

STUDIES ON THE PHYSIOLOGY OF PRUNING TEA

2—THE EFFECT OF SOIL CULTIVATION AND RESTING ON RECOVERY AFTER PRUNING

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The effect of soil cultivation and 'resting' on the level of reserve assimilates in the roots, and recovery after pruning was investigated in two tea clones. In clone TRI 2024 stem thickening and root reserves were greater in the rested plants, but to a lesser extent in those where the soil was cultivated before resting. Clone TRI 2025 did not respond similarly. Resting, with or without soil cultivation, resulted in better recovery after pruning in both clones. In clone TRI 2024 resting without soil cultivation accentuated the depletion of root reserves during recovery, possibly due to increased consumption in root respiration. It is inferred that this practice can be detrimental to recovery under conditions of limited root reserves. The feeder roots damaged during forking appear to be replaced only in the presence of sufficient foliage. It is suggested that forking should be done when the plant has sufficient foliage, and if done after pruning, it should be deployed at least until tipping time.

Soil cultivation (by forking) is a common cultural operation in tea plantations and is intended to improve the root environment of the tea plant. Although forking is primarily intended to improve soil tilth by improving root aeration and facilitating better seepage of water and nutrients (Eden 1939; 1941; 1949; Portsmouth 1955) it is also associated with some damage to the root system, especially the feeder root component (Paterson 1950). In the previous paper of this series (Kandiah 1971) the importance of feeder root respiration as a sink for root reserves during recovery from pruning was indicated. Resting of tea plants prior to pruning by suspending the harvesting of new shoots (flush) increases the foliage, and forking reduces the respiratory sink in feeder roots. A combination of these two could be expected to markedly increase root resources. Further, root resources lost in root respiration following pruning should be less if feeder roots are reduced by damage resulting from forking immediately after pruning rather than two weeks later. These in turn will affect recovery after pruning. This paper reports studies on the effect of forking at critical periods prior to, or after pruning, on the level of root resources and the rate of recovery of the plant after pruning.

MATERIALS AND METHODS

Plants of two clones—TRI 2024 and TRI 2025 at St Coombs (1500 m amsl) were used. There were five replicates of five treatments in randomized blocks.

1—Forking was done and the plants were then rested for three months prior to clean pruning when all leaf-bearing branches were removed (FRP).

2—The plants were rested for three months prior to clean pruning (RP), and no forking was done.

- 3—The plants were plucked until pruning and forking was done immediately after pruning (PF).
- 4—Same as treatment 3 but forking was done two weeks after pruning (PF₂).
- 5—The plants were plucked until pruning. No forking was done—Control (P).

Treatment 3 was only done on Clone TRI 2024. These treatments will be referred to by the respective code letters.

The effect of resting on shoot growth was estimated by assessing fresh leaf weight and pruned stem weight at the time of pruning. Recovery was assessed by periodical bud counts and also by observations of shoot number and weight at tipping (cutting back of new shoots to form an uniform plucking surface six months after pruning). Reserves were estimated at the time of pruning and 11 weeks after pruning in both clones. In Clone TRI 2024 an estimate of reserves was also made just before tipping. On each occasion five bushes were sampled per treatment.

Analysis of reserves

The method of sampling and estimating resources has been described in the previous paper (Kandiah 1971). The main steps in the extraction procedure remain the same except for the following modification in the extraction of the water fraction in step 2. It was found that solubilization of starch was more efficient with 2% HCl in 80% aqueous methanol. Further, extraction of starch with water in Soxhlet extractors was found to be incomplete; direct boiling of the samples with water gave better results. After solubilization of starch the sample bags were, therefore, transferred to a beaker and repeatedly boiled with water until washings gave a negative reaction for starch test with iodine.

