

ARTIFICIAL DEFOLIATION, DECAPITATION AND DISBUDDING ON GROWTH AND BRANCHING IN YOUNG TEA (*CAMELLIA SINENSIS* (L.) O. KUNTZE)

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The effects on the growth of young tea plants of disbudding, decapitation and of removing one third of the foliage in relation to their age and condition of the terminal bud and of removing two thirds of the foliage and clipping of foliage in relation to fertilizer level were studied in two experiments. In experiment 1, clones DT 1 and TRI 2025 were used. In DT 1, plants with active buds grew faster and produced longer side shoots than dormant plants while in TRI 2025 the dormant plants produced more side shoots. In both clones, disbudding and decapitation produced more and longer side shoots and more leaves. Removal of mature leaves arrested the growth of the plants in both clones. At the 2nd assessment, after repeating the treatments, in both clones removal of bud + young leaves, bud + mature leaves and mature leaves alone reduced plant height. Disbudding increased the length of side shoots, leaf production and plant weight in DT 1, while it produced only longer side shoots in TRI 2025. Removal of mature leaves again arrested growth in both clones.

In experiment 2, using clone TRI 2026, defoliation and clipping two thirds of every leaf caused buds to change from a dormant to an active state earlier. This tendency was depressed subsequently. Defoliation of the youngest leaves reduced plant height and weight but increased total leaf number. Removal of youngest + oldest leaves also reduced plant height. Removal of the oldest leaves, as well as the removal of the youngest + oldest leaves resulted in a temporary drop in the rate of leaf production on the main stem but total leaf number on the plant increased. Removal of the oldest leaves also resulted in shorter side shoots. Clipping two thirds of every leaf reduced height and weight of the plant but increased the number of side shoots and leaves. At the 2nd assessment, after repeating the treatments, clipping produced more side shoots but reduced plant weight as did the defoliation treatments.

A significant interaction between levels of fertilizer and defoliation treatments was noted for height and weight of plants. At the higher level of fertilizer, all defoliation treatments resulted in the production of less dry matter than in the undefoliated plants. These results will point the way to obtaining the best growth of nursery plants.

INTRODUCTION

Tea is now vegetatively propagated in Sri Lanka almost exclusively by single-node cuttings. The time taken for root initiation under standard nursery conditions varies from 8 to 12 weeks, depending on the clone and on elevation. Fertilizer application is commenced only after the cuttings have formed roots which is around 10 to 12 weeks. Fertilizer is applied every fortnight until the plants are removed for field planting. It was shown that clones differ in their requirements of fertilizer (Kathiravetpillai, Kulasegaram, Senanayake and Gunasena 1976). This may be related to increased leaf area of the vigorous clones. Leaf area also increases rapidly as the plants grow older in the nursery which may necessitate a progressive increase in the quantity of fertilizer applied (Kulasegaram and Kathiravetpillai 1972; Kathiravetpillai *et al.*, 1976). Differences in the photosynthetic efficiency of the leaves of clones differing in growth vigour have also been shown (Barua 1964). Increase in leaf area is, however, affected when the plants show premature defoliation.

Premature defoliation may result from several causes such as lack of or excess water, nonoptimal rates of fertilizer application, strong wind, mite infestation, *etc.* All these result primarily in a reduction of the leaf area of the plant which impairs the photosynthetic efficiency and the plants' response to applied fertilizer.

Thumb-nailing—an operation which involves the removal of the bud and the two adjoining leaves with the included stem (decapitation)—is often carried out in nurseries in order to encourage the spread of the plants by forcing lateral bud growth. Disbudding is less drastic than thumb-nailing for young plants. The time of commencement and frequency of these operations also affect the growth of the plants.

In the present investigation an attempt was made to study the effects of disbudding, decapitation and of partial defoliation of plants in relation to the age of leaves and condition of the terminal bud and of partial defoliation and clipping of leaves in relation to level of fertilizer, on the growth of young tea plants.

MATERIALS AND METHODS

Tea plants were raised in soil in polythene sleeves 18 cm long and 9 cm in diameter. The soil used was subsoil on which Guatemala grass (*Tripsacum laxum* Nash) had been grown for about 1½ years. The initial nutrient status of the soil was: organic matter 4.82%, nitrogen 0.21%, phosphorus 7.20 ppm and exchangeable cations (m eq. %) potassium 0.17, calcium 0.76, magnesium 0.36. T65 fertilizer (Tolhurst and Visser 1961) was applied when the plants were ten weeks old. This was done uniformly at fortnightly intervals unless otherwise stated.

Experiment 1

Single-stemmed uniform plants, 32 weeks old, of clones DT1 and TRI 2025 were used. In each clone the plants were grouped into an active and a dormant set. The treatments were:

1. Control
2. Terminal bud removed
3. Young leaves removed
4. Mature leaves removed
5. Terminal bud plus young leaves removed (decapitation or thumb-nailing)
6. Terminal bud removed plus mature leaves removed.

The plants had 12 leaves at the time the treatments commenced. The uppermost three leaves in the dormant plants and the uppermost four leaves in the active plants were classified as young leaves. The lowermost three leaves were designated mature leaves.

The layout was of a randomized block design with four replicates of 80 plants per treatment per clone. Each treatment was applied to a set of active and dormant plants for each clone. The first assessment was carried out 11 weeks after the treatments were applied when half the number of plants from each treatment were removed. The treatments were repeated on the remaining plants and a final assessment was done 16 weeks after the first assessment.

Experiment 2

Single-stemmed uniform plants of clone TRI 2026 were used in this experiment. The plants were given the recommended level of fertilizer (Tolhurst and Visser 1961) until the commencement of differential fertilizer treatments when they were 36 weeks old. These treatments were:

1. F2=0.58 g/plant/fortnight.
2. F4=1.16 g/plant/fortnight.

The defoliation treatments which were also given on the above date consisted of:

1. Control
2. Youngest leaves removed (2/3 of total)
3. Oldest leaves removed (2/3 of total)
4. Youngest plus oldest leaves removed (2/3 of total)
5. Two thirds of every leaf clipped off.

