STUDIES ON THE MINERAL NUTRITION OF TEA
I—TECHNIQUES FOR GROWING TEA PLANTS IN SAND CULTURE

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Methods which have proved successful for growing tea plants in sand, in pots are described.

Introduction

Relatively intensive inorganic fertilizer applications are a feature of tea cultivation in Ceylon. Experiments in the field form an invaluable basis for determining the optimum quantities and manner of application of fertilizers. An ever present complication in the interpretation of the data from such field trials is the influence of environmental conditions (climatic and soil) on the responses of the plant. Some of these complexities can be reduced by the study of plants grown under conditions which permit some degree of control of these two components of the environment. The study of the nutrition of plants grown under glasshouse conditions in water or sand culture is an acknowledged means of supplementing information from field trials with studies of a more fundamental nature. This forms the main reason for the initiation of studies on the nutritional behaviour of tea plants established in sand as the root medium and with that degree of control of other environmental conditions as is afforded by their maintenance in a glasshouse. A further challenge arises from the fact that few attempts have hitherto been made to study tea plants in soil-less culture. This paper, which forms the first of an intended series, assembles the information gathered and techniques that have proved successful in growing very satisfactory plants for nutritional experiments.

The earliest reported attempt to grow tea plants other than in soil was by Gadd (1928). In a study on the effect of the acidity of the root medium on growth, tea seedlings were maintained in solution culture. The experiment covered a total period of four months. Storey and Leach (1933) in studying sulphur deficiency in tea in Nyasaland grew tea plants in periodically aerated solution culture for six months. Tea plants growing in pots of quartz sand supplied with nutrient solutions were employed by de Haan and Schoorel (1940) and de Haan (1941) in studies on nutrient deficiency symptoms in tea. There have also been several subsequent unreported attempts at this Institute, which have met with varying degrees of success.

Experimental

The plants used in the studies were either young clonal plants grown under conventional nursery procedures, or young seedlings germinated in sand. Open pollinated seed from TRI 2024 and plants of six clones (TRI 2024, 2025, 2027, DT 1, CY 9 and TC 9) have so far been successfully grown. The roots of the plants selected for use were very carefully washed free of soil before planting in the sand.

Cement pots of three different sizes have been used. Prior to use, the pots are steeped in water, dried thoroughly and their insides painted with a bitumen-type paint which was also allowed to dry completely before use. A single centrally placed hole of about one inch in diameter was provided in the base of each pot for free drainage. The inside of each pot was lined with a suitably shaped, medium guage polythene lining also provided with a properly aligned hole in the base. This drainage aperture was covered over with either a piece of 'Saran' plastic mesh or an inverted watchglass, to support the sand in the pot while allowing unimpeded drainage of applied solutions.

White quartz sand of the highest possible purity was employed. Suitable sand has been obtained from the glass factory, Nattandiya, and from a site on Aislaby Estate, Bandarawela. The sand was first sieved and then very thoroughly washed in tap water that had been freed of suspended matter by being filtered through a bed of sand. For the more precise studies, the sand was further treated with large volumes of dinormal hydrochloric acid containing 1% of oxalic acid and then washed with demineralized water until the washings are completely free of detectable chloride.

All water used in the preparation of nutrient solution was 'demineralized' by passage through a portable 'Deminrolit', Mark 6A, ion exchange unit of a mixed bed type. All salts used in the preparation of nutrient solutions were of "analytical reagent" grade or similar purity.

The plants were grown in a glasshouse (24 ft x 20 ft) with concrete walls to a height of 4 ft, with the rest of the wall up to roof level consisting of an expanded metal open mesh on three sides and adjustable glass louvres on the fourth. The roof was of glass sheets lime-washed periodically to let in a light intensity of about 40-50% of full sunlight.

After transplanting, the pots were either stood on bricks or arranged on a 'Dexion' stand to facilitate free drainage. Semicircular wood covers with a notch for the base of the stem were placed on top of the pots to reduce water losses by direct evaporation and to prevent the growth of algae on the surface of the sand.

General observations

It is proposed to present the main conclusions that are possible from our experience since these studies began three and a half years ago and to suggest what appear to be the optimal techniques for producing healthy tea plants in sand culture, under controlled conditions of nutrient supply.

Figure 1 is of two seedlings from open-pollinated clone TRI 2024 growing in a mixed coarse grade of sand. The plants are thirteen months old from the date of planting of the seed (ten months from transplanting). Figure 2 is a close-up view of the base of the stem and root system of a plant of clone CY 9, at twenty one months from the date of planting the cutting (fourteen months from transplanting).