Periodate oxidizable compounds in the methanol, water and sulphuric acid fractions were estimated in terms of sugar by the method of Priestly (1962). The values expressed as percentage of the material extracted by the respective solvents was termed the 'sugar value' of each fraction. The water fraction of the wood tissues gave the maximum sugar value followed by the sulphuric acid fraction. The sugar value of the water fraction was 95-100% and that of the sulphuric acid fraction 50-70%. The methanol fraction had the least sugar value when the periodate estimate was made of sugars separated from this fraction by paper chromatography.

It was evident from these results that the quantitative estimation of resources by this method includes varying proportions of compounds other than carbohydrates, especially in the bark tissues. In this study although stem and root tissues were analysed, only the results of root wood tissues are presented, because this region contains more resources whose carbohydrate component is high, and should, therefore, be a suitable region to reflect the reserve status of the plant at any time.

RESULTS

Shoot growth during resting

Bushes of FRP and RP were rested for a period of three months from August, prior to pruning in November 1971. At the time of pruning, pruned wood and foliage were estimated in ten (two per block) randomly-selected bushes from each of the rested and plucked treatments. The values are given in Table 1.

TABLE 1 — *Fresh weight (Kg) of leaves and pruned stems per plant at pruning*

Treatment	Clone	Total leaves		Pruned stem	
		2024	2025	2024	2025
FRP		1.36	1.50	3.86	3.49
RP		1.59	1.45	4.76	3.04
PF, PF ₂ & P		0.86	0.77	2.95	2.90
LSD (<i>P</i> = 0.05)		0.41	0.36	1.18	1.27

It was observed that resting the bushes for three months resulted in an increase of more than 60% of leaves. New growth formed during resting did not vary between FRP and RP, nor between clones. The increase in weight of the pruned stem in the rested plants of Clone TRI 2024 indicated that secondary growth of stem was greater than in the plucked plants. Forking before resting suppressed this trend. The effect of resting for three months, on stem thickening in Clone TRI 2025 was negligible.

Recovery after pruning

(a) Utilization of resources.

The distribution of root resources at pruning and their subsequent depletion during the first 11 weeks after pruning is given in Fig. 1.

In Clone TRI 2024 resting resulted in an increase in root resources, but contrary to expectations, forking before resting reduced their accumulation. The increase in resources is reflected only in the water and sulphuric acid fractions *ie* the polysaccharides. Root resources in Clone TRI 2025 were not affected by this treatment.

The drain on root reserves during the period of active bud growth, estimated by a sample taken 11 weeks after pruning is shown by open areas in Fig. 1. The following observations were made :

- 1—Percentage depletion from the initial level is greater in Clone TRI 2025.
- 2—In both clones depletion is greatest in the water and sulphuric acid fractions—*ie* the polysaccharides.
- 3—Resting before pruning in RP accentuated the depletion of resources during recovery, but this is less evident in Clone TRI 2025.
- 4—Forking before resting (FRP) in Clone TRI 2024, reduced the extent of depletion that follows pruning.
- 5—Forking immediately after pruning (PF) minimized the depletion of root reserves.