The plants had 15 leaves when the defoliation treatments commenced. Ten leaves were usually removed but when the treatment necessitated removal of young leaves 11 were removed to compensate for their size.

The layout was of a randomized block design with 4 replicates of 20 plants per treatment, each treatment split to accommodate the two fertilizer levels. The first assessment was done 15 weeks after the treatments were applied when half the number of plants were removed. The treatments were repeated immediately following the first assessment, on the remaining plants. A final assessment was carried out seven weeks after the first assessment.

Analyses of variance were carried out on the results of the above experiments. Where necessary the data were subject to the appropriate transformation prior to analysis.

RESULTS

Experiment 1

At the first assessment done 11 weeks after the treatments were given, the height of the plants in both clones was unaffected by any of the treatments. In the slower growing clone DT1 but not in the vigorous clone TRI 2025 the active plants showed a greater increase in height compared with the dormant plants (Table 1).

TABLE 1 — *Effect of artificial defoliation, decapitation and dis-budding on increase in height over 11 weeks of active and dormant plants—1st assessment*

Clone	Condition of terminal bud	Increase in height (cm)
DT 1	Active	1.80
	Dormant	1.53
	LSD ($P=0.05$)	0.18
TRI 2025	Active	1.20
	Dormant	1.41
	LSD ($P=0.05$)	NS

In both clones, removal of the bud alone or the bud plus young leaves increased the number and length of side shoots and the total number of leaves produced (Tables 2 and 3). In TRI 2025 removal of young leaves alone also increased the number and length of side shoots and the total number of leaves produced. Removal of mature leaves appreciably reduced the number and length of side shoots and the number of leaves produced in clone DT1 but not in TRI 2025. While in both clones the treatments given to the dormant plants tended to increase the number of side shoots, only in TRI 2025 was this significant. The treatments given to the active plants increased the length of side shoots in DT1 but not in TRI 2025. In both clones removal of mature leaves or bud plus mature leaves, reduced the leaf area of the plant and in addition, greatly reduced the dry weight of stems, leaves (*i.e.*, tops), roots and total weight of the plant (Table 3). While removal of bud plus young leaves reduced the dry weight of these components in DT1, removal of young leaves alone reduced the dry weight of roots in TRI 2025. In both clones leaf production, leaf area and dry matter accumulation were unaffected by the condition of the terminal bud.

TABLE 2 — *Effect of artificial defoliation, decapitation and disbudding on the number and length of side shoots (means of 80 plants)—1st assessment (Back-transformed numbers are given in parentheses)*

Treatments	Number \sqrt{n}		Length (cm)	
	DT1	TRI 2025	DT 1	TRI 2025
Control	1.58 (2.50)	0.90 (0.81)	6.21	2.78
— Bud	2.21 (4.88)	1.53 (2.34)	17.43	10.62
— Young leaves	1.75 (3.06)	1.48 (2.19)	8.17	8.06
— Mature leaves	0.93 (0.86)	0.74 (0.55)	1.86	2.19
— Bud+Young leaves	2.32 (5.38)	1.85 (3.42)	16.80	15.90
— Bud+Mature leaves	1.70 (2.89)	1.19 (1.42)	5.86	3.50
L.S.D. ($P=0.05$)	0.25	0.30	3.46	4.25
Mean for all treatments: (Means of 240 plants)				
Active	1.68 (2.82)	1.17 (1.37)	10.52	7.31
Dormant	1.82 (3.31)	1.39 (1.93)	8.26	7.04
L.S.D. ($P=0.05$)	NS	0.17	1.99	NS

The final assessment was done 16 weeks after the first assessment. In both clones the heights of plants with bud plus young leaves, bud plus mature leaves and mature leaves removed were reduced both during the entire period of the experiment as well as during the 16 weeks after the treatments were repeated (Table 4). In addition, in DT1 the heights of disbudded plants were also reduced for these two periods. Removal of buds alone increased the length of side shoots (Table 4), the total number of leaves produced, dry weight of stems, tops, roots and total weight of the plant in DT1 (Table 5) whereas in TRI 2025 it increased only the length of the side shoots. Removal of bud plus young leaves increased the number and length of side shoots as well as the total number of leaves produced in both clones. While removal of mature leaves greatly reduced the number of side shoots, total number of leaves produced, dry weight of stems, leaves, roots and of plant in both clones, the length of side shoots was reduced only in DT1. In both clones removal of bud plus mature leaves reduced the dry weight of the components of the plant. The treatments given to the originally active set of plants increased the length of side shoots significantly in clone DT1 (Table 6). In both clones plant height, side shoot number, leaf production and dry matter accumulation were unaffected by the condition of the terminal bud. Fig. 1 shows the growth of the originally active and dormant set of plants for the two clones at the 1st assessment.

TABLE 3 — *Effect of artificial defoliation, decapitation and dis-budding on leaf production, leaf area (means of 80 plants) and dry matter production (means of 40 plants) —1st assessment (Back-transformed numbers are given in parentheses)*

