CHAPTER 2
PLANT BREEDING

2. Introduction

The aims of the plant breeding program are to produce new, high yielding and high quality vegetatively propagated (VP) cultivars and composite plants that are adapted to local conditions. This is achieved by crossing selected parental stocks of cultivars and plant selection based on ease of rooting, quality, yield and easily rooting invigorating rootstocks and high quality scions VP cultivars for the production of superior composite plants.

During the period under review, controlled cross pollinations were carried out using a wide range of plant material, and selections from these crosses were screened for quality, rooting potential, field tolerance to drought, extreme temperatures and pests and diseases. In addition, drought tolerant invigorating rootstocks for the production of composite plants through grafting were produced. The selected materials were evaluated for yield production in the multi-location final evaluation field trials in Malawi, Zimbabwe and South Africa. In Malawi, expert tea tasters also evaluated some of the potential cultivars for made tea quality potential using cultivar SFS 150 or PC 108 as a benchmark.

This report highlights results from trials of progeny cultivars (PC) of different series in Malawi and Zimbabwe during the period under review. Details of materials and methods of the experiments were presented in the previous annual reports.

2.1 Field Evaluation Trials

2.1.1 PC137 – 148 Series

Two rainfed field trials, one at Mimosa Research Station (MRS) and the other at Thyolo Research Station (TRS), were planted in December 1983 and 1985, respectively, to evaluate field performance of PCs 132 – 148 in comparison with SFS 150 as a control. As shown in Table 2.1, PCs 137, 142 and 144 compared very favourably with SFS 150 in yield, with PC144 being outstanding in both trials. PC 133 yielded better than SFS 150 at TRS whereas the opposite was true at MRS. However, all of these four cultivars have a quality potential only similar to SFS 150, and their erect leaf poise renders them unsuitable for mechanical harvesting.

Table 2.1. Mean made tea yield (kg ha^{-1}) over five years (1992-1997 and 1994-1999) and quality valuation as a percent of SFS 150 value of PC 132-148 series at Mimosa and Thyolo.

Cultivar	Mimosa (1992-97)	Thyolo (1994-99)	Valuation (%)
PC 133	5767	3272	103
PC 137	6165	3305	96
PC 138	5737	2904	105
PC 140	3697	3123	108
PC 142	6071	3226	103
PC 144	6475	3685	100
PC 148	5809	3050	103
SFS 150	6340	2759	100
Mean	5758	3166	
S.E.	177	214	
CV%	15.4	13.2	

Although none of the four promising cultivars were recommended for commercial cultivation, they were being evaluated as rootstocks for the production of composite plants.

2.1.2. PC 149-155 Series

In December 1987 a trial was planted at TRS to evaluate PCs 149 – 155 in comparison with PC 108 and SFS 150 under irrigation. Results obtained showed that PCs 152 and 153 had a very high yield potential, out-yielding both PC 108 and SFS 150. PC 151 also performed well, out yielding SFS 150. Unfortunately, they only had average quality potential, as compared to PC 108 (Table 2.2).

Table 2.2. Mean made tea yield (kg m. t. ha^{-1}) from 1994 to 1998 and made tea quality valuation as a percent of PC 108 value of PCs 149-155 series at TRS.

CLONE	Yield	%Valuation
PC 149	2453	91
PC 150	3007	95
PC 151	3665	94
PC 152	3943	96
PC 153	4481	95
PC 154	2668	98
PC 155	2732	96
PC 108	3243	100
SFS 150	3012	86
Mean	3245	
S.E.	223	
CV%	19.5	

These results showed that PC 153 has a higher yield potential than SFS 150. The cultivar also exhibited good off-season shoot development and could be a good alternative to SFS 150 in cooler tea growing areas.

Also, PC 152 and PC 153 (also coded as RC 15 and RC 7, respectively) performed very well as rootstocks and were provisionally released as rootstock cultivars in 2000/1.

2.1.3 PC 156 – 160 Series

In the trial that was planted at TRS in December 1987 to evaluate field performance of PCs 156 – 160 using PC 108 and SFS 150 as standards, PC 160 yielded highest and out yielded PC 108 and SFS 150. The cultivar however, made average quality black teas, just edging over SFS 150 (Table 2.3).

Table 2.3 Mean made tea yield (kg ha^{-1}) of seven cultivars over four seasons from 1994/95-1997/8 and made tea quality valuation results as a percent of PC 108 value at TRS.

Clone	Yield	Valuation (%)
PC 156	2524	90
PC 157	2464	92
PC 158	3082	95
PC 159	2536	89
PC 160	3738	94
PC 108	3079	100
SFS 150	2304	90
Mean	2818	
S.E.	216	
CV%	15.7	

These results showed that none of the above cultivars was suitable for commercial cultivation because of poor quality of made tea in comparison to SFS 150.

2.1.4 PC 161 – 173 Series

Three trials, two at MRS and one at TRS were established between 1987 and 1989 to evaluate yield and made tea quality of PCs 161 – 182.

As shown in Table 2.4, PCs 165, PC 168, 171, 172 and 173 had a high yield potential, comparing very well with, and / or out-yielding PC 108 and SFS 150. In addition, PC 168 had a very high made tea quality potential with a value of USc 140 kg^{-1}. This value compared very favourably with PC108. It was also found very suitable for machine plucking because of its horizontal leaf poise.