Size of container

The choice of container size is influenced by the type of experiment and the duration for which it is intended to maintain the experimental plants. However, it has been observed in our work that establishment of smaller plants is more readily accomplished in smaller pots. When employing larger pots we have on occasion, employed a finer grade of sand to surround the root system of small plants. With appropriate precautions, plants have been successfully grown in tapered cement pots of the three sizes given below and in 2-litre ploythene beakers.

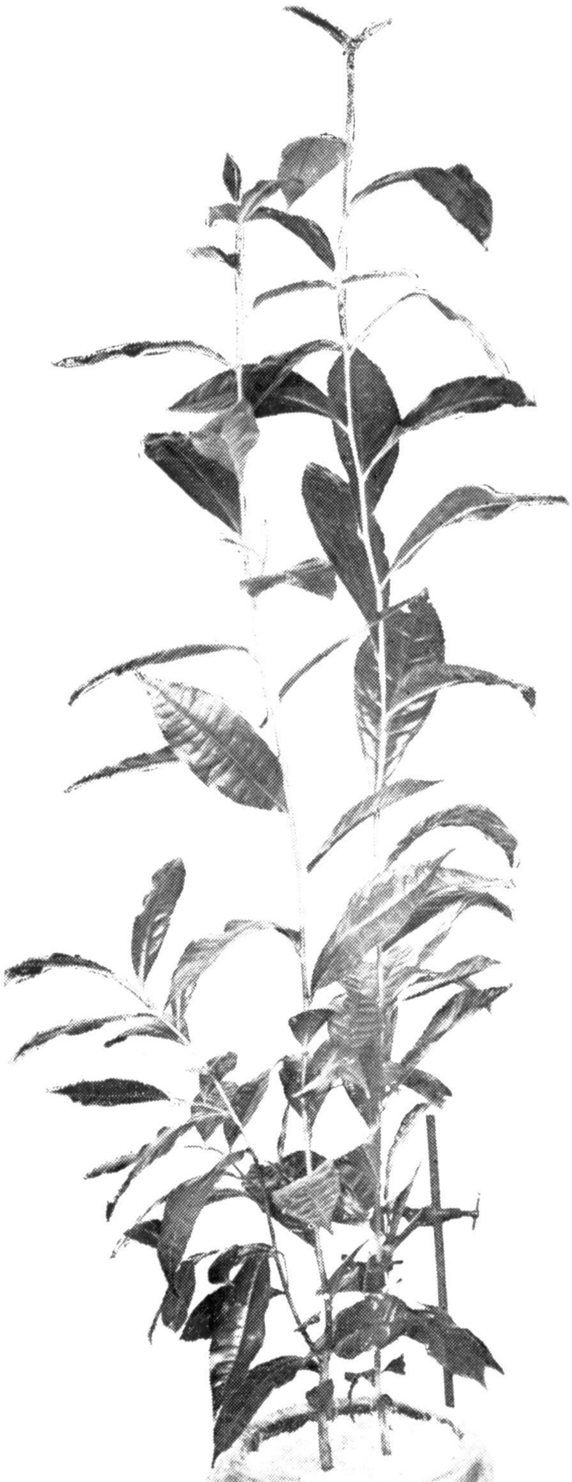

FIGURE 1 — *Thirteen month old seedlings of open-pollinated TRI 2024. Seeds germinated March 1968. Transplanted July 1968. Photographed May 1969.*

FIGURE 2 — *View of base of stem and roots of a twenty one-month-old plant of clone CY 9. Cuttings planted January 1966. Transplanted August 1966. Photographed October 1967.*

	Size		
	I	II	III
Inner diameter at rim (in.)	9	9	5
Inner diameter at base (in.)	6	5.5	3.5
Height (in.)	11	7.5	4.5

Texture of the sand used

It was quite evident from our earliest efforts that adequate drainage and the avoidance of over-wet conditions were very important for the satisfactory growth of tea plants. In addition to the arrangements already mentioned for ensuring free escape of excess water, a relatively coarse grade of sand was found to be necessary. While in the earlier experiments, sand with particle diameters within the range 0.5-1.0 mm was employed, the best performance so far has been obtained with a mixture covering a greater range of particle size and having the following mechanical analysis :

Diameter less than 2 mm	46% by weight
Diameter less than 2-3 mm	25% by weight
Diameter less than 3-4 mm	14% by weight
Diameter more than 4 mm	15% by weight

The plants in Figure 1 were grown in a medium of the above composition.

Establishment of plants

Cuttings ranging in age from 4-12 months from date of striking, and with root systems ranging from a few roots to well established clusters have been employed. Six-to nine-month-old cuttings appear to be optimal. Such cuttings are often in a state of hard banji and show less of the wilting normally encountered on sunny days in the first few weeks following transplanting. Their dormant state also perhaps enables them to suffer less of a growth setback from "transplantation shock".

