CHAPTER 3
PLANT PROPAGATION

3. Plant Propagation

3.1 Introduction

Nursery management techniques and methods of vegetatively propagating tea are important for the production of adequate and high quality plants required for planting or infilling. The aims of the plant propagation programmes are to develop improved techniques for the vegetative production of tea and fuel wood species. During the 1997 – 2001 period under review, there were several developments in this field of study and these are summarized below.

Routine activities in all nursery trials were done following TRF recommended practices with respect to type of planting material, propagation method, watering, hardening-off, fertilizer application and grading of plants except where such practices were experimental treatments.

3.2 Rooting and Growing Medium for Nursery Plants

The problem of finding good sub soil or topsoil at some estates prompted investigations into alternative rooting and growing media for un-rooted and rooted tea cuttings, respectively. Trials were conducted in 1998 on a wide range of materials. The new materials were tested both as pure media and mixtures with sub soil or top soil.

3.2.1 Rooting Media for Tea Cuttings

Alternative rooting media tested, either as pure or mixtures with sub-soil (1:1) are shown in Table 3.1. All materials were subjected to a pH test before the cuttings were planted.

The results showed that survival of the cuttings in the media where sub-soil was mixed with vermiculite or sand compared very well with pure sub-soil in terms of rooting and plant growth (Table 3.1). Mixtures of sub soil with decomposed tea waste or sub-soil with fresh sawdust also performed relatively well. Pure tea waste or sawdust attracted termites, which eventually resulted in collapsing of the pots.

It was therefore concluded that where good sub soil is scarce, vermiculite or river sand could be mixed with sub soil and used as rooting media for tea cuttings.

Table 3.1 Percentage rooting and initial growth of cuttings rooted in various rooting media

Medium	pH ($CaCl_2$)	Rooting (%)	Plant height (cm)
Vermiculite	8.5	29	8.6
Decomposed sawdust	5.0	0	-
Fresh sawdust	4.8	15	7.3
Vermiculite + decomposed tea waste	7.3	13	7.1
Decomposed tea waste + sand	6.1	33	7.0
Sub-soil + decomposed tea waste	6.1	52	8.7
Fresh coffee husk + sub-soil	4.8	35	5.8
Decomposed coffee husk + sand	5.3	13	3.1
Fresh coffee husk + sand	5.2	5	2.2
Decomposed coffee husk + sub-soil	5.0	33	5.2
Decomposed sawdust + Vermiculite	5.5	15	11.1
Vermiculite + sub-soil	5.0	83	22.4
Fresh + decomposed sawdust	4.8	8	10.3
Fresh sawdust + vermiculite	6.2	20	7.6
Fresh sawdust + sub-soil	4.5	53	12.7
Decomposed sawdust + sub-soil	4.8	41	11.1
Decomposed sawdust + sand	5.1	10	14.0
Sub-soil	4.2	86	22.6
Sub-soil + sand	4.5	90	23.5

3.2.2 Growing Media for Rooted Tea Cuttings

Rooted tea plants require a highly fertile topsoil of a sandy-loam texture for good growth. Good top soil is increasingly becoming scarce on or around some estates. In order to identify alternative growing medium for rooted tea plants a number of materials were tested (Table 3.2).

The results showed rooted plants or cuttings grown in the mixtures of fully decomposed tea waste or coffee pulp with top soil or sand in the ratios of 1:1, 2:1 and 3:1 promoted plant growth and dry matter production similar to top soil (Table 3.2). Use of pure decomposed coffee pulp greatly inhibited root and shoot system development.

From these results it was concluded that where it is difficult to find good top soil, the mixtures of decomposed tea waste or coffee with top soil in the ratios shown above could be very good alternative growing media for rooted tea plants or cuttings.

