

### III. PHYSIOLOGY OF THE TEA BUSH.

By

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#### Introduction.

In this short talk I propose to try and give you some idea of the essential physiology of the tea bush — in other words I want to take you behind the scenes and show you "how it works." A great deal of what I am about to tell you will necessarily be very much oversimplified and much will have to be omitted. However, I am hoping that when I have finished some at least of you will be in a better position to understand the reasons behind our insistence on certain types of agricultural practices and methods of crop protection.

#### Nutrition.

Before attempting to see how any machine or organism works it is only common sense to find out what it needs to keep it going. In the present case this question resolved itself into asking ourselves what are the nutritional requirements of the tea bush, or, to put it another way, what does the bush have to obtain from outside in order to keep it healthy and growing vigorously?

The answer is a rather long list of essentials, which may surprise some of you, but any way here it is (Table 1) —

Table 1. *Essential Requirements of the Tea Bush.*

	Source	Function
(1) Water (H <sub>2</sub> O)	—	Universal
(2) Carbon (C)	Carbon dioxide of air	"
(3) Oxygen (O)	Air	Respiration, etc.
(4) Major Mineral Nutrients		
Nitrogen (N)	Soils & Fertilisers	Proteins
Phosphorus (P)	" " "	Metabolic
Potash (K)	" " "	Water Relations
Sulphur (S)	" " "	Proteins
Calcium (Ca)	" " "	Water Relations
Magnesium (Mg)	" " "	Chlorophyll
(5) Minor Mineral Nutrients		
Boron (B)	Soil	Growth
Iron (Fe)	"	Chlorophyll
Manganese (Mn)	"	Enzymes
Copper (Cu)	"	"
Zinc (Zn)	"	"
Cobalt (Co)	"	"
Molybdenum (Mo)	"	"

Some idea of the relative proportions in which the different mineral nutrients are required by the plant can be seen in Table 2, which shows the results of ash analysis of leaf from three different elevations.