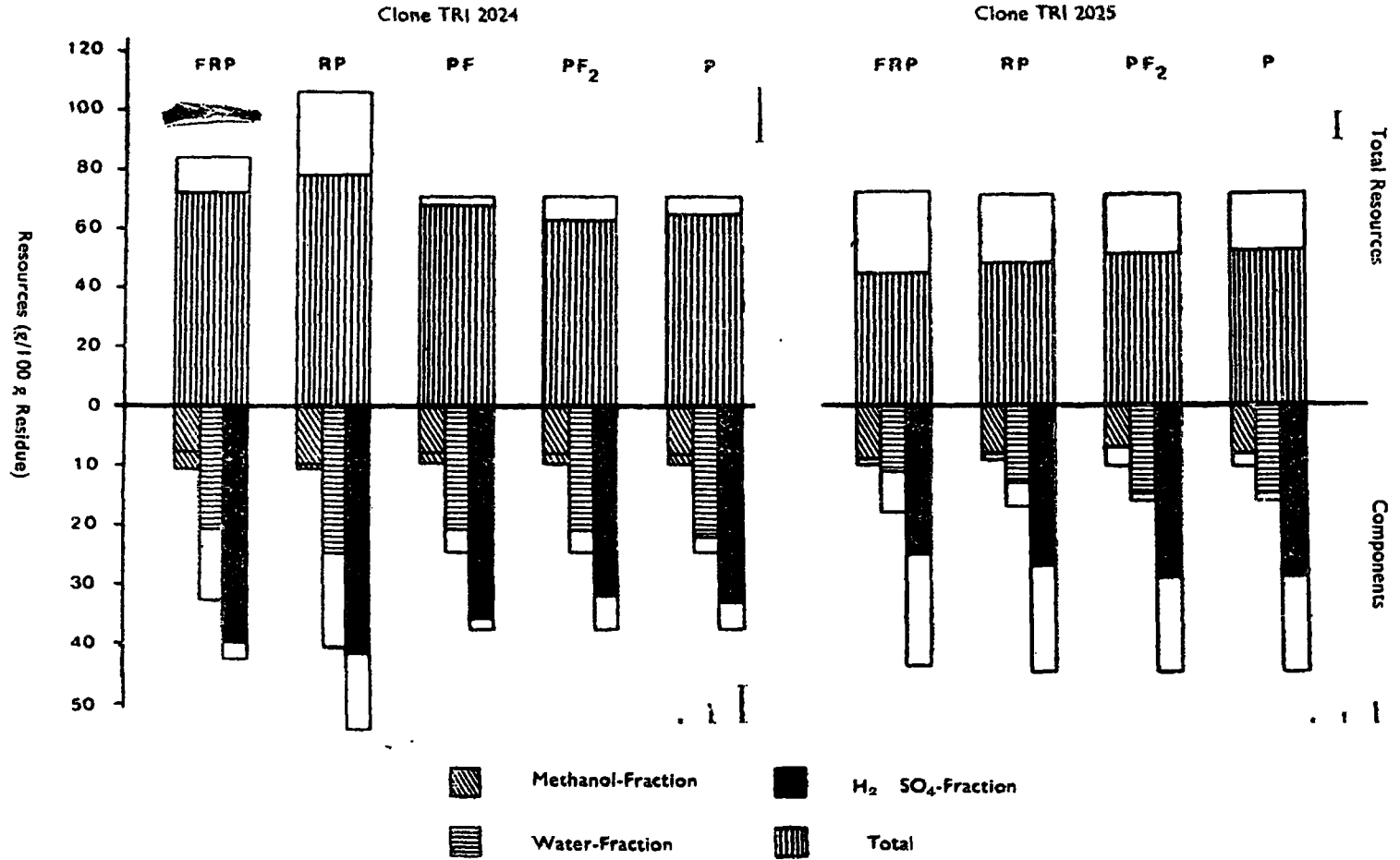


FIG. 1.—Distribution of root wood resources at pruning in clones TRI 2024 and TRI 2025. The drain on resources during the first 11 weeks after pruning is shown by open areas, and increase is marked off by a line. Bars refer to Standard error.

The distribution of root wood resources in Clone TRI 2024, six months after pruning is shown in Table 2.

TABLE 2 — *Distribution of root wood resources six months after pruning in Clone TRI 2024*

Treatments	Resources (g/100 g residue)—			
	Replenishment, expressed as a percentage of the value at pruning, is given in parenthesis			Total
	Component Fractions			
	Methanol	Water	H ₂ SO ₄	
1—FRP	12 (150)	13 (39)	42 (98)	68 (80)
2—RP	12 (125)	7 (17)	18 (33)	37 (35)
3—PF	13 (163)	10 (40)	35 (92)	58 (82)
4—PF ₂	12 (150)	12 (48)	40 (92)	64 (90)
5—P	12 (150)	12 (48)	39 (102)	63 (89)
LSD (<i>P</i> — 0.05)	2	4	15	19

It is evident from Table 2 that replenishment of root resources was not complete in any treatment even after six months of recovery from pruning. The water fraction (starch) was found to be the most affected, while the methanol fraction has gained, indicating interconversion of polysaccharides to the soluble components in the methanol fraction. A notable feature was that, replenishment of total resources is above 80% in all treatments except in RP, where it is only 35%—the water and sulphuric acid fractions being only 17% and 33% respectively, of the values at pruning.

