

# PLUCKING PRACTICES IN RELATION TO MAINTENANCE FOLIAGE

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## 1. General

To pluck shoots each consisting of two leaves and a bud for tea making is recognized and normal: but this may be done as soon as the shoot has grown only that much above the fish-leaf (fish-leaf plucking) or it may be done later, when the shoot carries three leaves and a bud (single-leaf plucking). The single leaf that is left behind in the latter method contributes young and active material to the maintenance foliage. It is evident that in fish-leaf plucking the shoots are taken earlier, and the growth potential of the bush can then divert to other shoots, so that increased yield is possible. On the other hand, if the most active part of the maintenance foliage is never allowed to develop at all, there may, in the long run, be a weakening of the whole bush. The question is, therefore, where does the balance of advantage lie? As we shall see, a combination of the two procedures may be best, according to other circumstances.

In this connexion, the part played by the maintenance foliage may be considered somewhat more closely. After the bush has been in plucking for some time, the photosynthetic activity of the leaves in the lower layers of the bush will gradually diminish, as the shade increases from new leaves formed at a higher level. Light conditions will gradually become insufficient for photosynthesis; this is a contributory, if not the main, cause of the continuous fall (abscission) of leaves under the plucking table. The diminished efficiency of the foliage under the plucking table is borne out by the fact that removal of a major portion of it did not decrease the subsequent yield by any large amount (Visser, 1960).

There are also indications that when there is a loss of maintenance foliage carbohydrate production can be kept up because of increased activity of other leaves if the light conditions are improved. This is suggested in the case of side-pruning, where the removal of a part of the bush in dense fields is not followed by a proportionate decrease in yield (Visser, 1960). In one of our earlier trials, the yield of side-pruned bushes was actually higher than that of unpruned bushes (Visser and Tillekeratne, 1958). This phenomenon is attributable both to the predominance of the bush centre as regards yield and also to the increased photosynthesis of the remaining foliage as a result of improved light conditions following side-pruning.

Accordingly, there seems to be a possibility that the bush can be made to yield more by a controlled system of harder plucking, without undue harm to it. Since a number of fish-leaf-plucking trials have reached the stage when appraisal is possible, the question of whether and to what extent one can deviate from the normal plucking standard will be discussed on the basis of the results obtained so far.

## 2. Perennial Fish-leaf Plucking

**HISTORY.**—Eden (1942) started a plucking experiment in September, 1940, to examine the long-term effects of fish-leaf plucking on the tea bush. Since fish-leaf plucking is usual in Assam, it was thought that crop might be needlessly lost by not

adopting some form of this practice in Ceylon. It was realised, however, that the difference in pruning-cycle length was likely to be an important factor. In the annual pruning of Assam, very little wood is removed, whereas in Ceylon, with its longer pruning cycles, a considerable part of the frame is taken away.

Initially fish-leaf plucking seemed to have promising possibilities, judging by the results of the 1st cycle in 1944 (Eden, 1947, 1949), when the fish-leaf-plucked bushes yielded nearly 50% more than normally plucked bushes. On the other hand, the fish-leaf-plucked bushes had formed only about half the wood and less than half the foliage (in terms of prunings) of the normal control. Subsequent yields of bushes plucked to the fish-leaf over the 2nd cycle (unpublished), and the 3rd and 4th cycles (Portsmouth, 1950, 1953) were found to be lower than yields of bushes plucked to the single leaf; and a further decrease in foliage and wood formation was observed.

Following increased manuring with potash and removal of a number of heavy shade trees, fish-leaf-plucked plots yielded more in the 5th (Kehl and Piyasena, 1956) and 6th cycles (Visser, 1960); also foliage growth improved slightly and wood growth considerably.

Since the 3rd cycle, which began in December, 1946, certain treatments were reversed at each cycle (from fish-leaf to single-leaf plucking and *vice versa*) thus making it possible to assess the long-term damage done by fish-leaf plucking. It appeared that a change-over from fish-leaf to single-leaf plucking almost restored the growth potential of the bush in a single cycle (Portsmouth, 1950; Kehl and Piyasena, 1956; Visser, 1960).

The experiment, whose history has been summarized above, completed its 6th cycle (of 3 years) in November, 1958, and has now been discontinued. Previous reports have been short, so the data on the 4th, 5th and 6th cycles, will now be presented and discussed in greater detail.

EXPERIMENTAL RESULTS.—The plucking treatments tested were:

- (a) S S — continuous single-leaf plucking.
- (b) F F — continuous fish-leaf plucking.
- (c) S F — single-leaf plucking in the previous cycle, fish-leaf plucking in the next cycle.
- (d) F S — fish-leaf plucking in the previous cycle, single-leaf plucking in the next cycle.