Table 3.2 The effects of growing medium on the plant height, stem thickness, number of branches per plant, and shoot and root dry weight of rooted tea cuttings transplanted into the various media

Medium	**Plant height (cm)**	**Stem thickness (mm)**	**No. of branches**	**Shoot dry wt. (g)**	**Root dry wt. (g)**
Decomposed coffee pulp (DCP)	28.9	3.5	3.0	2.8	1.4
Decomposed tea waste (DTW)	36.6	4.1	3.6	7.1	4.1
Decomposed coffee parchment (DC Parchment)	29.4	3.3	2.6	5.7	2.7
Top soil (control) (TS)	26.2	3.2	2.2	8.4	5.5
DCP + TS (1:1)	36.3	4.0	4.0	10.1	3.8
DTW +TS (1:1)	36.3	3.8	3.6	10.2	4.9
DC Parchment + TS (1:1)	29.0	3.3	3.0	7.4	3.1
DCP + sand (1:1)	36.5	3.8	4.4	8.6	4.1
DCP + sand (1:1)	36.8	3.9	4.0	9.2	3.7
DC Parchment + sand (1:1)	30.1	3.2	3.4	9.5	3.6
DCP + DTW(1:1)	35.5	3.7	4.2	4.3	2.4
DCP + DC Parchment (1:1)	34.6	3.8	4.0	5.3	2.4
DTW + DC Parchment (1:1)	35.7	3.7	3.8	7.6	3.4
DCP + TS (2:1)	31.4	3.5	4.0	8.0	3.4
DTW +TS (2:1)	35.2	4.0	5.2	10.0	5.1
DC Parchment + top soil (2:1)	29.7	3.3	3.2	6.7	2.7
DCP + sand (2:1)	34.3	3.9	4.0	7.7	3.2
DTW + sand (2:1)	37.2	3.8	3.8	9.2	4.0
DC Parchment + sand (2:1)	33.9	3.4	3.2	8.4	3.5
DCP + TS (3:1)	35.2	3.8	4.4	8.2	3.2
DTW+ TS (3:1)	37.2	3.5	4.0	9.3	4.4
DC Parchment + top soil (3:1)	30.1	3.5	2.8	8.2	3.6
DCP+ sand (3:1)	32.9	3.6	3.8	10.2	3.7
DTW + sand (3:1)	38.1	3.9	4.0	12.8	5.2
DC Parchment + Sand (3{1)	30.7	3.2	3.0	6.7	3.3

3.3 Nursery Manipulation

Nursery manipulation is a term that is used to collectively describe such nursery practices as pruning, nipping and tipping of nursery material. The practices in general result in an improvement in lateral branch development particularly for cultivars with an erect growth habit. However, this improvement is achieved at the expense of root development – plants that have been pruned or nipped tend to have retarded root systems, often significantly affecting subsequent field survival.

During the period under review, a trial was therefore conducted at MRS to determine the field performance of PC 108 (a spreading clone) and SFS 150 (an erect clone) plants that had received different nursery treatments. Results from this trial are shown in (Table 3.22).

Table 3.3 Made tea yield (kg ha^{-1}) and root dry mass (g plant^{-1}) for 18 months-old plants) of clones PC 108 and SFS 150 following different nursery treatments at MRS.

Plant size	Made tea yield								Root dry mass	
	PC 108				SFS 150					
Nursery treatment	97/98	98/99	99/00	Total	97/98	98/99	99/00	Total	PC 108	SFS 150
Large										
-untouched	1280	1554	1475	4309	496	1359	1608	3463	27.1	30.9
-prune/prune	1310	1261	1423	3994	597	1472	1633	3702	23.0	20.0
-prune/nip	1310	1300	1401	4011	592	1436	1411	3439	18.1	16.0
Medium										
-untouched	1335	1500	1246	4081	575	1362	1557	3494	27.3	21.6
-prune	1372	1058	1455	3848	585	1433	1549	3567	15.3	19.5
-nip regularly	1285	1261	1039	3585	585	1458	1680	3723	18.0	15.9
Small										
-untouched	1280	1635	1593	4508	607	1216	1418	3241	17.8	19.4
-prune	1253	1537	1586	4376	582	1389	1450	3421	16.4	13.5
-nip regularly	1199	1335	1526	4060	516	1298	1441	3255	16.7	16.5

Pruning and/or nipping in the nursery reduced root development because the untouched plants of PC 108 and SFS 150, respectively, produced up to 44% and 48% more root dry mass than the pruned or nipped plants (Table 3.3). Over three seasons, pruned and nipped SFS 150 plants yielded higher than the untouched plants. However, untouched PC 108 plants yielded marginally higher than the pruned or nipped plants. It was also noted that the pruned/nipped PC 108 plants showed very poor field survival. The results showed that nursery manipulation may result in some yield benefits for erect cultivars such as SFS 150, but not for those that spread naturally e.g. PC 108.