(b) Bud growth during recovery

Recovery after pruning was assessed by counting buds during the early stages of recovery, and later at the time of tipping, the number of tipped shoots and their weight was determined. Fifteen (3 per block) randomly-selected plants per treatment were used for this assessment. The results are presented in Fig. 2.

Recovery was found to be markedly better in the rested treatments RP and FRP. Comparing FRP and RP in Clone TRI 2024, forking before resting appears to favour recovery, because recovery as indicated by both bud number and tipped shoot number and weight was best in FRP. Forking immediately after pruning (PF) in Clone TRI 2024, or two weeks later (PF₂) in both clones, did not enhance recovery.

It was found that bud break after pruning is a prolonged activity starting around the fourth week and continuing up to 11 weeks or more. Only about 20-30% of the total number of buds that break attain the size of tipping shoots. Shoot growth during recovery, as reflected by the number of buds that break on the frame and the tipping shoots produced, is markedly greater in Clone TRI 2025 compared to Clone TRI 2024.

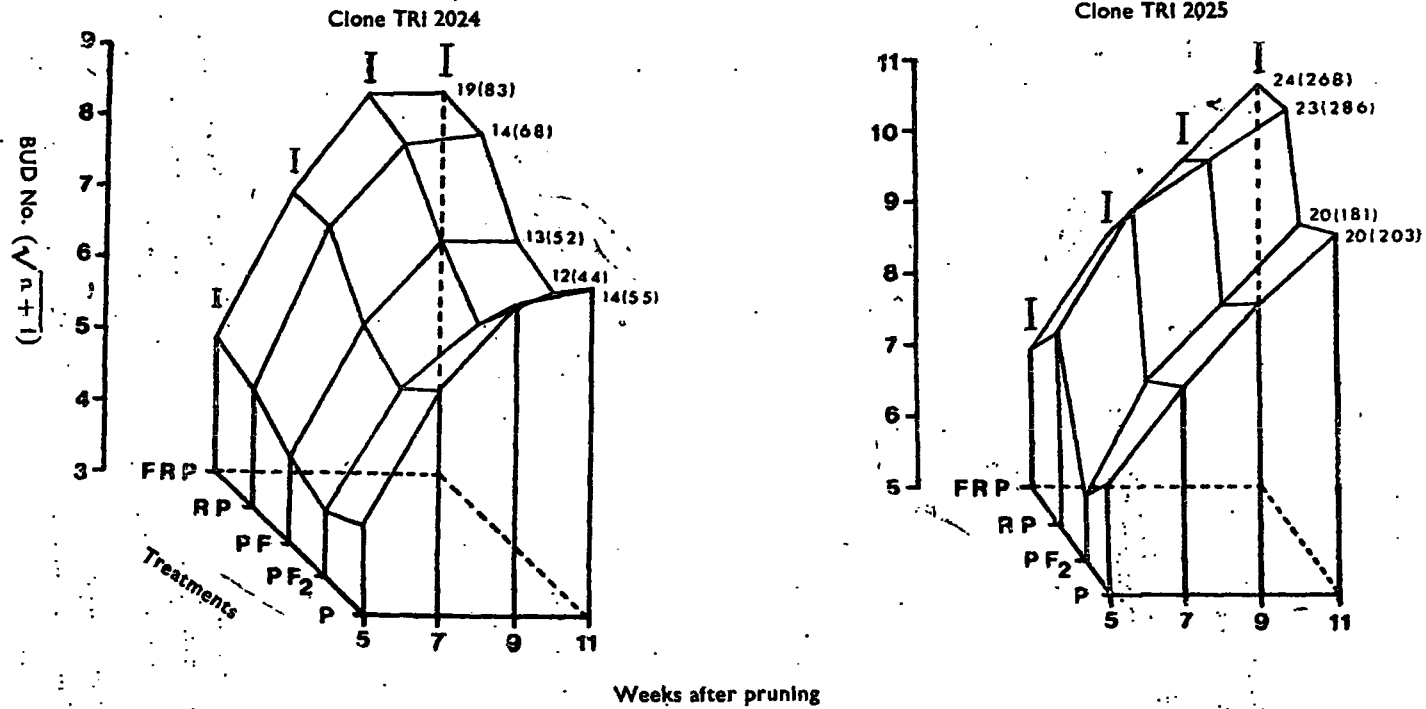


FIG. 2—Progressive increase in bud number transformed to $(\sqrt{n+1})$ at 5, 7, 9, and 11 weeks from pruning in clones TRI 2024 and TRI 2025. The number of shoots tipped and their weight (g in parenthesis) is given alongside the curve for 11 weeks. Bars refer to Standard error.

DISCUSSION

Resting resulted in enhancement of root resources only in Clone TRI 2024. As feeder roots, which are sites of high respiratory activity, were reduced at forking in FRP, it was expected that accumulation of resources during resting in FRP will be more than in RP. On the contrary RP had more resources than FRP. It is possible that forking leads to new feeder root formation which utilizes some of the resources which would otherwise be available as reserves.

In PF, where forking was done immediately after pruning, it was found that the drain on root reserves was least (Fig. 1). Unfortunately this treatment was not tested in Clone TRI 2025. The minimum drain on root reserves in this treatment suggests an effect of reduction of feeder roots at forking without feeder root renewal as has occurred in FRP. It appears that feeder roots are formed only at the expense of current assimilates supplied by the leaves, and not at the expense of stored reserve assimilates that are available soon after pruning. There would, therefore, be replacement of damaged feeder roots in FRP where excess assimilates are supplied by the leaves above, and not in PF, where all leaves have been removed at pruning. Alternatively the process of feeder root initiation may require some stimulus originating in leaves.