All treatments were tested at two levels of nitrogen application (4 replicates per treatment). The results obtained in the last 3 cycles are given in Table 1. Differences are regarded as significant at a level of  $P=0.05$  or less and this level of difference is shown in a separate line labelled "Sign. diff.". The foliage and the wood referred to in Table 1 are those from the prunings.

TABLE 1.—*Flush, foliage, and wood production, as affected by the method of plucking, in lb. dry weight/acre/cycle of 3 years. Figures in brackets are the amounts expressed as percentages of S S, the control.*

4th cycle: 10/49—11/52

Treatments	Flush	Foliage	Wood
S S	2208 (100.0)	3284 (100.0)	5836 (100.0)
F S	1931 ( 87.5)	3072 ( 93.5)	5496 ( 94.2)
F F	1993 ( 90.3)	976 ( 29.7)	1584 ( 27.3)
S F	2326 (105.3)	1064 ( 32.3)	1692 ( 29.0)
Sign. diff.	104 ( 4.7)	217 ( 6.6)	1259 ( 21.6)

Potash then increased and *Albizia* shade removed

5th cycle: 11/52—11/55

Treatments	Flush	Foliage	Wood
S S	3471 (100.0)	3232 (100.0)	8648 (100.0)
F S	3056 (88.0)	3192 (98.8)	7676 (88.8)
F F	4042 (116.5)	1020 (31.6)	2388 (27.6)
S F	4920 (141.7)	1148 (35.5)	2927 (33.8)
Sign. diff.	459 (13.2)	463 (14.3)	1126 (13.0)

6th cycle: 11/55—11/58

Treatments	Flush	Foliage	Wood
S S	3495 (100.0)	2716 (100.0)	7032 (100.0)
F S	3113 (89.1)	2644 (97.3)	6212 (88.3)
F F	3779 (108.1)	936 (34.5)	1708 (24.3)
S F	4513 (129.1)	1172 (43.2)	2204 (31.1)
Sign. diff.	357 (10.2)	374 (13.8)	488 (14.1)

**EFFECT OF MANURING.**—Comparing the results of the 4th and 5th cycles presented in Table 1, there was a marked beneficial effect from increased potash manuring (from 20 to 40 lb./acre/year) and from removal of the heavy *Albizia* trees at the start of the 5th cycle. Single-leaf-plucked plots (S S & F S) yielded on the average 58% more flush and 44% more wood (from prunings) and fish-leaf-plucked plots yielded 111% more flush and 62% more wood in the 5th cycle than in the 4th cycle. It is evident that the fish-leaf-plucked bushes benefited much more from the changed conditions of experiment than single-leaf-plucked bushes. Continuous plucking to the fish leaf, which in the 2nd, 3rd and 4th cycles decreased yield, produced in the 5th cycle significantly more flush than plucking to the single leaf.

It is quite probable that, apart from the favourable effect of increased potash application, the decrease in shade also played a part in enhancing the results of fish-leaf plucking. The maintenance leaves from a fish-leaf-plucked bush, with its thinner plucking table, are likely to profit more from the improved light conditions than bushes plucked to the single leaf.

The effect of increased potash manuring and decreased shade on maintenance foliage was negligible—average increases of only 2.5% and 6.3% for fish-leaf and single-leaf bushes respectively. This is not unexpected as the amount of foliage present on the bush is mainly determined by the type of plucking and by light conditions under the plucking table. Although the changed conditions (more potash and less shade) greatly encouraged flush production and thus increased the number of maintenance leaves left, light conditions for the lower layers of maintenance foliage would become too low sooner and lead to a higher rate of leaf fall.

Yield trends in the 6th cycle were very similar to those observed in the 5th cycle, but total growth was about 15% less for all treatments taken together, possibly due to less favourable climatic conditions in this cycle.

All four plucking treatments were tested at two levels of nitrogen, namely 40 and 80 lb. N/acre/year. The rates for phosphate (20 lb./acre) and potash (initially 20, later 40 lb./acre) were the same in both cases. The double dosage of nitrogen over the last three cycles increased the production of flush by 8–10%, of foliage by 9–12%, and of wood by 9–19%; significant interactions between nitrogen level and plucking treatment did not occur in any single instance. Under the conditions of the experiment, potash and shade rather than nitrogen seem to have determined the relative effect of the *type of plucking* on growth, particularly flush and wood production.

