

ASPECTS OF THE SHADE TREE QUESTION

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INTRODUCTION

Traditionally shade trees have been associated with tea cultivation because in its natural habitat tea grew under shade. The trees used generally belonged to the family Leguminosae because they were thought to be advantageous over those of other families in fixing atmospheric nitrogen in their roots.

The consequences of shade removal

Tea is not a sun loving plant and there is no need to expose it to the direct rays of the sun as it would lead to a reduction of the leaf canopy, maintenance foliage and consequently a poor return of leaf litter and mulch that it will provide resulting in a lowering of soil fertility. The other extreme of tea being a shade loving plant has also to be viewed with caution. Heavy shading will influence the formation of a larger canopy due to the limitation of sunlight and consequently may perhaps lead to a better soil fertility. However, sunlight being the limiting factor in this instance cropping would be affected. The ideal therefore is a compromise between these two extremes.

The removal of shade has led to a general increase of the ambient air temperature which has resulted in an increase in bark temperatures of pruned frames leading to wood rot and has also favoured the resurgence of warm weather pests.

No longer should we think of the physical effects of shade alone but of the effects that the tree contributes as a whole - the organic matter it contributes in terms of leaf litter, the depth to which its roots go deep down and forage for nutrients that are unavailable to the tea plant, etc.

In view of the serious detrimental effects that have been caused by the removal of shade all estates are urged to embark on an immediate programme of re-establishing shade both in new clearings as well as in mature tea whether pruned or even in those in plucking if they have already not done so. The problems caused by the droughts can be mitigated at least to a certain extent only by adopting systematic steps in the process of establishing shade. In this respect it is felt that establishing some sort of low shade in new clearings is important in addition to thatching the area, while steps are being taken to establish permanent shade.

OBJECTIVES OF ESTABLISHING SHADE TREES

The advantages of having shade trees include the following :

1. They provide shade to the crop and the soil and reduce the temperature of the ambient air and that of the soil.

2. Provide considerable quantities of green manure in the form of natural leaf fall or loppings, which form a mulch that helps preserve soil moisture in dry weather.

3. Shade trees afford shelter from winds and help reduce transpiration losses.

Establishment of shade

Any form of shade, whether temporary or permanent must be established during the period of the rehabilitation grass so that the shade would serve the purpose for which it is established by the time the tea is planted. For this purpose the grass around a planting hole should be kept trimmed low in order to admit light and prevent smothering of the shade plants.

If bush manure plants like *Crotalaria* are grown as "bush covers" to prevent erosion or to protect young plants from drying winds, they should not be allowed to compete with the tea for moisture or fertilizer. They

should be kept under control especially prior to a drought by frequent lopping.

Establishment of temporary low shade

Every attempt must be made to establish a dense cover of low shade with *Sesbania* in the new clearings. They must be lopped at a low height in order to encourage a low spreading habit.

Establishment of permanent shade

Since establishment of shade trees is easier under less acid conditions it is preferable to incorporate about 1 kg of garden lime or dolomite in deep planting holes. Shade trees should be planted at half the final spacing with a view to thin them out later. It is strongly recommended that shade trees should be planted as a mixed stand of high shade like *Grevillea* or *Albizia* and a medium shade like *Dadap* or *Gliricidia*.

The shade plants should be manured separately if we are to have a vigorous stand of shade. During the period of establishment, a preferred mixture is T 200 or T 250 fertilizer mixture. These may be tried out at the following rates:

1st year : Three applications at 6 oz (168g)
per plant per application.

2nd year : Three applications at 8 oz (224g)
per plant per application.

3rd year : Three applications at 10 oz (280g)
per plant per application.

4th year : Three applications at 12 oz (336g)
per plant per application.

From the 5th year onwards manure with NPK mixtures giving two applications per year at $1\frac{1}{2}$ lb (680g) per plant per application.