Treatments	No. of leaves fallen+ retained on main+side shoots	Leaf area (cm ²)	Dry weight (g)				
			Leaves	Stems	Tops	Roots	Plant
<i>Clone DT 1</i>							
Control ...	5.10 (26.01)	188.45	1.96	1.80	3.76	0.88	4.64
— Bud ...	5.69 (32.38)	194.94	1.92	1.80	3.72	0.86	4.58
— Young leaves ...	5.45 (29.70)	166.58	1.75	1.61	3.36	0.74	4.10
— Mature leaves ...	4.22 (17.81)	85.66	0.72	1.03	1.75	0.54	2.29
— Bud+Young leaves	5.98 (35.76)	153.74	1.48	1.40	2.88	0.69	3.57
— Bud+Mature leaves	4.73 (22.37)	72.11	0.61	1.15	1.76	0.55	2.31
L.S.D. (P=0.05)	0.43	35.02	0.32	0.28	0.57	0.15	0.68
<i>Clone TRI 2025</i>							
Control ...	4.13 (17.06)	224.15	2.32	1.76	4.08	1.25	5.33
— Bud ...	4.92 (24.21)	288.05	2.81	2.02	4.83	1.35	6.18
— Young leaves ...	5.05 (25.50)	208.46	2.03	1.57	3.60	1.03	4.63
— Mature leaves ...	4.05 (16.40)	113.76	0.97	1.35	2.32	0.82	3.14
— Bud+Young leaves	5.42 (29.38)	231.61	2.20	1.67	3.87	1.07	4.94
— Bud+Mature leaves	4.01 (16.08)	89.69	1.04	1.23	2.27	0.76	3.03
L.S.D. (P=0.05)	0.55	64.93	0.66	0.33	0.92	0.19	1.05

TABLE 4 — *Effect of artificial defoliation, decapitation and dis-budding on increase in height and side shoot production—2nd assessment (Back-transformed numbers are given in parentheses)—(means of 40 plants)*

Treatments	Increase in height (cm)				Side shoots			
	Over 27 weeks		Over 16 weeks		Number	\sqrt{n}	Length(cm)	
	DTI	TRI 2025	DTI	TRI 2025			DTI	TRI 2025
Control ...	3.81	3.52	3.66	3.40	3.00 (9.00)	2.74 (7.51)	63.69	49.53
— Bud ...	3.59	3.32	3.40	3.24	3.42(11.70)	3.07 (9.42)	117.39	88.68
— Young leaves	3.68	3.43	3.54	3.24	3.05 (9.30)	2.99 (8.94)	72.93	65.97
— Mature leaves	3.26	3.08	2.99	2.86	2.31 (5.34)	2.31 (5.34)	28.89	31.57
— Bud+Young leaves	3.11	3.03	2.77	2.66	3.54(12.53)	3.38 (11.42)	101.23	84.80
— Bud+Mature leaves	2.93	2.84	2.58	2.51	2.68 (7.18)	2.54 (6.45)	49.10	39.97
L.S.D. (P=0.05)	0.14	0.32	0.16	0.35	0.44	0.43	22.41	24.38

TABLE 5 — *Effect of artificial defoliation, decapitation and dis-budding on leaf and dry matter production—2nd assessment. (Back-transformed numbers are given in parentheses)—(means of 40 plants)*

Treatments	No. of leaves fallen + retained on main +side shoots \sqrt{n}	Dry weight (g)				
		Leaves	Stems	Tops	Roots	Plant
<i>Clone DT 1</i>						
Control	8.38 (70.22)	4.52	6.68	11.20	3.64	14.84
— Bud	9.87 (97.42)	6.00	8.86	14.86	4.78	19.64
— Young leaves	8.91 (79.39)	4.13	6.54	10.67	2.93	13.60
— Mature leaves	6.52 (42.51)	2.79	3.76	6.55	1.61	8.16
— Bud + Young leaves	10.23(104.65)	3.76	5.73	9.49	3.40	12.89
— Bud + Mature leaves	7.78 (60.53)	2.12	3.73	5.85	1.92	7.77
L.S.D. ($P=0.05$)	1.22	1.61	1.77	2.99	1.04	3.88
<i>Clone TRI 2025</i>						
Control	7.40 (54.76)	6.90	6.70	13.60	5.55	19.15
— Bud	8.37 (70.06)	8.71	7.74	16.45	5.73	22.18
— Young leaves	8.04 (64.64)	7.39	6.66	14.05	5.01	19.06
— Mature leaves	6.20 (38.44)	2.57	3.89	6.46	2.72	9.18
— Bud + Young leaves	8.93 (79.74)	5.28	5.18	10.46	4.54	15.00
— Bud + Mature leaves	6.79 (46.10)	2.80	2.87	5.67	2.42	8.09
L.S.D. ($P=0.05$)	1.19	2.56	2.07	4.39	1.34	5.53

TABLE 6 — *Effect of artificial defoliation, decapitation and dis-budding on length of side shoots of active and dormant plants—2nd assessment—(means of 120 plants)*