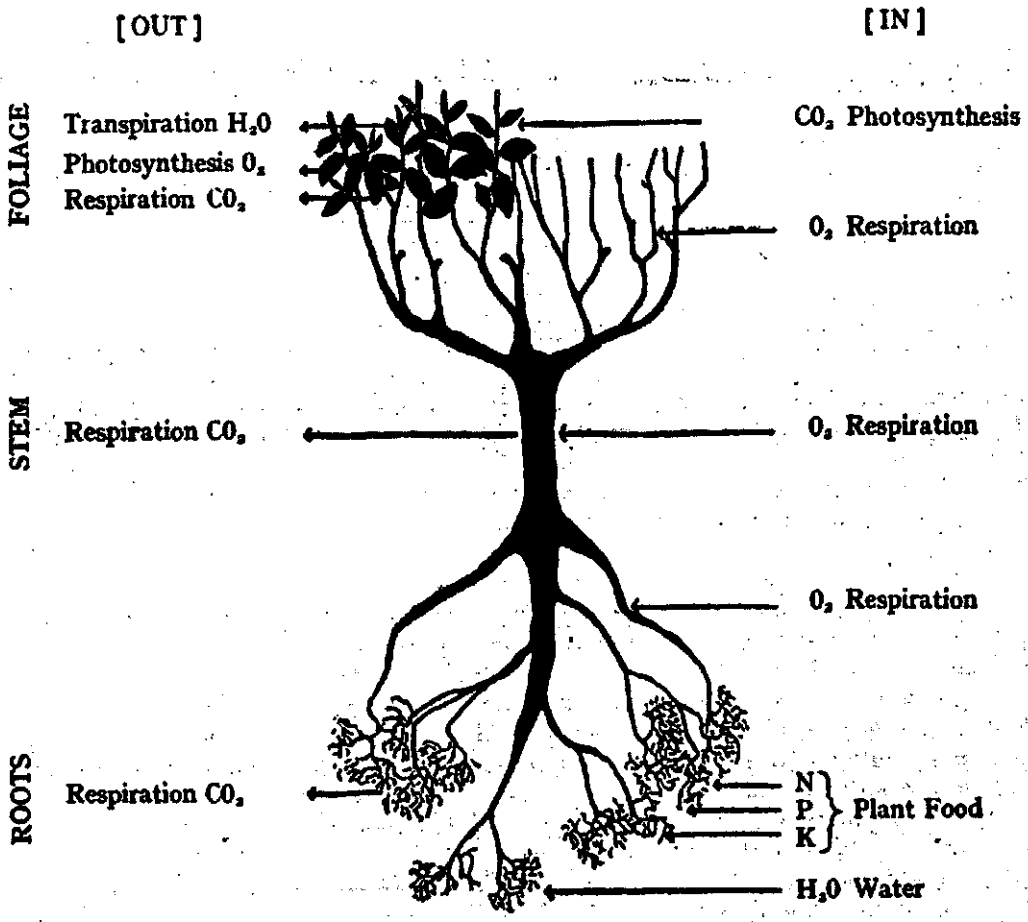


Fig. 1. Bush Balance Sheet.

Table 2. *Analysis of Tea Leaf grown at Different Elevations.\**

Total ash	Low-Country	Mid-Country	Up-Country
		5.22%	5.13%
Analysis of Ash. Percentage of Ash.			
Potash as (K <sub>2</sub> O)	44.22	41.11	44.63
Soda as (Na <sub>2</sub> O)	1.15	0.46	0.92
Lime as (CaO)	10.72	13.27	10.80
Magnesia as (MgO)	7.55	7.19	7.25
Iron as (Fe <sub>2</sub> O <sub>3</sub> )	0.34	0.50	0.51
Aluminium as (Al <sub>2</sub> O <sub>3</sub> )	2.53	2.44	2.94
Manganese as (Mn <sub>2</sub> O <sub>3</sub> )	0.49	0.38	0.25
Phosphoric Acid (P <sub>2</sub> O <sub>5</sub> )	11.86	15.05	18.31
Sulphur as (S <sub>2</sub> O <sub>3</sub> )	5.51	4.05	3.82
Silica as (SiO <sub>2</sub> )	0.97	0.75	1.56
Chlorides as (Cl)	1.04	1.70	0.84

The copper content of Ceylon tea leaf varies from 25 to 30 parts per million in most areas.

Carbon, nitrogen and boron do not remain when plant material is ashed and, therefore, do not appear in the analytical results. Copper, zinc, cobalt and molybdenum, on the other hand, are present in such small amounts that they are not detectable by the ordinary analytical procedure. The copper content of tea leaf is, of course, of considerable importance to us at the present time and I have accordingly included some average values, obtained by another method, at the foot of Table 2. These figures are expressed in parts per million, which should give you some idea of the smallness of the amounts normally present. The amounts of the other elements required are, however, very much smaller still and I should expect zinc and cobalt each to be present to the extent of about one part per million, while the molybdenum content may not exceed about one part in one hundred million.

In Table 1 you will see that I have referred to both potash and calcium as being concerned with water relations. In this connection it is interesting to observe that the various analytical figures given for these two elements in Table 2, add up to approximately the same total in every case.

You will note that certain element such as sodium, aluminium, silica and chlorine, which are not essential, appear in the ash. This is because the plant is not one hundred percent selective and so, in the process of absorbing what it needs, also takes up certain unessential elements which are present in the soil. Tea, in particular, readily takes up large quantities of aluminium and, in fact, belongs to a group of plants known as "Aluminium accumulators". This unselective absorption has an important bearing on what is known as "Toxicity", since, if an undesirable element is present in quantity in the soil, the plant may easily take up more of this element than it can tolerate, with the result that toxic symptoms are developed.

Having now, I hope, given you some idea of what makes the plants work let us now try and see how it works.