Table 2.4. Mean made tea yield (kg ha^{-1}) over five years from 1995 to 2000 of PC 161 – 173 cultivars at MRS and TRS and made tea quality valuation as a percent of PC 108

Cultivar	Made Tea Yield			Valuation (%)
	MRS Trial 1	MRS Trial 2	TRS	
PC 161	2816	4201	1714	n/a
PC 162	2731	4444	1917	n/a
PC 163	2663	3253	1442	n/a
PC 164	3414	4273	2931	88
PC 165	4838	5726	2865	81
PC 166	3021	4475	2098	n/a
PC 167	3247	N/A	2358	86
PC 168	3657	4812	2424	105
PC 169	2559	2898	-	85
PC 170	2777	3572	1762	n/a
PC 171	3146	5163	3146	86
PC 172	3291	4824	2409	n/a
PC 173	3840	4899	1890	80
PC 108	1869	4337	2596	100
SFS 150	3113	3461	1863	82
Mean	3132	4310	2244	
S.E.	468	439	342	
CV%	11.8	18.6	21.3	

2.1.5 PC 174 – 182 Series

Two rainfed trials, one at MRS and the other at TRS, were planted in December 1989 to evaluate PCs 174 - 182. The control entries were PC 108 and / or SFS 150.

At MRS nearly all new cultivars, except PC 178, highly out yielded PC 108, with the best yields from PCs 175, 176, 177 and 182 (Table 2.5). At TRS there was no significant difference between PC 108 and the promising cultivars PC 175 and PC 182, all of which significantly out yielded SFS 150. All four new selections lacked good quality. PCs 165, 168 and 175 were formally released for full-scale commercial cultivation.

Table 2.5. Mean made tea yield (kg ha⁻¹) over five years from 1995 to 2000 of PC 174 – 182 at MRS and TRS and made tea quality valuation as a % of SFS 150 value

Clone	Mean Yield		Valuation (%)
	MRS	TRS	
PC 174	3348	1859	97
PC 175	3798	1982	99
PC 176	3588	-	98
PC 177	3593	-	96
PC 178	2317	1543	92
PC 179	3124	1884	100
PC 180	3047	1657	96
PC 181	3220	1766	104
PC 182	3561	1973	100
PC 108	2089	1945	119
SFS 150	-	1588	100
Mean	3168.5	1799.7	
SE	246	124	
CV%	11.2	13.6	

2.1.6 PC 183 – 199 Series

In an irrigated trial planted at Nsuwadzi Research Station in December 1998, cultivars PCs 184, 185, 186, 187, 193 and 199 had high yield potential as compared to PC 108 (Table 2.6). Their quality potential, however, was below that of PC 108.

PCs 187, 193 and 199 have had erratic rooting performance in the nursery. PC 198 is easy to root, and has good off-season shoot growth, which could result in, extended cropping season. PCs 184, 185 and 198 have since been formally released for full scale commercial planting.

Table 2.6 Mean made tea yield (kg ha⁻¹-) of PC 183 to PC 199 over five seasons and annual yield of the 2000/1 season and made tea quality valuation as a percent of PC 108 value

Clone	2000/01 Yield	Mean yield	Valuation (%)
PC 183	4137	3778	96
PC 184	3789	4030	94
PC 185	5598	5231	90
PC 186	5608	4711	85
PC 187	4733	4131	88
PC 189	4363	3826	96
PC 190	4109	3786	96
PC 192	4387	3886	93
PC 193	4779	4178	91
PC 194	4011	3621	88
PC 195	3763	3412	89
PC 196	297	3013	95
PC 197	4239	3935	95
PC 198	3705	3756	91
PC 199	4401	4101	91
PC 108	3958	3569	100
SFS 150	4248	3883	88
Mean	3873	3932	
S.E.	427		
CV%	10.2		

2.1.7 PC 200 – 221 Series

An irrigated trial comprising PCs 200 – 223, using PC 108 and SFS 150 as control cultivars, was planted at Nsuwadzi Research Station in December 1993. The results in Table 2.7show that in 2000/1 and over the 1997 - 2001 five-year period, PCs 206, 213 and 218 yielded higher than PC 108 and SFS 150. PCs 206 and 213 also had very good cool season growth. In addition, PC 213 had a high degree of drought tolerance. However, the made tea quality potential of PC 206 was inferior to the quality potential of the two controls. PC 213 has since been formally released for full scale commercial planting.

Table 2.7 Mean made tea yield over five seasons from 1997-2001 and the yield in 2000/1 season (kg ha^{-1}) of PC 200 – 221 series and made tea quality valuation as a percent of PC 108 value.

Clone	Yield in 2001	Mean Yield	Valuation (%)
PC 200	2352	2137	96
PC 201	2657	2536	88
PC 202	3128	2900	88
PC 203	3075	2625	84
PC 204	4617	3533	89
PC 205	3156	3090	87
PC 206	5078	4497	72
PC 207	4192	3820	82
PC 208	2070	2645	90
PC 209	4090	3911	-
PC 211	4142	3955	81
PC 212	4336	3933	89
PC 213	5414	4882	95
PC 216	3200	2600	86
PC 217	4083	3883	-
PC 218	4721	4663	-
PC 221	3952	3853	-
PC 108	3915	3811	100
SFS 150	4126	3733	88
Mean	3805	3527	
S.E.	319		
CV%	21.0		

2.1.8 PC 113 – 119 Series

Table 2.8 presents yields from a trial established in February 1995, which was aimed at evaluating the performance of new TRF cultivars (PCs 113-119) under irrigated conditions at Jersey Tea Estate, in Chipinge area, Zimbabwe.

PC81, followed by PC 108, PC 114, WT 90 and TN 14/3, generally yielded very well relative to SFS 150, with PC 81 producing a total of more than 23t made tea ha-1 over the past five seasons. Ejulu had the lowest yield in 2000/1 season.

Table 2.8 Made tea yield (kg ha-1) in 2000/01 and cumulative yield (kg) over five year period from 1997 to 2001 of PC 113 – 119 series under irrigation at Jersey, Zimbabwe.