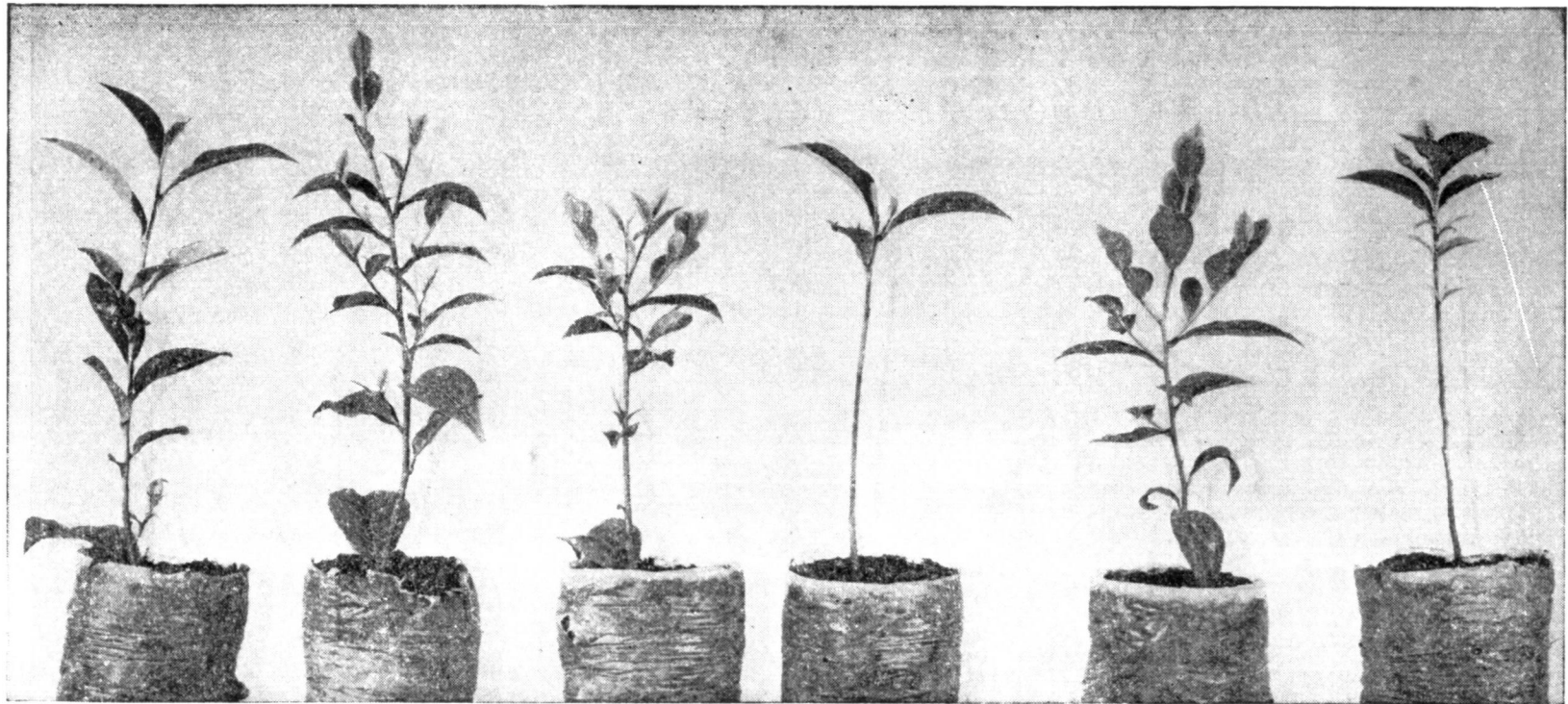
Clone	Condition of terminal bud	Length (cm)
DT 1	Active	80.10
	Dormant	64.31
	L.S.D. ($P=0.05$)	12.95
TRI 2025	Active	62.42
	Dormant	57.75
	L.S.D. ($P=0.05$)	NS



FIG. 1 — *Growth of originally active and dormant set of plants in clone DT1 at 1st assessment.*

Left to right: 1. Control, 2. Terminal bud disbudded, 3. Terminal bud+young leaves removed, 4. Terminal bud disbudded+mature leaves defoliated, 5. Young leaves defoliated, 6. Mature leaves defoliated.

(a) Plants of clone DT 1 with originally active terminal buds.



(b) Plants of clone DT 1 with originally dormant terminal buds.