3.4 Tea Propagation Using Plucking Shoots

Conventional methods of tea vegetative propagation require leaving the source bushes un-plucked in the main growing season. The propagation season is also confined to the period when the source bushes are in their vegetative growth phase, which limits the number of plants that can be produced in one season. Where large-scale planting/replanting is to be undertaken, there is a need for the production of large numbers of VP plants within the propagation season.

The rooting potential of immature (apical shoots) and over-mature (brown stem) cuttings was compared to the rooting potential of green stem cuttings (Nyirenda, 1995) in order to assess their potential in increasing number of propagated plants from a unit area of source bushes. It was shown that apical shoots had good potential for use as propagation material.

Work was therefore initiated in 1995 to assess the use of plucking shoots as propagation material, in order to establish the most appropriate propagation method and the optimum shoot size to be used.

3.4.1 Appropriate Propagation Method for Plucking Shoots

A nursery trial was planted using

plucking shoots of three clones, comprising three leaves with or without the apical bud, some of the plants were under misting and the other the polythene tunnel.

The results (Table 3.4), show that survival and rooting were generally better under polythene tunnels than under misting, as it was easier to maintain high humid conditions in the tunnels (Table 3.4). It was also noted that removal of the apical bud (decapitation) improved rooting. In order to get high success rate, the results suggested that plucking must be raised under polythene tunnels.

Table 3.4 The effects of nursery treatments on the rooting for shoot propagated plants for different cultivars raised under misting and plastic tunnel conditions at Mimosa in 1997.

Clone	Shoot type	Proportion of plucking shoots rooted at 5 months from propagation (%)	
		Misting	Polythene tunnel
PC 108	3 leaves + bud	26.7	50.7
	3 leaves – bud	26.7	66.7
SFS 150	3 leaves + bud	51.3	60.7
	3 leaves – bud	69.3	81.3
C182-40	3 leaves + bud	44.7	59.3
	3 leaves – bud	51.3	66.7
	Mean	*45.0*	*64.2*

3.4.2 Optimum shoot size

In the initial attempts to use plucking shoots as propagation material it was observed that the most critical factor for plucking shoots to survive and root was the level of lignification in the stem that goes into the rooting medium. It was further noted that in the main growing season, a fully lignified stem would be found below the four leaf, whereas in the off-season the stem below the second or third leaves would be fully lignified. It was therefore concluded that an ideal sized plucking shoot should have at least four leaves in the main growing season and 2 or 3 leaves and a bud in the off-season.

3.5 Use of Speedling Trays in Tea Propagation

Tea has traditionally been propagated in plastic pots; mini-pots for rooting and standard pots for rooting and/or growing. However, these require large volumes of rooting or growing medium and extensive nursery space, especially tunnel area. The labour costs to carry out the various nursery activities associated with using pots are also high.

3.5.1 Advantages of Using Speedling Trays

Studies done during the period under review showed that the use of speeding trays in large-scale propagation was a very cost-effective method of raising tea plants because the volume of soil required per plant was greatly reduced and the use of tunnel space was maximized. For example, using speedling trays with 96 x $50cm^3$ plugs, only $50cm^3$ of soil was required for each plant compared to about $228cm^3$ used in one mini-pot or 2 litres in one standard pot. With this size of trays it was possible to plant 576 shoots per square metre of bed area, as compared to only 200 or 100 shoots planted in mini-pots or standard pots, respectively.

It was also observed that plucking shoots planted in trays were generally rooted and ready for transplanting into standard pots at 2_ - 3 months, the trays as well as the polythene tunnel could therefore be reused several times within one propagation season. Other nursery operations such as checking for rooting, carrying of plants and transplanting are also very easy to carry out.

3.5.2 Procedures of Using Speedling Trays

3.5.2.1 Filling the Trays

Before a tray is filled with soil, it is important to check that each plug has a good-sized drainage hole at the tip of the plug. Dry and well sieved soil must be spread over the tray plugs whilst gently tapping the tray on the ground to settle the soil into the plugs. Never press the soil down into individual plugs with the fingers as this may lead to soil compaction within the plug, which may subsequently impede free drainage and impair root penetration and development.