Cultivar	Yield in 2000/01	Cumulative Yield
EJULU	5872	**17199**
KC7	6472	**18819**
PC119	6019	**19130**
PC110	6180	**19389**
PC113	6345	**17175**
PC117	6035	**19548**
PC118	6826	**19931**
SFS150	6675	**20131**
PC105	6679	**19943**
PC114	6809	**20920**
PC108	6889	**21891**
TN14/3	6743	**21336**
WT90	6922	**21827**
PC81	7079	**23305**
Mean	6539	
S.E.	232	
CV%	4.4	

It can be concluded from these results that all cultivars, probably apart from Ejulu had high yields, particularly PC 81, PC 108 and WT 90, and were suitable for Jersey area.

2.1.9 PC 135 – 224 Series at Zona, Chipinge

The yield results from the irrigated trial at Zona show that PCs 140 and 206, followed by PC 217 and PC 144, produced the most crop over the past five seasons (Table 2.9). Furthermore, PCs 140 and 206, together with PCs 159 and 202, gave the highest yield in 2000/1 growing season. However, quality screening in Malawi showed that these cultivars, except PC 217, which requires further screening, had average quality potential.

Table 2.9 Made tea yield (kg ha^{-1}) in 2000/1 and the cumulative made tea yield (kg) of PC 135 – 224 series under irrigation at Zona, Zimbabwe.

Clone	Yield in 2000/01	Cumulative yield
PC135	4227	9750
PC108	4460	10913
PC150	5003	11919
WT90	4654	11145
PC224	4610	10819
PC148	5084	12087
PC144	5122	12337
PC220	4688	11965
PC203	4585	10938
PC111	4589	10765
PC213	5034	11992
PC221	4844	12142
PC217	5122	12547
PC202	5521	12066
SFS150	4982	11562
PC152	4624	11560
PC159	5378	12066
PC201	4548	11496
PC216	4936	11686
PC153	4772	11700
PC141	4642	11813
PC160	4992	11898
PC218	4897	11907
PC140	5988	12952
PC206	5691	13712
PC137	5140	12260
Mean	4928	
S. E.	467	
CV %	8.3	

Although PCs 137, 140, 144, 159, 202 and 206 had a high yield potential, their average made tea quality was unsuitable for commercial cultivation while PC 217 required further screening for made tea quality.

2.1.10 PC 135 – 224 series at Clearwater, Chipinge

In an irrigated trial planted at Clearwater, several cultivars including 33/15-41, PC 137, PC 152, PC 219, PC 217, PC 144, PC 221, PC 148, PC 140, PC 141, PC 212, PC 213 and PC 206 compared very well with both PC 108 and SFS 150 in yield potential (Table 2.10). However, they needed to be evaluated at other sites in Zimbabwe to check on their adaptability.

Table 2.10 Mean made tea yield over five year period from 1997/8 to 2000/1 and yield in 2000/01 season (kg ha^{-1}) of PCs 135 to 224 under irrigation at Clearwater, Zimbabwe.

Cultivar	Yield in 2000/01	Mean yield
PC122	3408	6911
33/9-5	2243	4427
PC198	3198	7953
PC185	3561	8501
PC200	2938	6392
PC135	2878	7090
PC108	3096	6791
33/15-46	3148	7111
33/15-31	2578	6869
33/15-5	2940	6457
PC150	3212	7057
33/10-4	3109	7172
33/9-1	3044	7280
PC201	3096	7549
SFS150	3321	7151
PC223	3230	6937
33/23-10	3320	7560
33/23-7	2941	7014
PC186	3135	7622
33/23-11	2996	6622
33/17-20	3526	7951
PC131	3023	7274
PC14	3453	8534
PC111	2967	7860
33/23-12	3175	8288
PC158	3446	7733
PC153	3417	7951
33/23-9	3130	7602
PC202	3096	8148
PC216	2936	8234
PC160	2996	8219
PC195	3366	7714
PC220	3038	7844
PC199	3186	8709
PC203	3361	7501
PC159	3480	9410
PC224	3220	8545
PC222	2963	8444
PC218	3590	8430
PC221	3429	9132
PC213	3101	8664
PC144	3632	8827
PC217	3551	8685
PC212	3511	9193
PC141	3419	9393
PC192	3285	9444
PC148	3618	9526
PC140	3396	9370
PC137	3755	9634
33/15-41	3986	10402
PC152	3624	10444
PC219	3600	9990
PC206	3580	10795
Mean	3189.8	
SE	276	
CV%	23.1	

Promising cultivars 33/15-41, PC 137, PC 152, PC 219, PC 217, PC 144, PC 221, PC 148, PC 140, PC 141, PC 212, PC 213 and PC 206 had to be evaluated further in properly designed field trials in Honde Valley.

2.2 Composite Plants

Trials of composite plants to assess congeniality between rootstocks and scions and evaluate their field performance were planted in Malawi and Zimbabwe. Tables 2.11 to 2.13 show the results by the scion used.

2.2.1 PC 105 Composites in Malawi.

Two trials were planted to evaluate PC 105 scions grafted on different rootstocks in Mulanje under rain fed conditions. The first trial was planted at MRS in December 2005 and the second one at Esperanza Tea Estate in December 1996.

The results presented in Table 2.11 show that PC 105 produced highest yields when grafted onto released rootstocks RCs 2, 4 and 6, as well as on rootstocks RCs 7, 13 and 16.

Table 2.11 Made tea yield (kg ha⁻¹ in 2000/01 and cumulative yield over five years from 1997 to 2001 (kg) of PC 105 grown on different rootstocks.