**EFFECT OF PLUCKING METHOD.**—Apart from the favourable influence on yield of increased potash manuring and decreased shade, it is noteworthy that the main effects of the plucking treatments (see Table 1) have remained qualitatively the same over the past 9 years. This indicates that the bushes have reached a stage where treatment and response have become balanced. After the change-over from fish-leaf to single-leaf plucking, the bushes gave nearly as much maintenance foliage as with continuous normal plucking, but the bushes had not quite overcome the after-effects of previous fish-leaf plucking, for growth in terms of flush and wood was about 12% less than that of single-leaf-plucked bushes.

The change over from single-leaf to fish-leaf plucking produced in all instances more flush than plots plucked normally, presumably because the bush can draw upon reserves built up during the preceding cycle. Foliage and wood formation were somewhat better than those of bushes fish-leaf plucked throughout, but both treatments produced only about one-third of the prunings obtained from normally plucked bushes.

TABLE 2.—Yields of flush from continuously fish-leaf and single-leaf-plucked bushes over 6 cycles (1941-1958)

Plucking method	1st cycle	2nd cycle	3rd cycle	4th cycle	5th cycle	6th cycle	Total over 18 years
Fish leaf	4430	1196	2006	1993	4042	3779	17446
Single leaf	3020	1492	2435	2208	3471	3495	16121
Difference	+1410	-296	-429	-215	+571	+284	+1325

As regards the long-term effect of the two main plucking treatments on yield, it can be seen from Table 2 that continuous fish-leaf plucking for 18 years yielded 8% more flush than continuous plucking to the single-leaf. This is rather surprising, taking into account the frame deterioration and the fact that the fish-leaf-plucked bushes yielded at pruning only about one-third of the maintenance foliage present on single-leaf-plucked bushes. Evidently, flush production has partly been maintained at the expense of shoot (wood) growth. The other factor which probably contributed to the undiminished flush yield is the enhanced photosynthetic activity of the maintenance foliage. Light conditions in fish-leaf-plucked bushes—due to the thin plucking table—are better and remain favourable for photosynthesis longer than in normally plucked bushes.

With respect to the long-term effect of perennial fish-leaf plucking in alternate cycles it appeared that it had given, over the 12 years of the test (since 1946), 19% more yield on the average than normal plucking throughout.

**RECOVERY AND STARCH RESERVES.**—Table 3 gives an indication of recovery in terms of tipping weights recorded after pruning.

TABLE 3.—Dry weights of tipplings in lb./acre determined following pruning after completion of the 5th and 6th cycles.  
For meaning of symbols, see text relating to Table 1.

Plucking treatments	After 5th cycle	After 6th cycle
S S	754 (100.0)	579 (100.0)
F S	665 ( 88.2)	439 ( 75.8)
F F	197 ( 26.1)	312 ( 53.9)
S F	637 ( 84.5)	422 ( 72.9)
Sign. diff.	90 ( 11.9)	74 ( 12.8)

The figures show that the bushes subjected to alternating treatments (S F and F S) recovered after pruning equally well, irrespective of whether they had been previously plucked to the fish-leaf or to the single-leaf, and notwithstanding the fact that the treatments had markedly different effects on foliage and wood growth in the preceding cycle.

Presumably, the constant treatment over *several* cycles produced a balanced framework and root system which was not significantly altered by a change in treatment in *one* cycle only. This is also borne out by the fact that the amount of tippings removed after the *first* cycle of the experiment was the same for fish-leaf and single-leaf-plucked plots, although fish-leaf plucking decreased total growth by one-third (Eden, 1947, 1949).

Recovery of those bushes that were continuously fish-leaf-plucked was significantly slower than that of bushes fish-leaf-plucked in alternate cycles and still slower than that of normally plucked bushes.

As regards the starch reserves of the differently plucked bushes, (Eden, 1944, 1945) determined starch indices during the first cycle; they indicated that roots of fish-leaf-plucked bushes contained almost the same amount of starch as those from single-leaf-plucked bushes. Actual starch contents were determined twice during the first year of the 7th cycle, at 7½ and 13 months after pruning, when the bushes had been plucked for 2½ months (10 plucks) and 8 months (29 plucks).

TABLE 4.—Starch reserves (in % of dry weight) of roots of bushes continuously plucked to the fish-leaf and single-leaf respectively.