Although an increase in quantity of foliage during resting was observed in both clones, percentage resources in roots had increased only in Clone TRI 2024. Assuming that photosynthetic efficiency of the leaves of the two clones do not vary markedly, this would mean that either the proportion of assimilates diverted to the root system during resting is different or that the manner of utilization of such resources varied between clones. If the proportion diverted to the root system had been less in Clone TRI 2025 then more would have been available for new shoot growth during resting, but the weight of new shoots assessed at pruning was found to be comparable in the two clones. Shoot development may also be more demanding on resources in Clone TRI 2025 than in Clone TRI 2024. It is further possible that the manner of utilization of the excess resources reaching the mature regions below differed in these clones. In the rested plants of Clone TRI 2024 the resources reaching the mature region below appears to be utilized in secondary growth of stem, percentage resources being unaffected, and in the root, a part of it may be utilized for new growth and a part stored as reserves in the mature roots. In Clone TRI 2025 it is possible that most of this excess is utilized in new root growth.

Although root growth was not assessed in this study, it has been observed that when excess assimilates reach the root system there is new root growth (Priestly 1964; Hansen 1967). It could, therefore, be expected that tea rested before pruning would have more feeder roots than tea continuously plucked. If root respiration is a major drain on root resources, the depletion following pruning should be greater in the rested bushes. This was found to be the case (see Fig. 1).

In both clones depletion of resources, particularly of starch (water fraction) is greater in the rested treatment than in the control. The difference is not as marked in Clone TRI 2025 as in Clone TRI 2024. Further in Clone TRI 2024, where root resources were estimated six months after pruning there was a marked depletion of resources in RP (Table 2). It was assumed that after six months of uninterrupted

shoot growth following pruning, the replenishment of root resources would be complete. A clonal difference in this was not expected, and therefore observations were made only on clone TRI 2024. The results are presented in Table 2. Such accentuated depletion was not evident in FRP, where the plants would have lost some of their feeder roots at forking and the quantity of feeder roots at pruning would have been less than in RP.