Rootstock	**Trial 1**		**Trial 2**	
	Yield in 2000/01	Cumulative Yield	Yield of 2000/01	Cumulative Yield
Un grafted PC 105	2865 (100)	8787 (100)	1904 (100)	4937 (100)
RC 1 (MSF 87)	3080 (108)	8936 (102)	-	-
RC 2 (PC 87)	3442 (120)	10751 (122)	2350 (123)	6105 (124)
RC 3 (7-7)	3320 (116)	10065 (115)	1701 (89)	4615 (93)
RC 4 (14-22)	-	-	2599 (137)	6825 (138)
RC 6 (PC141)	3176 (111)	9712 (111)	2611 (137)	6571 (133)
RC 7 (PC 153)	-	-	2670 (140)	6838 (139)
RC 12 (R5 193)	3315 (116)	-	1982 (104)	5112 (104)
RC 13 (RS 233)	-	-	2652 (139)	6177 (125)
RC 14 (RS 245)	-	-	2427 (127)	5964 (121)
RC 15 (PC 152)	-	-	2399 (126)	6002 (122)
RC 16 (22 – 70)	-	-	2712 (112)	7128 (144)
RC 17 (29-36)	3335 (116)	10014 (114)	2176 (114)	5584 (113)
RC 18 (29 – 44)	3528 (123)	10296 (117)	2335 (123)	5599 (113)
Mean	3258		2348	
S.E.	181		209	
CV%	5.7		12.3	

Note: Figures in parentheses are percentage of the yield of un-grafted PC 105

These results suggested that PC 105 would best be utilised as a scion when grafted on the released rootstocks RCs 2, 4, 6, 7, 13, 15 and 16. Rootstocks 7, 13, 15 and 16 performed very well and were earmarked for release as rootstocks to PC 105 scions.

2.2.2 PC 108 Composites in Malawi

Three trials were planted between 1994 and 1996 to evaluate the performance of PC 108 under rain fed conditions when grown on different rootstocks. Two trials were planted at MRS and the third one at Esperanza.

PC 108 had marginal yield benefit when grafted on RC1, RC 4 and RC. 6. However higher yields were obtained with PC 108 as a scion on rootstocks RCs 7, 13 and 15 (Table 2.12)

Table 2.12 Made tea yield (kg ha^{-1}) of PC 108 grafted on different rootstocks in 2000/01 and cumulative yield (kg) over the 1997-2001 period

Rootstock	Trial 1		Trial 2		Trial 3	
	Yield in 2000/1	Cumulative Yield	Yield in 2000/1	Cumulative Yield	Yield in 2000/1	Cumulative Yield
PC 108	3740	12486	4239	11502	2338	5858
RC 1 (MFS 87)	-	-	4400	-	2321	6076
RC 2 (PC 87)	3777	12562	4366	11430	2316	5831
RC 3 (7-7)	3484	11468	-	-	2045	5624
RC 4 (14 – 22)	3917	13386	4531	11911	2303	5644
RC 6 (PC 141)	-	-	4259	-	2545	6299
RC 7 (PC 153)	-	-	-	-	2793	7116
RC 12 (R5 193)	-	-	-	-	1843	4937
RC 13 (RS 233)	-	-	-	-	2372	6386
RC 14 (RS 245)	3601	11260	-	-	-	-
RC 15 (PC 152)	-	-	-	-	2670	6827
RC 16 (22 – 70)	-	-	4166	11306	2316	5823
RC 17 (29 – 36)	3680	10895	-	-	2291	5992
RC 18 (29 – 44)	3680	12285	3901	10253	2304	5464
JRS 7	3154	10893	-	-	-	-
RS 9	2889	9794	-	-	-	-
PC 168 / RC 4	-	-	4736	13551	-	-
PC 183 (own)	-	-	3448	9634	-	-
PC 185 (own)	-	-	4757	12902	-	-
Mean	3547		4373		2343	
S.E.	461		293		311	
CV%	12.9		7.2		17.8	

These results suggest that PC 108 should be grafted on rootstocks RCs 6, 7, 13 and 15 for maximum yield benefit from grafting. The encouraging results of rootstocks 7, 13 and 15 suggest that they should be released for use with PC 108 scions.

2.2.3. PC 114 Composites in Malawi.

The performance of PC 114 as composite plants was evaluated under rain fed conditions in two trials at MRS in Mulanje.

The results in Table 2.13 show that PC 114 performed better when grafted than when planted as a straight cultivar. Best yields were obtained when PC 114 was grafted on rootstocks RCs 2, 3, 4, 6, 12 and 18 (Table 2.13).

Table 2.13 Made tea yield (kg ha^{-1}) in 2000/01 and cumulative made tea yield over four years (kg) of PC114 grown on different rootstocks.

	Trial 1			Trial 2		
Rootstock	Yield in 2000/1	Cumulative Yield		Yield in 2000/1	Cumulative Yield	
PC 114 own	2429	7647	(100)	3294	8542	(100)
RC 2	3585	9253	(121)	4499	11225	(131)
RC 3	3261	8947	(117)	3778	9259	(108)
RC 4	3589	9406	(123)	4085	9935	(116)
RC 6	3870	9482	(124)	4159	10504	(123)
RC 12	3702	9865	(129)	3503	8785	(103)
RC 16	-		-	3952	8654	(101)
RC 17	2833	8106	(106)	-		-
RC 18	3927	10018	(131)	3667	9199	(108)
PC 168 on RC 4	-		-	-		-
Mean	3400			3867		
S.E.	351			212		
CV%	10.3			7.5		

Note: Figures in parenthesis are percentages values of the un-grafted PC 114.

2.2.4 PC 105 Scions at Clearwater in Zimbabwe

In the irrigated trial at Clearwater, PC 105 grafted on rootstocks RC 6, 20 – 7 and RC 7 together with un-grafted SFS 150 performed well relative to those grafted on control rootstock RC 2 (Table 2.14). Rootstocks RC 3, RC 16 and 29 – 36 also performed well.