In transplanting it is most convenient to arrange the root system around a low "mound" in the centre of a pot filled with sand up to about three inches from the top. More sand is then sprinkled over the extended roots until they are completely covered and the sand reaches up to the base of the mother leaf of the cutting. The sand is immediately watered freely to aid consolidation.

A coir matting shade at a height of about 6 ft within the glasshouse is necessary if very sunny weather follows transplanting. The matting is kept moist and the floor wet, to cool the glasshouse.

During the first week or two, the plants receive only demineralized water applied at a frequency and volume to ensure relatively moist conditions during the early stages of establishment.

Composition, strength and pH of nutrient solution

The nutrient solution supplied to the plants was based on the Long Ashton formula (Hewitt 1963). This was further modified to provide two-thirds of the requirements of nitrogen in the nitrate form and the remaining third as ammonium. The potassium requirement was met in the form of potassium sulphate. Aluminium sulphate was additionally included. All solutions were stored as concentrated stock solutions for batchwise dilution as required (Table 1).

TABLE 1 — *Composition of stock solutions and the required dilutions before use*

Salt	Stock solution (g/l)	Required dilution (times)
$(NH_4)_2SO_4$	165.0	1000
K_2SO_4	87.0	400
$Ca(NO_3)_2 . 4H_2O$	590.0	1000
$NaH_2PO_4 . 2H_2O$	208.0	2000
$MgSO_4 . 7H_2O$	185.0	1000
Ferric citrate ($5H_2O$)	16.80	1000
$Al_2(SO_4)_3 . 16H_2O$	11.66	2000
*Micronutrient solution		
$MnSO_4$	2.23	2000
$CuSO_4 . 5H_2O$	0.240	
$ZnSO_4 . 7H_2O$	0.296	
H_3BO_3	1.860	
$(NH_4)_6Mo_7O_{24} . 4H_2O$	0.035	
$CoSO_4 . 7H_2O$	0.028	
NaCl	5.85	

*The appropriate amount of each salt is weighed and the mixture made up to 1 litre of a combined stock solution.

When appropriately diluted in accordance with the above table, the quantities of essential elements supplied to the plants are given in Table 2.

TABLE 2 — *Levels of supply in the nutrient solution of the elements essential for plant growth. All figures are in parts per million*

Nitrogen 105	Phosphorus 21	Potassium 98	Calcium 100
Magnesium 36	Sulphur 129	Iron 2.8	Aluminium 0.5
Manganese 0.28	Copper 0.032	Zinc 0.033	Boron 0.185
Molybdenum 0.0095	Cobalt 0.003	Sodium 16.7	Chlorine 1.78

The figures in the two foregoing tables refer to nutrient solutions when applied at half the normally recommended dilutions (Hewitt 1963). It was, however, found that tea plants, particularly in the early stages after transplanting, were intolerant of salts even at these strengths.

Once the plants are established after transplanting, they are supplied with the above solution at half strength. This is changed to full strength (*ie* half of the normally recommended amounts) when the plants have attained vigorous growth. Growth is quite adequate at this supply of nutrients and it is generally not necessary to change to a nutrient supply at the full recommended strength.

All dilutions are with demineralized water. The diluted solutions are adjusted to pH 3.5 (by adding 7 ml of 2N sulphuric acid per 20 litres of solution) before application to the plants.

The larger sized pots generally receive 500 ml of nutrient solution daily and the smaller pots, 100 ml. These volumes are sufficient to cause a fair amount of percolation through the sand when applied uniformly over the sand surface.

The sand is leached free of any accumulated salts by being washed through once a week with approximately three times the daily applied volume of demineralized water.

Pests and disease control

The use of chemicals in the control of the occasional outbreaks of insect and mite attacks is minimised. Reasonably effective control of pests is possible by rubbing over the leaves occasionally with a pad of moist cotton wool. Where pest infestations become too heavy to cope with in this manner, the recommended chemicals for control are used with extreme caution. The requirements of special experiments may often preclude the use of certain compounds. For example, plants in sulphur-deficiency studies could not receive sulphur dust or sulphur-containing acaricides.

No outbreaks of diseases have yet been encountered in the glasshouse experiments.

Conclusions

By following the procedures outlined above, tea plants have been very successfully cultivated in sand culture.

The growth obtained under the conditions of these experiments has been very much superior to the growth obtained in a nursery over an equivalent period. This suggests that the use of more complete nutrient solutions as nursery fertilizers may be useful in achieving faster growth. The better drainage conditions obtained may also be a contributory factor.

Acknowledgements

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