Tea Q. 44 (2 & 3), 113-119. 1974. Printed in Sri Lanka.

THE EFFECT OF ROOT AERATION ON THE GROWTH OF YOUNG TEA PLANTS IN WATER CULTURE

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The water culture technique was employed to study the effect of aeration of the root system on the growth of vegetatively propagated young tea plants of clone TRI 2025. Aerating the nutrient solution enhanced root initiation and subsequent root growth and, therefore, increased shoot growth. Aeration increased weights of roots and leaves more than that of the stem. Leaf area, leaf number and the height of plants were markedly increased by aeration. Inadequate aeration prevented root initiation, suppressed root growth and produced a bluish discolouration in roots. It also prolonged shoot dormancy, suppressed height of plants, resulted in the chlorotic appearance of leaves, and caused premature defoliation.

INTRODUCTION

The growth of roots of tea plants in the nursery or in the field, can be affected by various physical properties of soil including inadequate aeration, soil compaction and impeded drainage. This has been emphasized by de Silva (1967) and de Silva and Seevaratnam (1968). However, one or more of these factors in combination may impede root growth and consequently shoot growth. Identifying and quantifying the contribution made by each of these factors in impeding root growth is rather difficult when the investigation is carried out with plants grown in soil. For instance, in studies of this nature in soil-grown plants the concomitant effects of deficient aeration in the soil, such as the accumulation of toxic compounds like methane, sulphides, nitrites *etc,* cannot be eliminated or cannot even be minimized. It was, therefore, of interest to study the effect of aeration as a single factor, on the growth of tea plants by adopting the water culture technique which minimizes, if not eliminates, the effects of other factors mentioned above. This paper reports preliminary findings in an experiment which forms a part of a series that are being conducted to evaluate the effect of various physical properties of soil on the growth of tea plants.

MATERIALS AND METHODS

The experiment was conducted in a glass house at the Tea Research Institute of Sri Lanka, St Coombs, Talawakele (1200 m amsl).

Plants

On 19.12.1973 ten 7-month old young tea plants of clone TRI 2025, grown in soil in polythene sleeves and selected for uniformity, were transferred to nutrient solution contained in 800 ml soda glass jars. The roots were thoroughly washed to remove all adhering soil particles and were clipped off to about 5 cm from the collar. The plants were supported in the jars by means of a split cork with the aid

of non-absorbent cotton wool wrapped around the internode of the original cutting used for propagation. The solution for five plants was aerated and that for the other five was left unaerated.

Nutrient Solution

The nutrient solution used was similar to that used by Pethiyagoda, Krishnapillai and Nagarajah (1969) for sand culture experiments. The plants were grown in quarter-strength nutrient solution during the first two weeks, in half-strength solution during the next two weeks, and subsequently in full-strength solution. The solution was renewed weekly to minimize any changes in pH and to avoid the accumulation of toxic products, if any. Loss of water due to transpiration was replenished by adding water twice daily.

Aeration

Aeration was accomplished by passing air from a motor driven pump through capillary tubes, of bore diameter 0.75 mm, which were dipped into the solution. The air was first passed through water in an aspirator bottle, then through a column of cotton wool before entry into the culture solution, to prevent the entry of any traces of oil from the pump. Uniform aeration for all the plants was ensured by regulating the air flow through the capillary tubes with the aid of screw clips attached to the rubber lead-tubes.

Assessments

Dry weight was determined by drying the samples at 105°C for 24 hr in a forced-draught oven. Leaf area was measured using the grid developed by Pethiyagoda and Rajendram (1965). Plant height was measured from the point of attachment of the plant to the mother cutting, upto the tip of the terminal bud.

RESULTS

About three weeks after the plants were transferred to the nutrient solution new roots had emerged from the old roots in those plants which were grown in aerated nutrient solution. At this time there were no signs of new roots forming in the plants in non-aerated solution. No new roots were seen in the non-aerated plants during the course of the experimental period. With the appearance of new roots the aerated plants resumed vegetative growth whereas the non-aerated plants were still in the dormant state. The leaves in the aerated plants appeared dark green and glossy while those in the non-aerated solution were dull, leathery and chlorotic, showing signs of nitrogen deficiency. Observations made at the time of replenishing water lost by transpiration indicated that the aerated plants had transpired more water than the non-aerated plants, although no measurements of actual transpiration were made during the course of the experiment. This was found to be so even during the first few weeks when the leaf areas of the two sets of plants did not differ appreciably. The original root system of the non-aerated plants progressively turned bluish in colour, resembling those often seen in plants in waterlogged soils. There was also progressive defoliation in the non-aerated plants, the lower leaves falling off first (Fig.3).

The differences in the growth of the two sets of plants were finally assessed on 3rd May 1974. The results are presented in Table 1. It is seen from these results that aeration had greatly increased growth, the most pronounced effect being seen in the growth of the roots and leaves (see Table 1 & Fig.2).

FIG. 2—*The effect of aerating the nutrient solution on root and shoot growth of young tea plants of clone TRI* 2025—*Left, aerated; Right, non-aerated.*

FIG. 3—*The effect of aerating the nutrient solution on root and shoot growth of young tea plants of clone TRI 2025—Left, aerated; Right, non-aerated—Note the severe defoliation in the non-aerated plants.*

TABLE 1 — *The effect of aeration of the nutrient solution on the fresh and dry weights of leaf, stem, and root, leaf area and leaf number of young tea plants of clone TRI 2025 in water culture*

(Means of 5 plants per treatment)

	Fresh Weights (g)			Dry Weights (g)			Difference between initial and final	
	Leaf	Stem	New Roots	Leaf	Stem	New Roots	Leaf Area (cm^2)	Leaf Number †
Aerated	8.27	5.34	8.22	2.45	1.64	0.630	130.6	3.44 (+8)
Non-Aerated	2.95	3.31	0.01	1.10	1.29	0.002	–23.6	1.34 (—2)
LSD (P=0.05)	2.80	1.90	2.93	0.86	NS	0.21	5.91	0.65

† Analysis of leaf number was done on transformed ($\sqrt{n}$) values. The values within brackets refer to the actual means.