It appears that the alteration of the quantity of feeder roots by the treatment has affected root resources less markedly in Clone TRI 2025 than in Clone TRI 2024. Perhaps in Clone TRI 2025 the feeder roots may be capable of maintaining themselves for a longer period following pruning before drawing on reserves in mature roots. The greater depletion of initial resources in all treatments in Clone TRI 2025 may be related to more intense utilization in bud growth—bud number was about 75% more compared with Clone TRI 2024. These characteristics of Clone TRI 2025 should bring about lesser pruning hazards compared with Clone TRI 2024.

As resting could condition the plant for accentuated depletion of root reserves after pruning, by increasing the quantity of feeder roots, the merits of this practice should be re-examined. Although rested bushes have performed well during recovery under the conditions in this study, the response could well be different in situations where root reserves are limiting, such as in tea growing at lower elevations. Recovery after pruning will be satisfactory only when sufficient resources are available in the root system to maintain it viable until assimilates are provided by the new shoots. An extensive root system at pruning may not necessarily favour recovery if resources are limiting, especially in clones like TRI 2024. In this respect forking rested tea before pruning or immediately after pruning may seem desirable. In the low country Fernando (1965) had found that yield from rested tea was significantly lower during the first nine months of the new cycle. Even in higher elevations, a prolonged period of rest (six months) has been found to reduce the number of buds growing after pruning (Pethiyagoda 1965).

Evidence has been presented above to show that root resources are affected by soil cultivation. Forking immediately after pruning in Clone TRI 2024 helped conserve root resources during recovery (Fig. 1; PF) but this did not enhance recovery (Fig. 2). As efficient uptake of nutrients depends on the presence of well-developed feeder roots, forking will lead to temporary slackening of this efficiency, which will be rectified only when feeder roots damaged during forking are replaced by new root growth. When tea fields are forked immediately after pruning there will be a long time lapse before replacement of damaged roots takes place because new root growth seems to take place only at the expense of current assimilates for which there is strong demand during the recovery of pruned tea. The observation that replenishment of root resources is not complete even as late as six months after pruning (Table 2) indicates this. Fordham (1972) observed that root growth ceased for about three months following pruning of tea. If forking is done after pruning in tea that is not rested, it is, therefore, better to delay it till the demand on assimilates is less *ie* until tipping or later. Forking tea in plucking besides causing minimal retardation of growth would result in less soil erosion than would occur when plucking tables are not fully developed.

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REFERENCES

- EDEN, T. (1939). *Tea Quarterly* 12, 24-37.
EDEN, T. (1941). *Tea Quarterly* 14, 47-60.
EDEN, T. (1949). *Tea Quarterly* 20, 18-24.
FERNANDO, L. H. (1965). *Annual Report of the Tea Research Institute of Ceylon* (1964). 2, 52.
FORDHAM, R. C. (1972). *Journal of Horticultural Science* 47, 221-229.
HANSEN, P. (1967). *Physiologia Plantarum* 20, 1103-1110.
KANDIAH, S. (1971). *Tea Quarterly* 42, 89-100.
PATERSON, H. C. (1950). *Tea Quarterly* 21, 23-27.
PETHIYAGODA, U. (1964). *Annual Report of the Tea Research Institute of Ceylon* (1963). 2, 44-53.
PORTSMOUTH, G. B. (1956). *Tea Quarterly* 27, 67-69.
PRIESTLY, C. A. (1962). *Commonwealth Bureau of Horticulture and Plantation Crops, Technical Communication* 27, 116 pp.
PRIESTLY, C. A. (1964) *Annual Report of the East Malling Research Station* 1963, 104-106.

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