Table 2.14 Made tea yield in 2000/01 (kg ha^{-1}) and cumulative made tea yield (kg) of PC 105 composite plants at Clearwater, Zimbabwe

Clone	Yield in 2000/1	Cumulative Yield
RS245	2965	6906
RC 2	3143	7390
RC 3	3411	7638
PC108	3362	7333
RC 16	3488	7463
29-36	3321	7914
RC 7	3704	8131
20-7	3529	8033
RC 6	3549	8239
SFS150	3679	8304
Mean	3415	7735
SE	289	
CV%	7.7	

2.2.5 PC 108 and PC 117 Composites at Eastern Highlands Plantations Ltd, Zimbabwe.

In the rainfed field trial established in January 1999 at Eastern Highlands Plantations Ltd., to evaluate the performance of different rootstocks using PC 108 and 117 as scions, PC 108 performed well on rootstocks 29 – 36, 29 - 44, RC 6 and RC 3 but poorly on RC 16 and PC 185 whereas PC 117 performed well on RC 2, RC 3 and PC 185 rootstocks (Table 2.15).

Table 2.15 Made tea yield in 2000/1 (kg ha^{-1}) of PC 108 and PC 117 composite plants at EHPL, Zimbabwe

Composite	Yield
PC 108/ RC 16	1266
PC108/ PC185	1293
PC 108/ NVS 10	1433
PC 108/ RC 5	1433
PC 108/ RC 4	1498
PC 108/ RC 3	1549
PC 108/ 29-44	1678
PC 108/ 29-36	1703
PC 108/ RC 7	1733
PC 108/ RC 6	1752
PC 117/ PC 183	1256
PC 117/ 29-36	1274
PC 117/ RC 4	1292
PC117/ RC 7	1303
PC117/ RC 5	1321
PC 117/ 29-44	1326
PC 117/ RC 6	1372
PC 117/ NVS 10	1420
PC117/ PC207	1493
PC 117/ PC 185	1550
PC 117/ RC 2	1553
PC117/ RC 3	1598
Mean	1459
SE	126
CV%	9.7

Although it was too early to comment on the results, it looked certain that these two scion cultivars have different specific rootstocks for maximum yield benefit from grafting. At this stage, PC 185 seemed very unsuitable for PC 108 but very suitable for PC 117 as a rootstock at EHPL. The trial was decided to run to maturity before any conclusive statement can be made about which rootstocks are most suitable for these scion cultivars at EHPL.

2.3 Top working

The advantages of top working had been demonstrated during TRF field days and the tea growers appreciated the benefit of this technology but had not adopted it. Resistance by the tea growers to adopt the technology was attributed to its low labour productivity. An experiment was, therefore, started in August 1999 at Nsuwadzi Research Station on established PC 81 bushes to determine practices that could increase the productivity of the grafter and reduce grafting costs. The following practices were studied:

- Use of the tea bush supplemented with grass to provide shade to the grafted stem
- Tying moist moss around the graft with a plastic strap followed by covering it with a moistened polythene bag and secure with a plastic strap.

The results on number of scions grafted per man-day, total number of scions grafted and success rate for each method show that bypassing putting moist moss around the graft union area (T1) significantly raised grafter productivity by 65% with a success rate of about 80% (Table 2.16).

Table 2.16 Grafter productivity as measured by the number of grafted scions/man-day and success rate measured by the number of scions with union formed of grafted scions.

Water Method retention	Average number of scions /man-day	Total scions Grafted scions	Successful scions (%)
T1	132	528	423 **(80)**
T2	80	320	242 **(76)**
Mean	106	424	332.5
SE	5.1	-	2.0
CV%	6.2	-	4.6

The increased labour productivity and very high success rate in the formation of the graft union arising from by-passing the moist moss stage was a welcome outcome. Bypassing the moist moss stage led to considerable reduction in grafting costs since there was no need to look for moss or purchase any water retaining material and grafting tape or plastic straps for securing the moist moss around the graft. High labour productivity of 132 scions (equivalent to 33 bushes) per man-day suggested that only 336.7 man-days were required to upgrade one hectare as opposed to 555.6 man-days with the conventional moist moss method. Furthermore, this modified method showed potential to increase success rate even further because of minimum handling of the scion and, therefore, minimum risk of disturbing cambium alignment after inserting it into the rootstock cleft.

The exclusion of moist moss had however added costs because without the moist moss the frequency of replenishing moisture in the bag was higher and involved more man-days. Since bypassing the use of moist moss does not save labour, there is need to explore other and cost effective means of ensuring high humidity in the graft bag.

2.4 Shoot Growth Studies

New TRF cultivars yield very high under experimental conditions but do not yield as high under growers' conditions. A number of factors contribute to this discrepancy. Some growers use poor sites for their tea and/or do not prepare land adequately and timely, and generally employ sub-optimal crop husbandry practices. The other factor, which has been reported to contribute to the low yield levels of TRF cultivars under growers' conditions, is the shoot age at the time of plucking. Tanton, 1979; Cannell et al;

1990; Stephens and Carr, 1993 have reported that the optimum time to pluck is when shoots have just accumulated adequate dry matter required for black tea quality

Previous work at TRF has established that in the main cropping season from December to April in Malawi when growing conditions are optimum, shoots of seedling and old cultivars take on average 42 days to reach pluckable size. This information is not known for new TRF cultivars.

Studies on shoot growth were therefore started in 1998/9 growing season to determine the optimum plucking time of shoots from some new cultivars such as PCs 105-110, PCs 165-168, and PCs 184-213 series, together with composites derived from PC 105, PC 108 and PC 114. Shoot length from day 21 to day 49 following the removal of apical dominance (plucking) was measured. Results below are presented by the cultivars.

a) PCs 105 –110

As shown in Figure 2.1, shoots generated early in the main growing season from mid December to first week of February took about 42 to 49 days to reach pluckable size while those generated in mid May were still too small to be plucked at day 49.

PC 110 showed the most shoot extension growth, followed by PC 81 when shoots were generated on 18/12/98. There were no marked differences between PC 105, PC 108 and SFS 150 at day 42 and day 49.

When shoots were generated on 29/01/99, PC 110 and SFS 150, followed by PC 81, showed the most extension growth, while PC 105 and PC 108 again showed the least growth at day 42. When shoots were generated later on 09/02/99, PC 110 showed the most shoot extension growth followed by PC 81 and SFS 150, with PC 105 and PC 108 showing the least growth at day 42. Shoots generated in May had SFS 150 and PC 81 showing the most shoot extension growth followed by PC 110 and PC 105, with PC 108 again showing the least growth.