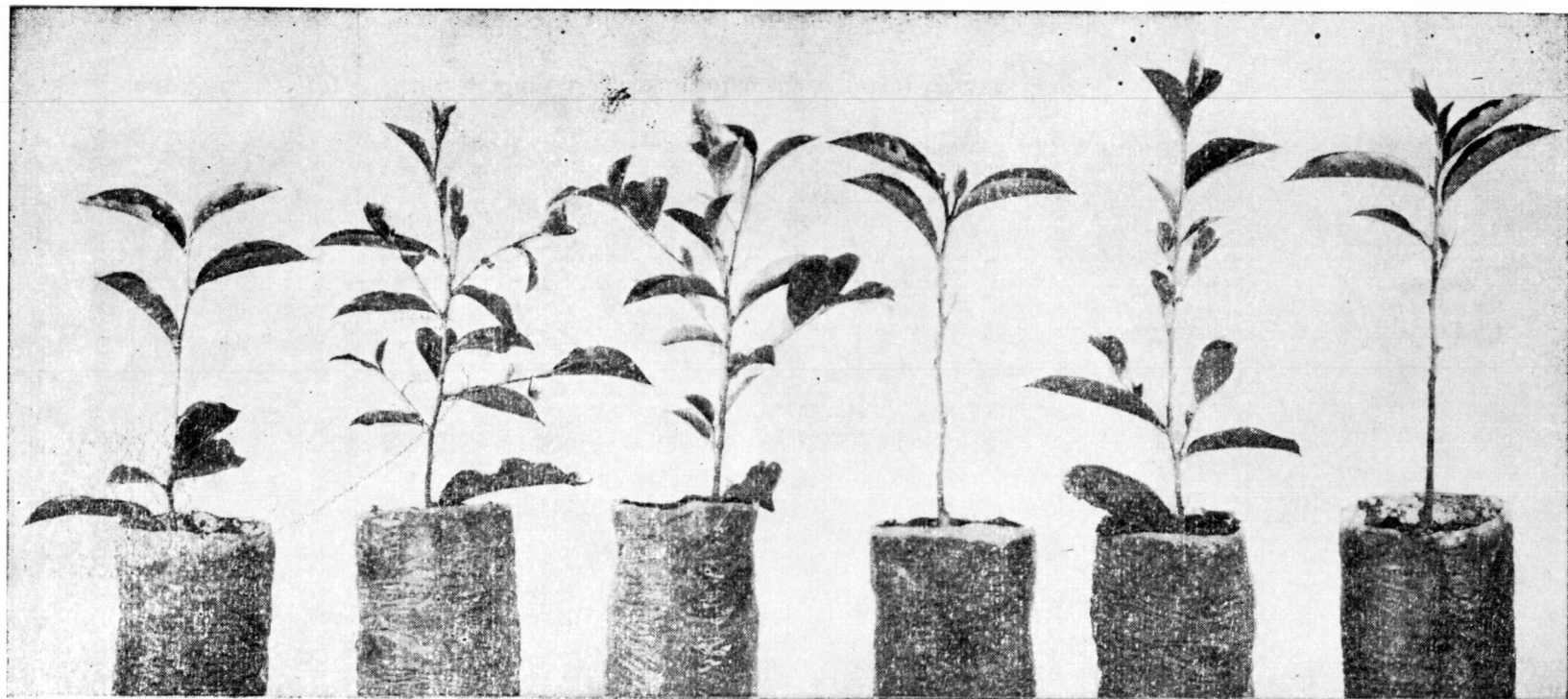
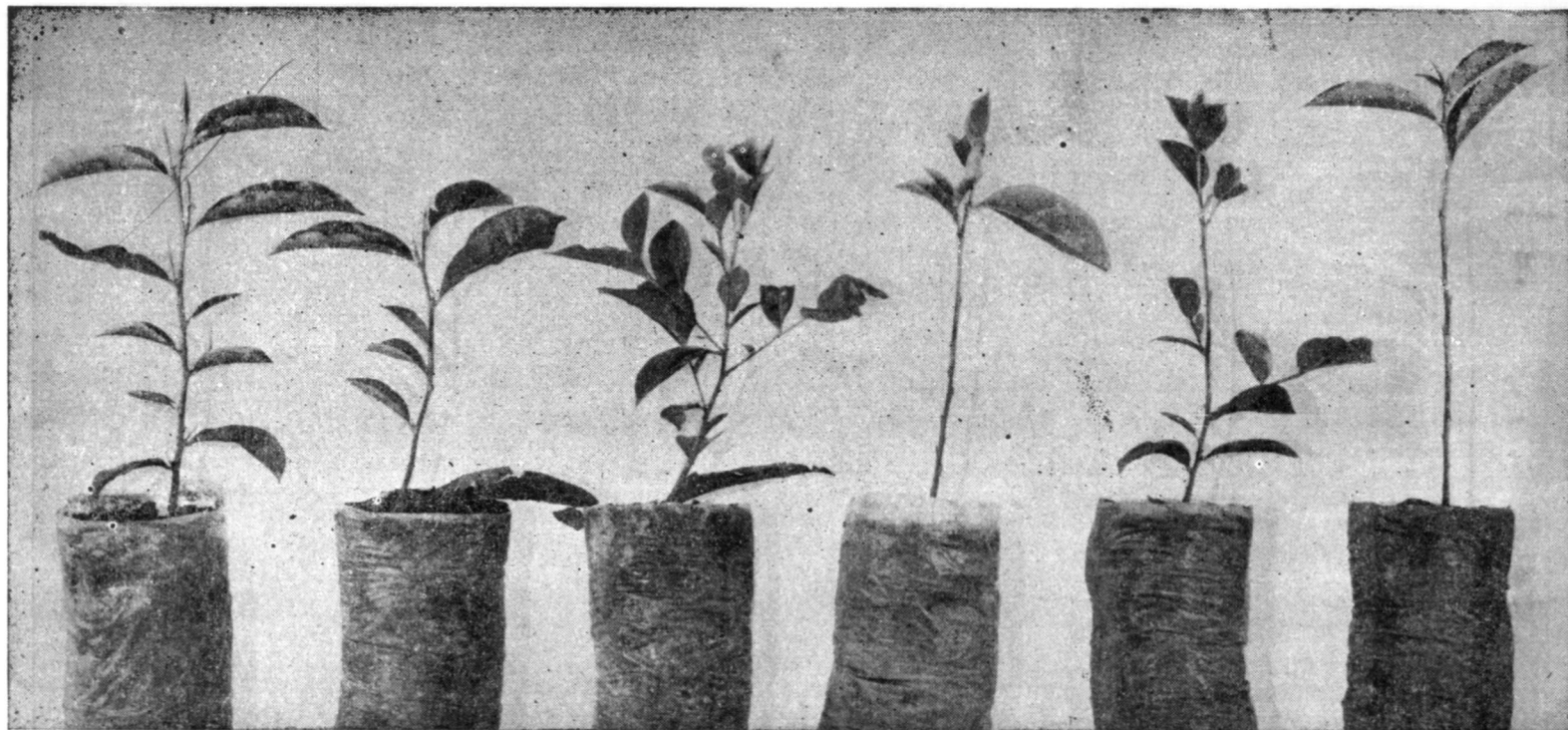


FIG. 1 — *Growth of originally active and dormant set of plants in clone TRI 2025 at 1st assessment.*

Left to right: 1. Control, 2. Terminal bud disbudded, 3. Terminal bud + young leaves removed, 4. Terminal bud disbudded + mature leaves defoliated, 5. Young leaves defoliated, 6. Mature leaves defoliated.

(c) Plants of clone TRI 2025 with originally active terminal buds.



(d) Plants of clone TRI 2025 with originally dormant terminal buds.

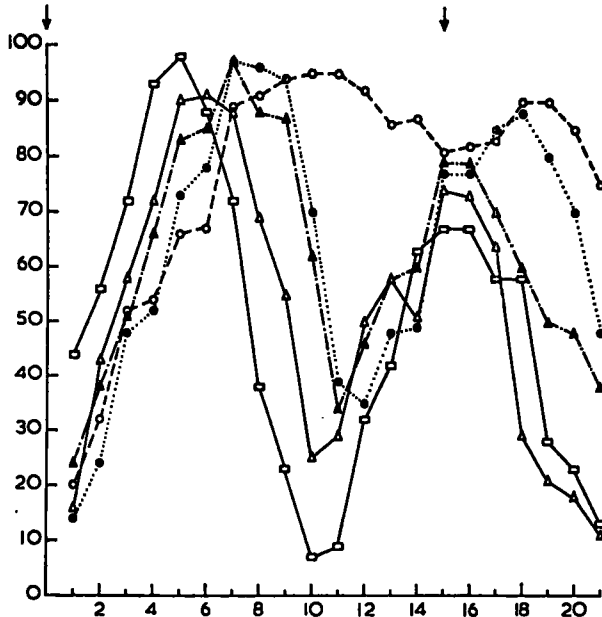


FIG. 2— *Effect of artificial defoliation treatments on percentage of plants with active terminal buds. Arrows indicate time of application of treatments.*

- - -○ = Control
- ...● = 2/3 oldest leaves defoliated
- △- - -△ = 2/3 youngest leaves defoliated
- ▲- - -▲ = 1/3 youngest + 1/3 oldest leaves defoliated
- - -□ = 2/3 of every leaf clipped off.

