that under normal conditions the damage to the root system of the tea bush, brought about by normal cultural operations, is of negligible importance, whereas similar injury in the time of drought may have a marked detrimental effect.

Our knowledge of the root system of plants is derived largely from the work carried out on other crop plants, particularly those whose root systems are more easily excavated in detail. This work shows that root systems are much influenced by the nature of the soil, its cultivation and drainage and by root competition.

It must not be assumed that because two species of plants are grown in the same soil their roots are necessarily in severe competition. Much will depend upon the types of the root systems and the regions of soil they explore. Competition in some cases may result in more extensive root systems, which penetrate to deeper levels. I have seen young tea, thickly interplanted with Grevilleas which survived the drought when adjacent mature tea, without the heavy stand of Grevilleas, was affected. From appearance alone it seemed that the young tea plus the Grevilleas were making heavier demands for soil moisture than was the mature tea. In the Welimada district, which normally has a long dry season, tea is frequently grown with a heavy cover of Grevillea without detriment to the tea's water requirements. One can only conclude, in the absence of evidence to the contrary, that whatever competition exists between tea and Grevilleas forces root development of both plants to lower levels, to their mutual advantage in times of drought.

From this brief survey of the water relationships of the tea bush it will be evident that so far as immediate treatment of the bush is concerned the reduction of leaf area affords the best means of minimising the effects of unusual, severe drought. More attractive is the thought that it may be possible to encourage the development of a root system, such that it fully occupies the soil to an adequate depth and throughout a radius sufficient to secure water and nutrients at all times. That is an ideal. The practical standard to which we are forced to conform is the production of crop of maximum quantity and quality. Possibly, it will be found that in general practice something of the ideal will have to be sacrificed for the economic standard, and that, at best, a compromise has to be achieved.

The plant's search for water cannot be disassociated from its search for food. Where the food is, there also will the roots be found. Root development, therefore, is much influenced by cultural practices, but on that subject I must give way to Mr. Eden.