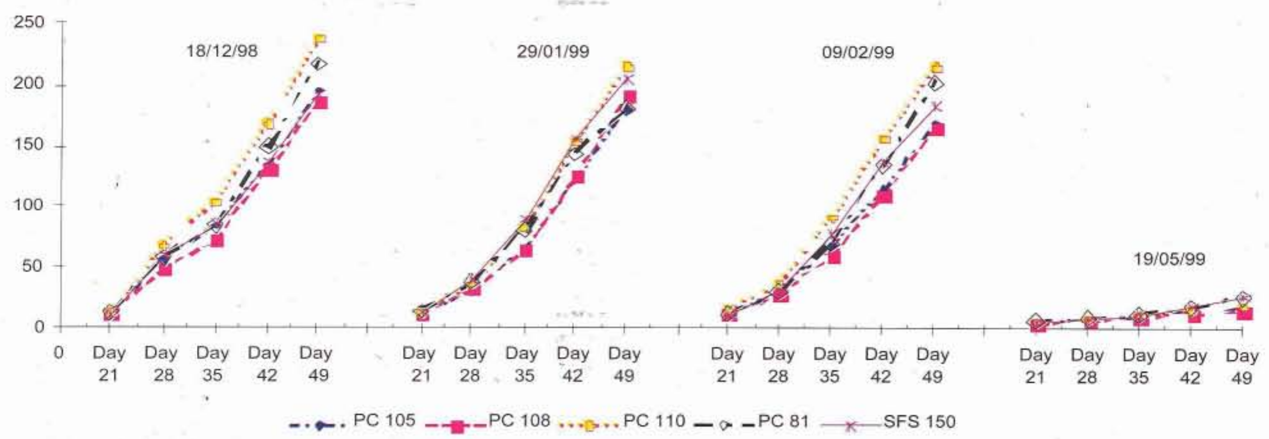

Figure 2.1. Shoot length (mm) of PCs 104, 105, 108, 110, 81 SFS 150 at three dates of shoot initiation

b) PCs 165 and 168

The results in Figure 2.2 show that for shoots generated in the main growing season between December and early February, PC 165 and PC 168 (those generated on 28/12/98), or PC 165 followed by PC 168 (those generated on 28/01/99), showed the most shoot extension growth followed by PC 108, with SFS 150 showing the least growth at day 42 whereas for shoots whose growth was initiated in March/April PC 165 and PC 168 again showed the most growth but the least growth was shown by PC108, though they were all too small for plucking even at day 49 for those initiated at the end of April.

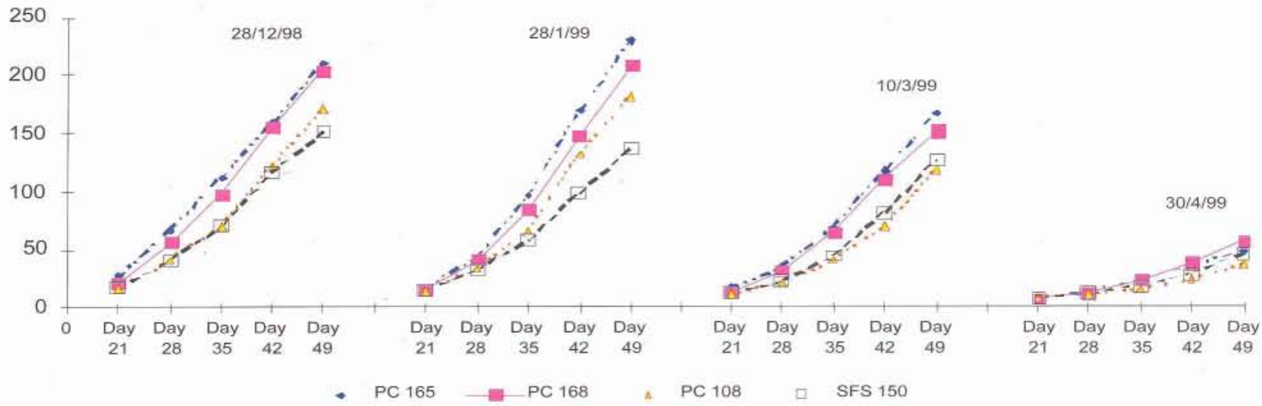

Figure 2.2. Shoot length (mm) of PC's 165 and 168 compared with PC 108 and SFS 150. Date shown is date of shoot initiation

c) PCs 184, 185, 198 and 213

As shown in Figure 2.3, i PC 198, together with PC 185 and PC 213, had the most shoot extension growth, followed by PC 184 and then PC 108 or PC 108 and SFS 150 together in the main season. In the cold season, PC 198, PC 213 along with PC 185 again showed the most shoot extension, followed by PC 184 and SFS 150, both producing significantly more growth than PC 108.

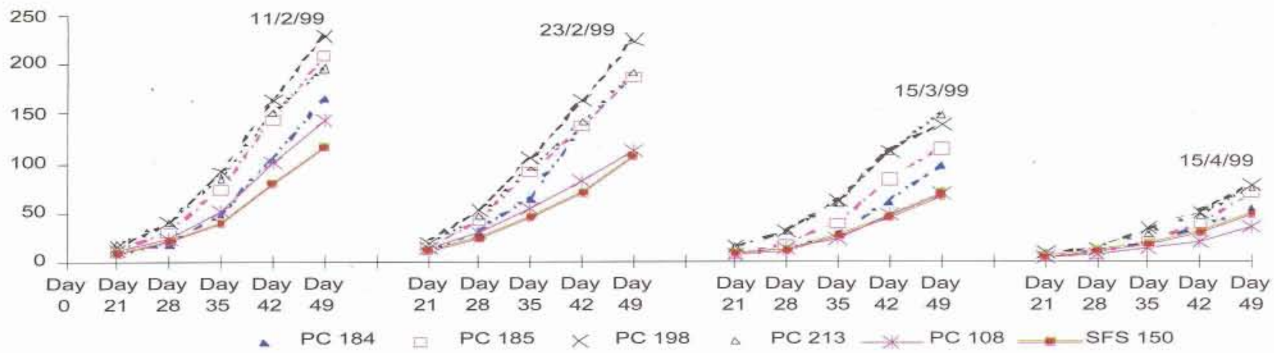

Figure 2.3. Shoot length (mm) of PCs 184, 185, 198 and 213 compared with PC 108 and SFS 150. Date shown is date of shoot initiation