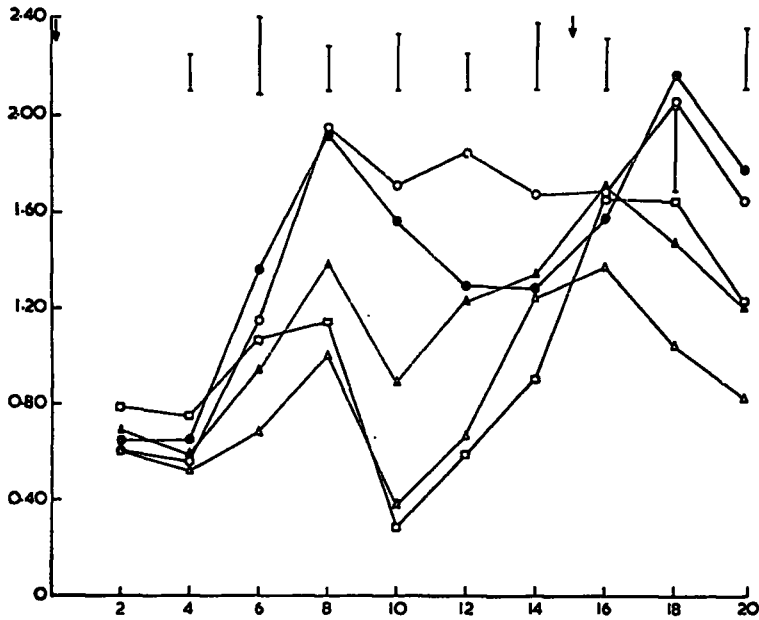


FIG. 3 — *Effect of artificial defoliation treatments on fortnightly increase in mean height. Arrows indicate time of application of treatments. Vertical lines=L.S.D. for $P=0.05$*

- =Control
- =2/3 oldest leaves defoliated
- △—△ =2/3 youngest leaves defoliated
- ▲—▲ =1/3 youngest + 1/3 oldest leaves defoliated
- ◻—◻ =2/3 of every leaf clipped off.

Experiment 2

The percentage of plants with active terminal buds averaged over the fertilizer levels is given in Fig. 2. It will be seen that the treatments caused peaks of activity to be reached comparatively early compared with the undefoliated control, there being two peaks of activity. Generally, defoliation of the oldest leaves delayed the peak of activity. Subsequent bud activity was, however, depressed by all treatments. Repeating the treatments did not affect subsequent bud activity.

Differences in height as a result of some treatments were significant four weeks after the treatments were first given (Fig. 3). In general, defoliation of the youngest leaves, the youngest leaves plus the oldest leaves and clipping off two thirds of every leaf depressed the height of plants while defoliation of the oldest leaves did not markedly affect the height of plants. Growth was similarly affected when the treatments were repeated.

Defoliation of the youngest leaves depressed leaf production during the 1st, 3rd and 4th month. Defoliation of the oldest and the youngest plus the oldest leaves depressed leaf production during the 1st month while clipping off two thirds of each leaf depressed leaf production during the 3rd and 4th month (Table 7). Defoliation of the oldest leaves, and the youngest leaves plus the oldest leaves increased leaf production during the 2nd month. Repeating the treatments depressed leaf production in all treatments. No differences in plant height or leaf production were noticed between the levels of fertilizer used.

At the first assessment done 15 weeks after the treatments were given, clipping off two thirds of every leaf increased the number of side shoots and total leaf production on the main and side shoots (Table 8). Removal of the youngest leaves and the youngest leaves plus the oldest leaves also increased leaf production. Removal of the oldest leaves produced shorter side shoots. Removal of the youngest leaves and the youngest leaves plus the oldest leaves depressed the dry weight of stems. In addition, removal of the youngest leaves reduced the dry weight of the tops, the roots and the entire plant. Clipping off two thirds of every leaf reduced the dry weight of the roots and of the entire plant.

The F4 level of fertilizer increased the dry weight of the stems, the tops and the total weight of plant compared with the F2 level.

At the final assessment done seven weeks after the first assessment, clipping off two thirds of every leaf increased the number of side shoots (Table 9). The

TABLE 7 — *Effect of partial defoliation on monthly mean differences in total leaf number per plant on the main stem averaged over the fertilizer levels*

Treatments	Weeks	Total leaf number (Transformed \sqrt{n} data)				
		4	8	12	15	22*
Control	...	0.81 (0.66)	1.51 (2.28)	1.57 (2.46)	1.51 (2.28)	1.34 (1.80)
—2/3 oldest leaves	...	0.36 (0.13)	2.01 (4.04)	1.59 (2.53)	1.59 (2.53)	0.50 (0.25)
—2/3 youngest leaves	...	0.46 (0.21)	1.62 (2.62)	0.93 (0.86)	1.17 (1.37)	0.53 (0.28)
—1/3 youngest + 1/3 oldest leaves	...	0.35 (0.12)	1.82 (3.31)	1.58 (2.50)	1.30 (1.69)	0.47 (0.22)
Clipping off 2/3 of every leaf	...	0.87 (0.76)	1.47 (2.16)	0.66 (0.44)	0.84 (0.71)	1.01 (1.02)
L.S.D. ($P=0.05$)	...	0.21	0.14	0.21	0.28	0.31

* Treatments were repeated at the end of 15 weeks.