### Water Relations.

First of all let us look at the basic role played by water in the physiology of the tea bush. In the diagram (Fig. 1) you will see that water (H<sub>2</sub>O) is taken in by the roots and is given off from the leaves. Between the water-

\* Reproduced from the report of the Chemical Division for the year 1949. (Bulletin No. 31, p. 28.)

absorbing roots and the leaves a continuous connection is maintained through the wood, which is the principal water conducting tissue. In this tissue the water moves through special water-conducting "vessels" which are really microscopic tubes or capillaries. This continuous movement of water through the plant has received the name of the "transpiration stream".

On reaching the leaves the water is mainly evaporated from the cell surfaces into the air channels, or "intercellular spaces", within the leaf, and passes out as water vapour through the breathing pores or "stomata" which are dotted all over the underside of the leaf. This process is known as "transpiration." An increase in the rate of air movement over the leaf surface, or a drop in the relative humidity, will increase the rate of water loss from the leaf. Thus, one of the functions of shade is to reduce the amount of water lost by transpiration during periods of drought or high wind.

The evaporation of water from the leaf cells causes more water to enter them from the vessels and creates a "capillary pull" on the water columns in the vessels, which is transmitted right down through the plant to the water absorbing cells of the roots. This causes them to give up some of their water to the vessels and to absorb more water in replacement from the surrounding soil.

This is, fortunately, only part of the mechanism whereby the plant is enabled to absorb water from the soil. The cell sap is not pure water but contains a number of minerals such as potassium and calcium in solution and, as long as the concentration of this internal solution is higher than that outside, water will continue to be absorbed by the root hairs. If it were not for the existence of this second process a clean pruned bush would be unable to obtain any water, since the transpiration stream and its capillary pull are destroyed by the pruning operation. However, with only one water absorbing process remaining, it is now obvious why a pruned bush is more likely to suffer from the effects of drought than an unpruned bush.

Well now that we have got our water entering and leaving our tea bush — what does it do?

Firstly all the mineral nutrients absorbed from the soil by the plant enter in solution in this water stream. These include the familiar N, P, K supplied as fertilisers, as well as the other essential mineral nutrients given in Table 1.

As I have just told you, a pruned bush finds difficulty in absorbing enough water to keep itself from drying out and is certainly not in a position to absorb mineral nutrients as well. This is one of the scientific reasons for the abandonment of the old pruning mixture!

Secondly, water as such makes up some 75 — 80% of all plant tissue, while, in combination as carbohydrates, it accounts for about 60% of the total dry matter as well.

### Photosynthesis.

The next most important physiological function with which we have to deal — and one which is specific to green plants — is that of "photosynthesis." This is in essence the only process which leads to the building up of new organic matter from the simpler inorganic compounds, which are commonly available in the natural environment.

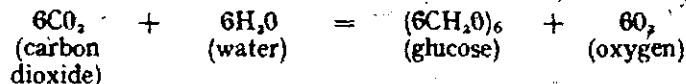
Photosynthesis takes place —

- (1) as the name implies, only in the light, and
- (2) only in the green leaves (See Fig. 1).

It is this latter connection that blister blight begins to assume importance. By destroying maintenance foliage blister reduces the bush's capacity to manufacture new organic matter and to maintain its growth and give us crop.

This, therefore, is one of the reasons why we have always stressed that the initial development of a good canopy of maintenance foliage, protected from blister blight damage, is all important.

Water and carbon dioxide, taken in through the breathing pores on the underside of the leaf, form the raw materials of the photosynthetic process — another name for which is "Carbon assimilation", which should be self explanatory. Reduced to essentials, the basis reaction is one in which 6 molecules of carbon dioxide combine with 6 molecules of water to give one molecule of sugar (glucose) and 6 molecules of oxygen.



The oxygen is liberated into the air, which fact is, of course, the origin of the idea that flowers or pot plants purify the air of a sickroom during the day, but must be removed at night.