d) PC 105 composites

This was rainfed young tea planted in December 1995, and the bushes were last pruned on 01/07/98. PC 105 grown on the root systems of different rootstocks was compared with the un-grafted.

The results presented in Figure 2.4 show that for the shoots generated on 04/02/99 there were no significant differences in shoot extension growth between un-grafted PC 105 plants and those grown on rootstocks at day 42, though those on RC 1 were slightly longer and those on RC 3 slightly shorter than the un-grafted ones. In the cold season there were no differences in shoot length at day 42 except for those grown on RC 3 which had the least shoot extension growth.

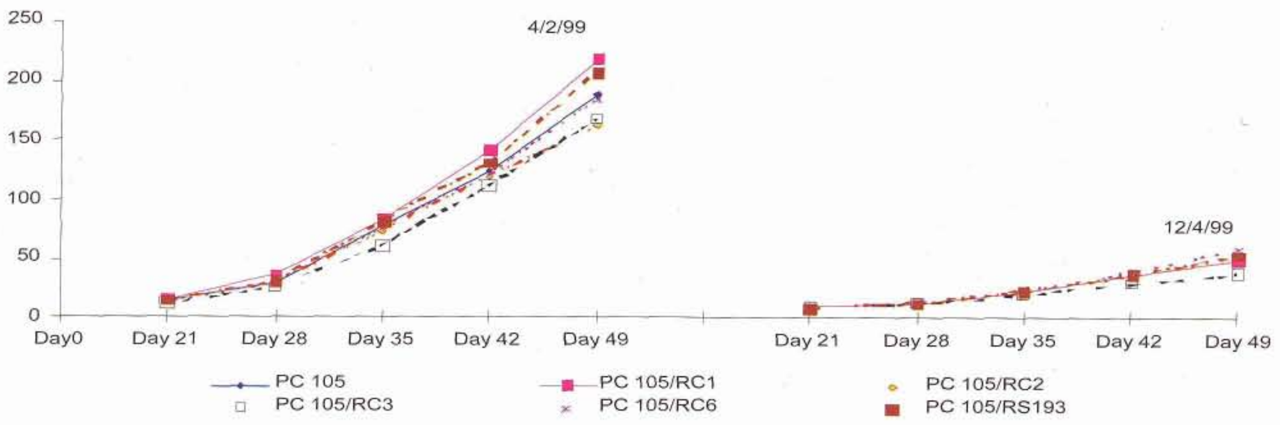

Figure 2.4. Shoot length (mm) of PC 105 composites compared with un-grafted PC 105.

e) PC 108 composites

As shown in Figure 2.5 there were generally no significant differences at day 42 between un-grafted PC 108 plants and those grown on rootstocks in the main growing season. Composites of RC 2 and/or RC 6 tended to exhibit less growth than those un-grafted.

In the cold season, however, the un-grafted PC 108 plants had the least growth, much less than those grown on RC 1, RC 2 and RC 4 rootstocks, particularly at day 49. PC 185 showed more growth than all PC 108 plants, both in the main growing season and in the cold season.

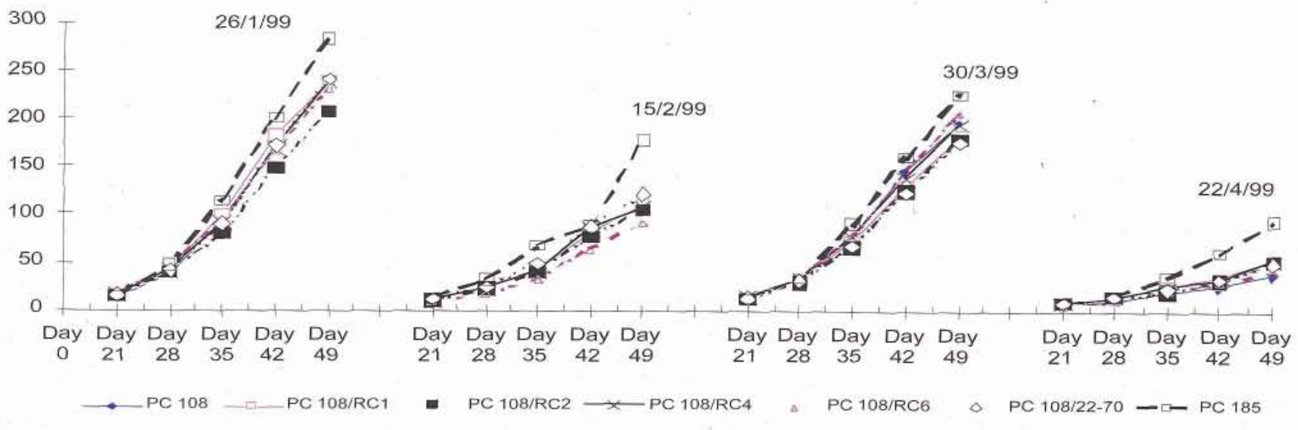

Figure 2.5. Shoot length (mm) of PC 108 composites compared with un-grafted PC 108.

f) PC 114 composites

Figure 2.6 shows that there was generally no marked difference between un-grafted PC 114 plants and those grafted onto different rootstocks except for those grown on RS 193 which gave the least shoot extension on day 42 and day 49. In the cold season the least shoot growth was observed in PC 114 plants grown on RC3.