TABLE 8 — *Effect of partial defoliation in relation to age of leaves (means of 40 plants) and fertilizer levels (means of 20 plants) on growth and dry matter production at 1st assessment (Figures in parentheses indicate back-transformed numbers)*

Treatments	Side shoots Number \sqrt{n}	Length (cm)	No. of leaves fallen + retained on main + side shoots \sqrt{n}	Dry weight (g)				
				Stems	Leaves	Tops	Roots	Plant
Control ...	2.76 (7.62)	72.69	7.16 (51.27)	4.74	3.35	8.09	3.04	11.13
— 2/3 oldest leaves	2.83 (8.01)	57.71	7.18 (51.55)	4.71	3.60	8.31	2.96	11.27
— 2/3 youngest leaves	2.76 (7.62)	62.98	7.89 (62.25)	3.33	2.84	6.17	2.02	8.19
— 1/3 youngest + 1/3 oldest leaves	2.80 (7.84)	74.45	7.76 (60.22)	3.80	3.84	7.64	3.18	10.82
Clipping off 2/3 of every leaf ...	3.31 (10.96)	80.95	8.72 (76.04)	4.42	2.93	7.35	2.49	9.84
L.S.D. ($P=0.05$) ...	0.21	12.07	0.50	0.59	0.63	0.96	0.47	1.11
Between fertilizer treatments:								
F2 ...	2.91 (8.47)	66.53	7.66 (58.68)	3.70	3.20	6.90	2.66	9.56
F4 ...	2.87 (8.24)	72.98	7.82 (61.15)	4.70	3.42	8.12	2.81	10.93
L.S.D. ($P=0.05$) ...	NS	NS	NS	0.38	NS	0.61	NS	0.70

TABLE 9 — *Effect of partial defoliation in relation to age of leaves (means of 40 plants) and fertilizer levels (means of 20 plants) on growth and dry matter production at 2nd assessment. (Figures in parentheses indicate back-transformed numbers)*

Treatments	Side shoots Number \sqrt{n}	Length (cm)	No. of leaves fallen + retained on main + side shoots \sqrt{n}	Dry weight (g)				
				Stems	Leaves	Tops	Roots	Plant
Control ...	3.06 (9.36)	95.00	9.72 (94.48)	10.71	8.87	19.58	7.61	27.19
— 2/3 oldest leaves	3.18 (10.11)	102.56	10.08 (101.61)	6.29	6.60	12.89	4.83	17.72
— 2/3 youngest leaves ...	3.29 (10.82)	95.67	9.77 (95.45)	7.52	6.38	13.90	6.32	20.22
— 1/3 youngest + 1/3 oldest leaves	3.11 (9.67)	100.63	10.00 (100.00)	9.71	7.91	17.62	6.14	23.76
Clipping off 2/3 of every leaf ...	3.56 (12.67)	106.15	10.26 (105.27)	8.67	6.88	15.55	7.85	23.40
L.S.D. ($P=0.05$) ...	0.27	NS	NS	0.92	1.15	1.56	1.60	2.67
Between fertilizer treatments:								
F2 ...	3.24 (10.50)	97.58	9.84 (96.83)	7.83	6.21	14.04	6.25	20.29
F4 ...	3.23 (10.43)	102.43	10.09 (101.81)...	9.32	8.45	17.77	6.86	24.63
L.S.D. ($P=0.05$) ...	NS	NS	NS	0.58	0.73	0.99	NS	1.69

TABLE 10a — Interactions between partial defoliation and levels of fertilizer on increase in height and dry matter production at the 1st assessment

Treatments	Increase in height (cm)		Dry weight (g)							
			Stems		Tops		Roots		Plant	
	F2	F4	F2	F4	F2	F4	F2	F4	F2	F4
Control ...	1.91	1.77	3.02	6.44	6.34	9.82	2.10	3.98	8.44	13.80
— 2/3 oldest leaves ...	1.46	1.13	5.02	4.41	8.81	7.81	2.89	3.04	11.70	10.85
— 2/3 youngest leaves ...	0.41	0.71	3.09	3.57	5.57	6.77	2.21	1.83	7.78	8.60
— 1/3 youngest + 1/3 oldest leaves ...	1.29	1.16	2.73	4.87	6.66	8.61	3.38	2.97	10.04	11.58
Clipping off 2/3 of every leaf ...	0.46	0.73	4.64	4.20	7.11	7.60	2.73	2.25	9.84	9.85
L.S.D. ($P=0.05$) ...	0.22		0.84		1.35		0.67		1.57	

TABLE 10b — Interactions between partial defoliation and levels of fertilizer on difference in leaf number and dry matter production at the 2nd assessment. (Figures in parentheses indicate back-transformed numbers)

Treatments	Difference in leaf number		Dry weight (g)							
	\sqrt{n}		Stems		Leaves		Tops		Plant	
	F2	F4	F2	F4	F2	F4	F2	F4	F2	F4
Control	0.88 (0.77)	1.80 (3.24)	7.37	14.06	5.79	11.95	13.16	26.01	20.21	34.18
— 2/3 oldest leaves	0.45 (0.20)	0.54 (0.29)	6.35	6.23	5.38	7.82	11.73	14.05	15.11	20.33
— 2/3 youngest leaves	0.62 (0.38)	0.45 (0.20)	7.68	7.36	6.43	6.33	14.11	13.69	21.12	19.31
— 1/3 youngest + 1/3 oldest leaves	0.50 (0.25)	0.45 (0.20)	9.38	10.03	7.71	8.11	17.09	18.14	22.61	24.90
Clipping off 2/3 of every leaf	1.03 (1.06)	0.99 (0.98)	8.40	8.95	5.72	8.05	14.12	17.00	22.40	24.42
L.S.D. ($P=0.05$)	0.44		1.30		1.62		2.21		3.77	

defoliation and clipping treatments reduced the dry weight of the stems, the tops and of plants compared with the control. Removal of the oldest leaves, the youngest leaves and clipping off two thirds of every leaf reduced the dry weight of leaves. Removal of the oldest leaves reduced the dry weight of roots. The F4 level of fertilizer increased the dry weight of stems, leaves, tops and the total weight of the plant.