3.5.2.2 Preparing the Planting Material

For materials that are to be planted in speedling trays, all the mother leaves must be trimmed to about two-thirds of their normal size to reduce leaf overlapping which may result in water-logging, leading to damping-off and/or rotting of the material. The length of the stem going into the rooting medium should not be too long as to hit the bottom of the plug.

3.6 Further Experimental Work to Investigate Nursery Procedures

3.6.1 Induction of Early Callusing and Rooting in Tea Cuttings or Plucking Shoots

In order to hasten callusing and root development, and allow for re-use of trays and polythene tunnels, a range of treatments were applied to cuttings and plucking shoots in August 1999. These included dipping the stem ends in hot water for 15 seconds, keeping the material in the cold room overnight, and dipping the stem ends in a 1% sucrose solution.

At five months after planting, survival and rooting was very low (38%) when the materials' stem ends were dipped in hot water whereas keeping the propagation material in the cold room overnight and dipping sucrose solution gave comparable results, 72% and 76%, respectively, to the control method (81%). These results showed that none of the new treatments was found to be valuable to the overall rooting percentage at five months from propagation, as compared to the standard method.

3.6.2 Biochemical Slow-Releasing Fertilizers for Nursery Plants

Sulphate of ammonia is the fertilizer normally used in tea nurseries. There has however, been great interest in the use of biochemical fertilizer products for promoting early growth in the nursery. Separate trials were therefore conducted in 1999 to assess the effects of foliar sprays of Vegimax, Kelpak and Folifert on the growth of nursery plants. After the first trial, Vegimax and Kelpak were also tried at a higher dosage than was prescribed by the manufacturers (Table 3.5b).

Both Vegimax and Kelpak when applied at the rates prescribed by the manufacturers appeared to have no effect on plant growth. Folifert application resulted in some improvement in plant growth but the trend was inconsistent (Table 3.5a). However, Kelpak tended to improve growth when used at a very high dosage of 5 ml per litre (Table 3.5b).

Table 3.5a Effects of Vegimax, Kelpak and Folifert sprays on nursery plant growth assessed at 8 weeks after the last chemical spray.

Chemicals applied at manufacturer's prescribed dosage					
Change in height (cm) at 8 weeks after last spray of chemical					
	Vegimax		Kelpak		Folifert
Treatment code	PC 108	PC 198	PC 108	PC 198	PC 185
T0	22.0	27.3	23.9	28.1	32.4
T1	21.6	25.5	23.2	29.2	38.1
T2	23.0	28.7	20.5	30.0	32.2
T3	-	-	-	-	45.5

Note:

Vegimax	:	T0 = Water	T1 = 0.4ml/L	T2 = 0.6ml/L	
Kelpak	:	T0 = Water	T1 = 0.7ml/L	T2 = 2.0 ml/L	
Folifert	:	T0 = Water	T1 = 2ml/L	T2 = 3.0 ml/L	T3 = 4.0 ml /L

Table 3.5b Effects of Vegimax and Kelpak sprays on plant growth when applied at higher dosage than recommended by manufacturers on nursery plant growth assessed at 8 weeks after the last chemical spray

	Vegimax		Kelpak	
Treat Code	Change in height (cm)	Leaves/plant	Change in height (cm)	Leaves/plant
T0	32.5	4.8	32.4	5.0
T1	30.1	4.7	38.1	5.9
T2	30.4	4.6	32.2	5.2
T3	29.2	4.9	45.5	5.8

Note:	Vegimax:	To = watering	T1 = 10ml/l	T2 = 25ml/l	T3 = 50ml/l
	Kelpak:	To = watering	T1 = 2ml/l	T2 = 3ml/l	T3 = 5ml/l

3.6.3 Storage duration for plucking shoots

The advantages of using plucking shoots in tea propagation have been acknowledged and accepted by the tea industry. TRF supplies propagation material for new VP cultivars and pre-releases to estates within and outside Malawi. Since plucking shoots are very tender, work was therefore initiated in 2000 to establish how long the material could be kept before planting without loss of rooting potential by comparing the material kept in the cold room and under ambient temperature conditions for up to five days before planting. Results are presented in Table 3.6.