The negative values shown in Table 1 for leaf area and leaf number for the non-aerated plants indicate a net decrease in these two parameters during the course of the experiment. This was because of defoliation. During the entirety of the experimental period the non-aerated plants did not resume vegetative growth and there was virtually no increase in the height of the plants. This is seen clearly in Fig. 1.

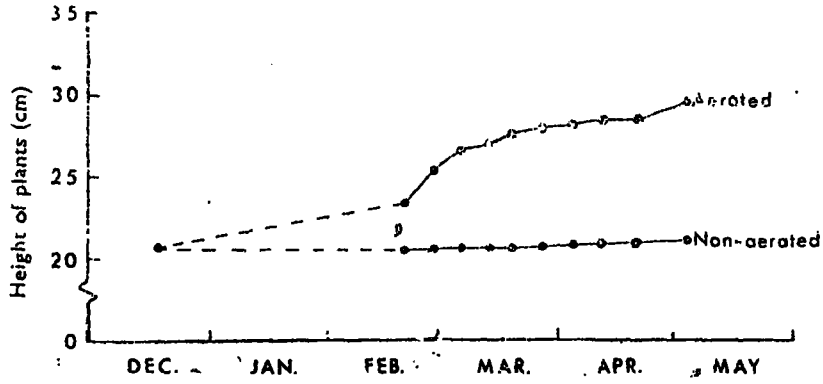

FIG. 1—*The effect of aerating the nutrient solution on the height of young tea plants of clone TRI* 2025

It is to be noted that although aeration increased the fresh weight of the stem, this is not reflected in the dry weight of the stem despite the fact that height of plants was affected.

DISCUSSION

That all plant species require the presence of oxygen in the rooting medium in order to grow and function is well documented (Durrell 1941; Russell 1952). In respect of tea, the importance of an adequately aerated soil has been emphasized by de Silva (1967) and de Silva and Seevaratnam (1968). Mukasa and Kawai (1956) found that a supply of oxygen, obtained by adding 3% H_2O_2, was necessary to prevent root rot in tea in their water culture experiments conducted to demonstrate deficiency symptoms of N,P,K, and Mg. There is, however, no report in the literature where a systematic evaluation of aeration *per se* on the growth of tea has been done, eliminating or minimizing the interfering factors such as the various physical and chemical changes that occur when a soil is flooded to restrict aeration. In the present study, the effect of root aeration *per se* on the growth of young tea is demonstrated. This work provides evidence to confirm the observations made by de Silva (1967) and de Silva and Seevaratnam (1968) in nursery and field-grown plants. The check to growth recorded in the plants in solution that was not aerated may have been due to decreased absorption of water and minerals (Kramer 1940), lack of root-synthesized growth factors (Went 1943; Reid, Crozier & Harvey 1969), production and translocation to the shoot system, of toxic amounts of ethanol and ethylene in the damaged root system (Needham 1969) or due to an alteration in the balance of hormones as a result of the accumulation of auxin in the shoot system (Phillips 1964).

Whatever the causes, it is clear that check to growth results from restricted aeration of the root system. One of the major processes affected shortly after restricting the oxygen supply to roots has been reported to be absorption of water (Kramer 1940) which results in the loss of turgidity of leaves, ultimately leading to desiccation and defoliation. Defoliation was one of the most noticeable symptoms in the non-aerated plants in the present investigation (Fig. 3). This was also reported

in mature tea plants growing in water-logged soils by de Silva (1967) and in nursery plants grown in clayey soil with impeded drainage by de Silva and Seevaratnam (1968). Defoliation in tea, young or old, seedling or vegetatively-propagated, can be ascribed to various causes such as senescence of older leaves due to natural causes, nutritional disorders, incidence of pests and diseases *etc.* However, the evidence presented here shows that one of the causes of defoliation can be a nonfunctional or malfunctioning root system due to restricted root aeration. This evidence obtained with plants in water culture confirm the previous observations on soil-grown plants. It therefore seems well worth ascertaining the causes of such symptoms which are sometimes observed in tea growing in clayey soil on slopes, in terms of soil physical properties such as aeration, compaction, infiltration capacity, permeability of subsoil *etc.*

It could be argued that drainage and therefore aeration, cannot be limiting in soils on slopes. It is not difficult, however, to visualize a situation where, in a clayey soil lacking sufficient organic matter with impeded drainage due to soil compaction there could be temporary waterlogging for a few days during heavy and continuous rainy weather as suggested by de Silva (1967). That such temporary waterlogging can have deleterious effects on plant growth and yield has been reported for other crops (Erickson and Van Doren 1960; Hoveland and Webster 1965; Russell 1971). The remedial measures to be adopted to combat such situations have been discussed by de Silva and Seevaratnam (1968). It has also been reported that different clones may react differently to deficient aeration following submergence of roots (Harade & Mitsui 1957).

Finally, it has to be borne in mind that the results presented here strictly apply to plants grown in water culture, an artificial medium for root growth, and the growth of plants in soil may not, therefore, be identical. The present evidence and previous observations, however, support the need for adequate aeration as an important requirement for the growth of tea roots.

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Accepted for Publication—15th May 1974