Establishment of watersheds

In view of the recurrent droughts it would be a sound policy if watersheds are established on the crests of hills by planting rapidly growing shade trees such as Albizzias or Acacias at a spacing of 6m x 6m to 9m x 9m. The purpose of this exercise is to keep the crests of hills covered at all times so that there will be a general lowering of the ambient air temperature in the lower reaches of a field. In establishing watersheds even if production is affected over a couple of hectares in which the trees are established, it will still be worth the effort in the long term.

Removal of shade trees

When tea is uprooted prior to replanting, old stands of shade trees should also be uprooted. This operation must commence well ahead. The quickest and safest way to kill a shade tree completely is to rim bark it, the idea being to deplete food reserves in the root and the stump and thereby kill the tree in time. To achieve this only the bark must be removed over a length of one foot along the trunk at chest height.

Wind and shelter belts

For this purpose, in the up-country districts, a mixed stand of *Grevillea* and *Acacia* species could be used. The spacing between rows of shelter belts should be 45 m to 60 m (150 to 200 ft) depending on the intensity of the wind. A suitable mixture in the low-country would be *Fragraea fragrans* and *Gliricidia maculata*.

EFFECTS OF SHADE ON TEA

The overall assessment of the effects of shade trees is complicated by the existence of interactions which understandably vary with climate and soils and this accounts for the different practices adopted in different countries. In some countries shade trees have been traditionally planted whereas in others they have in recent times been thought unnecessary or their value disputed.

In some countries, notably East Africa, Indonesia and Sri Lanka, increased yields were immediately obtained by the removal of shade trees but in Assam the removal of shade trees led to a decrease in yield. In East Africa a limiting factor for optimum tea production under their conditions is the general low temperature prevailing in plantations in spite of the complete removal of shade cover.

Most of the studies made in the past on shade concentrated only on immediate yield changes and a few on quality. Adequate attention was not paid to the long-term effects on yields and their fluctuations, debilitation of bushes, problems of recovery from pruning and scorch, nutrient losses, etc., which are equally important in a perennial crop.

Studies on artificial shade on tea

In the study of shade tree effects on crops it is customary to isolate the effects of shade *per se* from the other complex effects of the tree. For this purpose shade levels are established by the use of artificial screens permitting different amounts of light to be transmitted through them.

From these studies it was seen that heavy shade (light intensity below 30% light) reduces bud activity and increases dormancy, reduces the number of branches, number and area of leaves and total dry weight of the plant. Height of plant and total leaf area were more at 30% than at higher or lower light intensities. This is understandable because when light is reduced the plant makes every attempt to arrest as much of the incident light by increasing its leaf area. At 60% light intensity growth and yield were better, if not at least the same as at 100% light. It is also to be noted that tea under light shade shows less fluctuation in bud activity and crop.

In times of severe drought, tea under shade tended to yield more and the teas manufactured had more colour and strength but lower quality and flavour. Interactions were noted for growth and yield between levels of shade and nitrogen. Generally better responses were

obtained at 60 and 100% light, higher levels of nitrogen were required at higher light intensities than at lower light intensities.

Studies on natural shade on tea

The results of artificial shade trials have to be applied under field conditions if they are to be of any practical value. The planting of shade trees introduces other complications and interactions of several factors. The shade level itself cannot be uniformly applied with trees and it will greatly depend on the canopy density and spread of the trees used.

In studies on natural shade, the shade was removed by removal of the branches only and not the whole trees. Under these conditions, it was observed that removal of the shade (i.e. by removal of branches) did not result in higher crops than the tea where no reduction in shade was done. Therefore, under field conditions if immediate increases in crop are consistently observed after removal of shade trees, this could be attributed to the effects of the trees other than shade level. If yield increases are not sustained over a long period after shade removal this could be due to some effects of the trees contributing to crop which are now absent.

Effect of shade on transpiration

Water is lost from leaves through openings on leaves called stomata. Shade reduces transpiration by affecting the microclimate of the leaf. These include a reduction in solar radiation and wind speed. In addition shade could reduce transpiration by affecting the stomatal and cuticular resistance, leaf water potential and leaf temperature. Shade increases stomatal and cuticular resistance. In addition to the altered microclimate, the increased stomatal resistance in shade leaves reduce transpiration. Under water stressed conditions when stomates are closed transpiration takes place through the cuticle of the leaf. Thus increased cuticular resistance would reduce transpiration. Shade leaves have high cuticular resistance and this is a desirable drought resistant characteristic.