The results suggested that where there were no cooling facilities, plucking shoots had to be planted within two days from preparation but where there were some cooling facilities, plucking shoots could be kept and planted up to five days after preparation without any significant effect on survival and rooting. It was therefore concluded that plucking shoots can be supplied to distant estates where they will be planted within two days unless in transit cooling facilities are guaranteed (Table 3.6).

Table 3.6 Percentage rooting of plucking shoots planted after different storage period under cold room or ambient temperature conditions.

Storage period (planting day)	Cold room storage	Ambient storage
Planted on Day 1 (control)	87	92
Planted on Day 2	88	73
Planted on Day 3	89	42
Planted on Day 4	85	46
Planted on Day 5	88	58

3.6.4. Hardening-Off Time for Plucking Shoots

Plucking shoots are raised under polythene tunnels, where conditions of high humidity can be maintained. Hardening-off starts after rooting has been established, usually 2_ - 3 months from propagation. Trials were conducted to establish whether plucking shoots could be hardened-off earlier and kept under misting so as to re-use the tunnel space sooner and thus reduce costs.

Results showed that with a relatively heavy grass shade, plucking shoots could be hardened-off from as early as four weeks after planting with success (Table 3.7). At 3_ months after propagation survival for plants raised in mini-pots was higher than those in small trays with a plug holding about 22 cm3 of soil. This was probably due to root coiling and fast drying of the soil in the tray plugs.

Table 3.7 Percentage survival of plucking shoots hardened-off after different times under polythene tunnels.

	% Survival at hardening-off		% Survival at 3_ months	
Hardened-off time	**Mini-pots**	**Trays**	**Mini-pots**	**Trays**
T1 (4 weeks)	84	77	70	48
T2 (6 weeks)	92	74	79	49
T3 (8 weeks)	90	76	72	65
T4 (10 weeks	94	85	88	72

3.6.5 Enrichment and Acidification of Rooting Media

Acidic soil conditions are conducive to root formation of tea cuttings or plucking shoots unlike alkaline soil conditions which promote heavy callusing and poor root formation. A trial was conducted in 1999 to examine the acidifying effects of sulphate of ammonia and aluminium sulphate on the rooting medium (sub-soil) at planting.

Rooting assessment at three and five months after planting showed that the application of aluminium sulphate and sulphate of ammonia had not affected the rooting of the shoots (Table 3.8). There were no benefits from acidifying/enriching the medium with either of the two fertilizers at planting.

Table 3.8 Percentage Rooting of plucking shoots planted in media enriched/acidified with sulphate of ammonia or aluminium sulphate at planting.

Treatment	Aluminium Sulphate % Rooting at:		Sulphate of Ammonia % Rooting at:	
	3 months	**5 months**	**3 months**	**5 months**
T1 (water only)	25	73	20	56
T2 (30g/10 l water)	25	66	36	53
T3 (45g/10 l water)	15	65	24	50

3.7 Composite Plant Production (Nursery Grafting)

Work on composite plant production focussed on improving the graft success rate and increasing labour productivity during grafting. The use of plucking shoots for making composites and different methods of securing the scion/rootstock union were examined.

3.7.1 Use of Plucking Shoots for Making Composites

The procedures for propagating ungrafted plants using plucking shoots were established and refined. The need to produce composites plants for yield benefits for some cultivars is well established and accepted. While the emphasis was placed on propagating using plucking shoots, there was need to see if grafted plants could be produced using plucking shoots. Graft success rates for composites made using conventional cuttings and plucking shoots were compared (Table 3.9)

Table 3.9. Number and percentage of successful grafts of plucking shoots and conventional cuttings of PC 168 scions on RC 4

Grafter	Cuttings	Plucking shoots
A	194 (97%)	192 (96%)
B	194 (97%)	196 (98%)
Mean	*194 (97%)*	*194 (97%)*

3.7.2 Use of Stapling to Secure Scions onto the Rootstock

In order to improve the productivity of the grafters, attempts were made to use techniques that would save time. Securing the scion onto the rootstock with a desk stapler was therefore investigated and compared with tying with a polythene strip. The results are presented in Table 3.10.