In the first assessment a significant interaction between levels of fertilizer and leaf treatments was noted for increase in plant height (12th week) and for dry weight of stems, tops, roots and the entire plant (Table 10a). At the second assessment also there was a significant interaction between levels of fertilizer and leaf treatments for increase in leaf number (22nd week) and for dry weight of stems, leaves, tops and plant (Table 10b).

DISCUSSION

The results of experiment 1 clearly showed that disbudding was effective in producing more and longer side shoots and more leaves on the plant (Tables 2 and 3). The dry weight components of the plant were, however, unaffected and the lateral spread of the plant was achieved by a redistribution of growth. Repeating the treatment was found to be more effective with the slower-growing clone DT1 where the dry weight components of the plant also increased (Tables 4 and 5).

Removing the bud plus young leaves ('thumb-nailing') also resulted in the production of more and longer side shoots with more leaves but this reduced the growth of the slower-growing clone DT1, while the growth of the vigorous clone TRI 2025 was unaffected. This may be due to the smaller leaf area of the slower-growing clone whose photosynthetic capacity became significantly reduced by the operation. Repeating the same operation when the plant has produced more leaves does not affect the dry weight of the plant and from the point of view of early spread appears to be desirable for both clones. If thumb-nailing is to be done on slower-growing clones, it would be advantageous, therefore, to delay the operation until sufficient leaves have been produced on the plant so that the operation does not greatly reduce the leaf area of the plant.

Removal of young leaves alone did not affect clone DT1 but in the vigorous clone TRI 2025 the improved spread obtained in the early stages was achieved at the expense of root growth.

Removal of bud plus mature leaves or mature leaves alone to the extent of about a third on the plant severely arrested growth (Tables 3 and 5). Likewise, the removal of about two thirds of the number of leaves on the plant (Experiment 2) also adversely affected the growth of the plant irrespective of the age of the leaves (Table 9). Clipping two thirds of every leaf resulted in a greater number of side shoots but the growth of the plant was arrested (Tables 8 and 9). Under natural conditions a leaf undergoes abscission only when the leaf yellows as a result of maturation and senescence or when subjected to nutritional or environmental stresses which lead to physiological changes similar to those that occur during normal senescence. In healthy tea plants maturation and senescence are slow processes and abscission does not readily occur. Under good nursery management defoliation should not normally take place and it should, therefore, be possible to raise plants with the full complement of leaves produced being retained on the plant. Defoliation is, however, not uncommon in tea nurseries. While in most instances the underlying causes of defoliation may be readily evident there may be cases where the causes may not be easily recognized.

In nurseries light is not considered a limiting factor once the artificial shade is removed. The results of this investigation clearly show the contribution of the mature leaves to the growth of the plant. It has been shown that every maintenance leaf is capable of making an equal contribution towards the growth of a plucked tea bush (Barua 1961). This is further supported by the work of Sanderson and Sivapalan (1966 *a, b*) who have shown that mature leaves are as efficient in photosynthetically assimilating carbon dioxide as the most efficient immature leaves and because of their large size they have a greater capacity for carrying out this process than the immature leaves. Mature leaves have also been shown to contribute towards the development of new shoots and roots.

Premature defoliation in nurseries should therefore be considered as a serious problem. The agencies which cause premature defoliation are many: Yellow mite, *Hemitarsonemus latus* Banks, defoliating mainly the young leaves; Tea Red Spider mite, *Oligonychus coffeae* Nietner, causing defoliation of mature leaves (Cranham 1966) and diseases like *Cercospora theae* (Petch 1923) which also cause premature defoliation, wind, lack or excess of fertilizer and water, etc. Damage to leaves can be caused by leaf-eating caterpillars, Tea Tortrix, *Homona coffearia* Nietner; the Tea leaf Roller, *Gracillaria theivora* Walsingham (Cranham 1966) which by rolling over the tips of leaves downwards causes a reduction in the photosynthetic area. Leaf cells can be damaged by frost resulting in scorch of young foliage. Some of these factors cause plants to defoliate more rapidly than others. It is important, therefore, to recognise the agency which causes this in time if defoliation is to be prevented. Close supervision of plants is, therefore, one of the essential pre-requisites of good management.

In experiment 2 there was a significant interaction between level of fertilizer and defoliation treatments for the dry weight components of the plant. The dry weight of stems, tops, roots and that of the whole plant were significantly increased at the higher level of fertilizer in the undefoliated control plants (Table 10*a*). In general, all defoliation treatments at the higher level of fertilizer produced less dry matter than the corresponding undefoliated control plants. At the lower level of fertilizer, however, defoliation did not seriously affect growth and some of the treatments even resulted in more dry matter production than that in the undefoliated plants. Increased dry matter production of stems, tops, roots and that of the whole plant was obtained when the oldest (senescing) leaves were defoliated. Clipping two thirds of every leaf also increased the dry weight of stems. Defoliating the youngest leaves plus the oldest leaves increased dry weights of roots and that of the whole plant. It would be clear from the above that with defoliated plants it may perhaps be desirable to reduce the quantity of the fertilizer applied. Furthermore, some of the defoliation treatments at the higher level of fertilizer produced more dry weight than the undefoliated control plant at the lower level of fertilizer used. This further supports the view that plants retaining the full complement of leaves would benefit by higher levels of fertilizer application. In the above experiment no symptoms of scorch were observed in defoliated plants as a result of higher levels of fertilizer being used although this could have occurred if the watering was not supervised closely and if the weather conditions had proved unfavourable.

At the second assessment after repeating the defoliation treatments there was again an interaction between levels of fertilizer and defoliation treatments. The undefoliated control plants continued to show a greater response at the higher level of fertilizer (Table 10 *b*). All defoliation treatments at the higher level of fertilizer resulted in a marked reduction in growth of the plants. Unlike in the first assessment a second removal of the oldest leaves of plants receiving the lower level of fertilizer greatly reduced their growth. It would, therefore, be clear that premature defoliation whatever the cause, reduces leaf area and therefore plant growth.

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