The sugars or carbohydrates produced in photosynthesis may be used either as the starting point for building up more elaborate organic compounds, or else may be stored as carbohydrate reserves in the form of starch. If they are to be built up into proteins, then nitrogen and sulphur, two of our major nutrients are required. Furthermore, this is where the plant's requirements of phosphoric acid come in, since the further elaboration of the sugars formed in photosynthesis requires the formation of sugar phosphates, which serve as intermediate products in protein formation.

The process of photosynthesis is brought about solely by the chlorophyll, or green colouring matter of the leaf. This is where the plant's requirements of magnesium and iron come in, since the element magnesium is actually an essential constituent of the chlorophyll molecule, whilst iron is necessary for its initial formation.

Apart from the carbon dioxide, which as I have already explained, reaches the green cells of the leaf through the stomata, all other raw materials reach the leaf through the medium of the transpiration stream. Thus we may expect that the photosynthetic process will be seriously impaired (1) by drought, and (2) after continuous heavy rain, when the leaves become gorged with water and the access of carbon dioxide to the green cells is impeded.

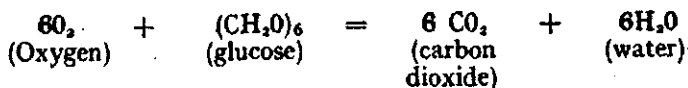
From the leaf factory the finished products are translocated to all parts of the plant by another special conducting tissue known as the "phloem", which need not concern us further.

Before passing on, however, I would like to stress the very important point that some 95% of all the dry matter in the plant is produced in the leaves.

### Respiration.

This is the process which provides the energy to keep life going. It goes on in all living tissue — in Figure 1 you will see that I have marked it as occurring in the roots, stem and leaves — and, unlike photosynthesis, it goes on continually — both day and night.

The basic reaction involved is to all intents the reverse of that which takes place in photosynthesis — oxygen is absorbed and used to burn up sugar, while carbon dioxide and water are produced.



In a normal healthy plant the amount of respiration going on is much greater than is generally realised, and may in fact amount to as much as one tenth of the reverse photosynthetic process. It is, therefore, easy to see that if photosynthesis is cut down; either by adverse weather conditions or by, what is much more important to us, a reduction in leaf surface, then the rate of respiration may well exceed that of photosynthesis. When this happens reserves of carbohydrates will begin to be drawn upon to supply the energy requirements of the living plant. Once these reserves are exhausted protein breakdown will set in, followed shortly by death of the tissues.

Thus once the rate of respiration becomes permanently greater than that of photosynthesis, and all carbohydrate reserves have been used up, there is no hope of saving the bush. However, if the leaf area, although much reduced, is still capable of making more food than is being continually lost through respiration, then the bush can still be saved provided it is rested. If, however, the leaf area of such poor bushes is brought below the danger level by continued plucking or by blister blight attack, then these bushes must inevitably die.

### Growth.

Finally just a few words about growth. All natural processes of the plant are affected by temperature. Hence growth is normally faster in the low-country. One of the consequences of this is that nearly all the food manufactured by the leaves is used up in making new growth and there is almost no storage of carbohydrate reserves under low-country conditions. This fact is one of very definite practical importance now that blister blight attacks appear to be increasing in severity in the low-country. With almost no reserves to support new growth, the results of continuing defoliation by blister blight may well be disastrous. In particular, it appears to me to be of paramount importance that low-country tea recovering from pruning in areas subject to persistent blister blight should be given efficient protection if a high casualty rate is to be prevented. Fortunately, such protection can now easily be provided with copper fungicides.

Furthermore, growth cannot go on properly if any essential nutrient element is in short supply. In this connection, the results of a shortage of potash, for example, are now familiar to most of us.

The need, therefore, is for a balanced manurial programme and, above all, for the maintenance of the necessary amount of mature foliage on our bushes. Spray protection during recovery from pruning will ensure an adequate amount of maintenance foliage at the start of the cycle. Provided, therefore, that we treat our bushes carefully during the course of the cycle, I see no reason to fear any further deterioration in capital values. In fact, with proper protection against blister blight, these may well be enhanced.