Table.3.10 Number and percentage of successful plucking shoots grafts with scions secured by tying with a polythene strip or stapling with a stapler (PC 168 / RC 4)

Grafter	Tying	Stapling
A	242 (84.0%)	176 (61.9%)
B	248 (86.1%)	219 (76.0%)
C	256 (88.9%)	199 (69.1%)
Mean	***249 (86%)***	***198 (68.8%)***

The studies further showed that stapling, using a desk stapler or staple gun, to secure the scion into the cleft gave comparable results to tying. In addition, it increased productivity of the grafters, since stapling only involves one hand movement as opposed to several movements made when tying with a polythene strip. The cost of labour associated with removing of polythene strips after graft take and rooting was also eliminated since the staples were left embedded in the composite.

3.8 Multiplication of new VP cultivars using top-working

Shortage of planting material has been one of the reasons for the slow uptake and use of new clones by the industry. This is partly due to the slow rate at which plant material can be multiplied using conventional propagation techniques. Research work during the period under review showed that top-working can greatly help to speed up VP cultivar multiplication even where conventional stem cuttings are used for propagation. The work also showed that grafting of brown stem scion material onto already established bushes allowed quick establishment of the new clone, such that it was possible to collect material for nursery propagation as early as eight months from grafting. It was demonstrated that starting with 500 scions to graft onto 125 established bushes, followed by harvesting and propagation of green stem cuttings, an estate can easily plant out about 19,000 plants and have about 30,000 more cuttings in the nursery three years after the release of a new clone, compared well to planting out only 500 plants where cuttings are used for conventional multiplication. It was also noted that number of field-ready plants may be increased further if plucking shoots are used for propagation and field planting is done using 6 – 9 months-old plants. Use of top-working and plucking shoot propagation can therefore allow quick multiplication and utilization of new VP cultivars by the industry.

3.9 Publications

1. Mc.Cubbin, P.D. and Steenkamp, J.W. (1998). Field establishment using rooted cuttings from speedling trays. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **131**, 13 – 15.
2. Mphangwe, N.I.K. (1997). Nursery manipulations and tea plant development in the nursery: the hidden half. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **128**, 17 – 19.
3. Mphangwe, N.I.K. (1998). Growing media for rooted cuttings: preliminary results. **Tea Research Foundation (Central Africa) Quarterly Newsletter 130**, 7 – 10.
4. Mphangwe, N.I.K. (1999). Growing media for rooted cuttings. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **134**, 18 – 21.
5. Mphangwe, N.I.K. and Nyirenda, H.E. (2000). Improving scion-take in top working *Tea Research Foundation (Central Africa) Quarterly Newsletter* **138**, 4 – 7.
6. Mphangwe, N.I.K. and Nyirenda, H.E. (2001a). Procedures for the propagation of plucking shoots and composites in speedling trays. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **142**, 12 – 14.
7. Nyirenda HE and Mphangwe NIK (2001b). Storage duration for plucking shoots propagation material – preliminary results. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **142**, 14 – 16.
8. Nyirenda, H.E. (1997a). Nursery management for successful vegetative propagation. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **125**, 11 - 13.
9. Nyirenda, H.E. and Mphangwe, N.I.K. (1998a). Rapid multiplication of new clonal material. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **131**, 8–9.
10. Nyirenda, H.E. and Mphangwe, N.I.K. (1998b). The potential of plucking shoots for large-scale clonal production. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **131**, 10 – 13.
11. Nyirenda, H.E. and Mphangwe, N.I.K. (1999). Progress with using plucking shots as VP material. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **134**, 9.
12. Nyirenda, H.E. and Mphangwe, N.I.K. (2000a). Production of composite plants – success rate and productivity. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **137**, 15 – 17.
13. Nyirenda, H.E. and Mphangwe, N.I.K. (2000b). Progress on vegetative propagation of tea using plucking shoots. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **131**, 17 – 19.
14. Nyirenda, H.E. and Mphangwe, NI.K. (2000c). Can estates achieve a high success rate in producing composite plants? *Tea Research Foundation (Central Africa) Quarterly Newsletter* **140**, 8-10.
15. Nyirenda, H.E. and Mphangwe, N.I.K. (2001). Top-working: could it supplement or replace standard replanting systems? *Tea Research Foundation (Central Africa) Quarterly Newsletter* **144**, 27 - 33.