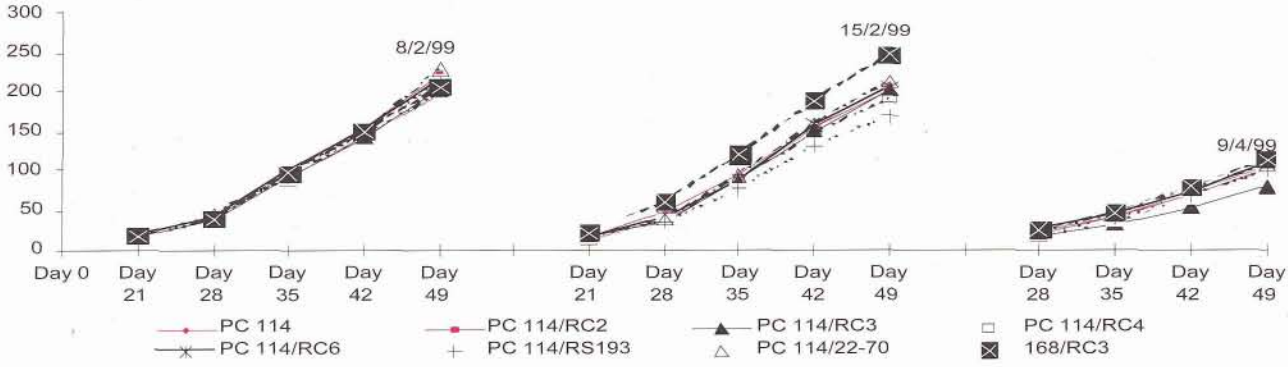

Figure 2.6. Shoot length (mm) of PC 114 composites compared with un-grafted PC 114.

Discussion

The results obtained from this study have revealed that field cultivars (straight vegetatively propagated) exhibit different patterns in shoot growth with rootstocks apparently having little effect on shoot growth. In the main growing season PC 81, PC 110, PC 165, PC 168, PC 198 and PC 213 had more shoot extension growth than PC 105, PC 108 and SFS 150. In the cold season SFS 150 showed more shoot extension growth than both PC 105 and 110, which in turn grew more than PC 108.

PCs 185, 198 and 213 apparently showed more shoot extension than SFS 150 both in the main growing season and in the cold season. This shows that these three cultivars and SFS 150, have a much lower base temperature than PC 105, PC 108 and PC 110. PC 108 appeared to be the most sensitive cultivar to low minimum temperatures.

These findings suggest that where two or more cultivars are to be planted in the same field PC 105, PC 108 and, probably, SFS 150 in one group, and PCs 165, 168, 185, 198 and 213 in another, may be matched together for ease of scheduling plucking and for leaf quality control in both warm and cold seasons. This would be particularly true where mechanical plucking is used. But more work is needed to investigate and compare the growth behaviour of different cultivars under a wide range of growing conditions, including altitude, fertiliser levels and various stages of the pruning cycle. Future studies would also include determining the shoot replacement ratio.

The lack of significant positive influence of rootstocks on shoot extension growth in this study confirms earlier findings, where Nyirenda (1987) found that shoot growth of PC 80 was not enhanced by grafting onto invigorating rootstocks, implying that this growth parameter must be selected for in the scion cultivar. However, grafting influenced shoot replacement ratio and shoot density suggesting that future work on composite plants should therefore be centred on determining the response of different scions to grafting with respect to shoot replacement cycle and shoot density.

2.5 New released cultivars

The following releases were made during the period under review:

- PC 165, PC 168 and PC 185 in 1998
- RC 3, RC 4, RC 5 and RC 6 in 1998
- PC 175, PC 184, PC 198 and PC 213 in 2001

2.7 Publications

1. Mphangwe, N.I.K. and Nyirenda, H.E. (1997). Screening for quality potential in tea clones by chlorophyll fluorescence. Tea Research Foundation (central Africa) Quarterly Newsletter *Tea Research Foundation (Central Africa) Quarterly Newsletter* **125**, 49-52.
2. Mphangwe, N.I.K. and Nyirenda, H.E. (2001). New clonal pre-releases. *Tea Research Foundation (Central Africa) Quarterly Newsletter Tea Research Foundation (Central Africa) Quarterly Newsletter* **142**, 9 – 11.
3. Nyirenda, H.E. (1997b). Replanting and how to realize maximum benefits from clones and composite plants. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **125**, 14 – 17.
4. Nyirenda, H.E. and Mphangwe, N.I.K. (1998b). Matching TRF clones for mixing in the field. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **132**, 8-9.
5. Nyirenda, H.E. and Mphangwe, N.I.K. (2000a). Shoot growth pattern of TRF (CA) clones – preliminary results. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **137**, 11 – 15.
6. Nyirenda, H.E. and Mphangwe, N.I.K. (2000c). Replanting for maximum total value: Which are the ideal clones possessing high quality and high yielding potential? *Tea Research Foundation (Central Africa) Quarterly Newsletter* **138**, 7-9.
7. Nyirenda, H.E. (2001). Studies of shoot growth. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **141**, 21 – 24.
8. Nyirenda, H.E. and Mphangwe, N.I.K. (2001). Maximising crop and total value of some TRF clones by plucking at optimum shoot age. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **143**, 18 – 24

9 Mphangwe, N.I.K. and Nyirenda, H.E. (1997). Screening for quality potential in tea clones by chlorophyll fluorescence. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **125**, 49-52.

10. Mphangwe, N.I.K. and Nyirenda, H.E. (2001). New clonal pre-releases. *Tea Research Foundation (Central Africa) Quarterly Newsletter* **142**, 9 – 11.

TRFCA (2000). Clonal Catalogue