The drought tolerant clone DN has a higher cuticular resistance than the drought susceptible clone TRI 2023. Further clone DN has a lower stomatal density conferring superiority in drought tolerance.

At similar water potentials leaves of clones DN and TRI 2025 maintain a higher relative water content compared to clone TRI 2026, thereby indicating a higher resistance to desiccation.

Deficiencies in mineral nutrients, notably potassium reduces cuticular resistance.

Response to fertilizer

This aspect is complicated by elevation, soil type, shade tree species, etc. The response to nitrogen in unshaded tea is larger than that in shaded tea.

Competition between shade trees and tea and within tea

Studies on competition between shade trees and tea plants employing young tea and shade plants in pots showed that during the first 4 months *Acacia* grew more vigorously and competed strongly with the tea while *Grevillea* did not affect the growth of the tea (Krishnapillai, unpublished). *Acacia* grew more vigorously than *Grevillea* and had a much more extensive root system. Water uptake studies also showed that *Acacia* absorbed and transpired 5-6 times and *Grevillea* about 3 times more water than the tea plants. It must be pointed out that under field conditions the shade trees are normally established before the tea and therefore their roots would have extended into deeper layers of the soil although the feeder roots may be in the shallower layers. When plants are grown sufficiently close as in the case of tea competition may be expected even between them in times of stress as much as would take place between shade trees and tea.

For fully efficient crop production each leaf must produce food materials in excess of its own requirements and the remainder added to the bush reserves. To do this each leaf must receive a certain amount of light. Below a certain critical level of light the leaf

will be a passenger on the bush to the extent that it receives food from leaves situated in an advantageous position. Present day planting methods involve using more plants per acre to obtain a rapid cover and hence more leaves are heavily shaded by those of adjacent bushes.

In tea planted 4' x 2', the lower leaves may receive only about 30% of the light. Thus in a fully matured bush with thousands of leaves, the proportion of overshadowed leaves becomes very considerable and once you shade such tea with heavy canopled shade trees the proportion rises still further until an appreciable percentage of the tea leaves are virtually parasitic. It is possible that the base of the canopy of some mature bushes in dense stands with a good cover of tea would receive as little as 2% of full sunshine and this is far below the level required for optimum photosynthesis. This low light intensity is a natural consequence of close planting and will be aggravated by trying to still further increase the stand of tea by various permutations and combinations.

Nitrogen fixation by shade trees

Nitrogen fixation by feeder roots and nodules of 20-month-old *Acacia* and *Albizzia* was established by determining the percentage nitrogen in these roots which are given below (Krishnapillai, unpublished):

<u>Shade tree</u>	<u>% nitrogen</u>
Acacia root nodules	4.65
Acacia feeder roots	1.96
Albizzia root nodules	2.00
Albizzia feeder roots	0.60
Grevillea feeder roots (non-leguminous tree)	0.96

The results show that leguminous tree roots fix nitrogen but it is not known yet whether this came from the soil or from the atmosphere. It was also observed that *Albizzia* roots had more nodules than the roots of *Acacia*.

Root system of shade trees

The size of the root system, the pattern of rooting and rooting depth of shade trees are important in relation to competition for nutrients and moisture, aeration, etc., but such studies are complicated by the fact that soils vary in depth and fertility. A study of the root systems of dadaps (*Erythrina lithosperma*) has shown that they are very shallow rooting with the roots extending over a fairly large area. Their roots are also fairly light and soft wooded. Tea roots extend much deeper and are also more heavier. *Grevillea robusta* root system was found to extend to variable depths depending on the soil type. On deep soils their root system extends to much deeper layers than tea roots. *Gliricidia* root systems were also found to extend fairly wide and were deeper than the roots of tea.