Type of plucking	1st Sample August, 1959	2nd Sample January, 1960
Fish leaf ...	16.2	18.8
Single leaf ...	13.1	20.6
Sign. diff. at P=0.05 ...	2.8	4.7

Table 4 shows that roots of fish-leaf-plucked bushes contained initially a significantly higher percentage of starch than single-leaf-plucked bushes. This is presumably the result of slower recovery—slower mobilization of reserves—in the former case, as can be derived from the total weight of tippings and flush intake recorded up to the date of sampling; for fish-leaf-plucked bushes these were 32% less than for bushes plucked to the single-leaf. Further evidence of an inverse relation existing between percentage of starch reserves and recovery rate was furnished by the existence of a *negative* correlation between starch contents and yields (tippings + flush) of the individual plots amounting to  $-0.4532$  (just not significant at  $P=0.05$ ).

Sampling of the bushes when they were in full plucking showed that roots of single-leaf-plucked bushes tended to contain higher percentages of starch than fish-leaf-plucked bushes; this is presumably due to the presence of more maintenance foliage in the normally plucked bushes.

When comparing the data of the two samplings, it would seem that between 8 and 13 months elapse after pruning before the bushes have reached the stage in which starch reserves have been restored (see also Table 8 and page 45).

FLUSH AND BANJI FORMATION.—The proportions of flush and of banji shoots, and their weights, were determined throughout the 6th cycle. The data for 7 alternate plucks recorded in the same period in the 1st, 2nd and 3rd years after

pruning (in November, 1955) are given in Table 5. This table presents the averages for the two single-leaf-plucked and the two fish-leaf-plucked treatments, irrespective of the treatment in the previous cycle. It appeared that the type of plucking in the preceding cycle had no effect on subsequent flush and banji growth in the next cycle.

TABLE 5. -Flush and banji shoot weights as affected by plucking methods and by time after pruning (fresh weights in mg.)

Period	Flush weight		Banji weight		Avg. weight*		% Banji	
	S	F	S	F	S	F	S	F
8/56--11/57	684	578	503	447	659	543	23.5	29.4
8/57--11/57	497	409	430	366	463	384	31.8	58.1
8/58--11/58	481	408	467	406	474	407	52.0	62.0

S - perennial single-leaf plucking. F - perennial fish-leaf plucking.

\*Based on total weight and total number of shoots of 7 samples.

Table 5 indicates that fish-leaf-plucking adversely affected the sizes of flush and banji shoots; they were on average 15% lighter than pluckable shoots from single-leaf-plucked bushes. Fish-leaf plucking also increased the proportions of banji shoots in the crop.

It is worthy of note that in the 1st year after pruning, shoot weights were much higher and banji percentages much lower than in the 2nd and 3rd year. Banji shoots are in all instances lighter than flush shoots, but the difference in weight tended to decrease with age after pruning (see also page 46).

### 3. Limited Fish-leaf Plucking

As it was clear from the results of the long-term plucking experiment that perennial fish-leaf plucking was detrimental to the bush, two experiments—one in the low country and one up-country—were initiated in 1955 and 1956 (Visser, 1957, 1959), with the object of investigating the practical possibilities of limited fish-leaf plucking.

The principal difference between these trials and the older experiment was that the bushes were normally plucked for some time after pruning in order to allow them to develop a fair canopy of maintenance foliage before fish-leaf plucking began.

#### 3.1 The St. Coombs Experiment.

EXPERIMENTAL. -This trial was laid out in August, 1955, and consisted of the following treatments (each replicated 5 times), manured at a ratio of 8 and 12 lb. N/100 lb. tea respectively (N:P:K=8:4:5):

- (a) S S S S S - continuous plucking to the single-leaf.
- (b) S S F F - nearly 2 years normal plucking (10/55-8/57) followed by 2 years fish-leaf plucking until pruning (9/59).
- (c) S F F F/R - 10 months single-leaf plucking (10/55-8/56) followed by 2½ years fish-leaf plucking (8/56-3/59) and then rested for 6 months until pruning.
- (d) S F F F/S - 10 months single-leaf plucking followed by 2½ years (8/56-2/59) fish-leaf plucking and then, after 1 month of resting, single-leaf plucked again (6 months) until pruning.

Twice during the experiment the canopy of the fish-leaf-plucked bushes was considered unsatisfactory (due to drought and mites); the bushes were then rested for 2 rounds and 1 round was plucked normally before fish-leaf plucking was resumed.

The experiment completed its first cycle of 4 years in September, 1959; the yields obtained in the individual years have been reported elsewhere (Visser, 1960). The total yield, the amount of residual maintenance foliage and wood obtained from the prunings, and the tipping weights recorded after pruning, are shown in Table 6.

TABLE 6.—*Cycle yield, foliage and wood production, and tipplings, as affected by restricted fish-leaf plucking, in lb. dry weight per acre: the symbols are explained in the text*

Treatment	Flush	Foliage	Wood	Tipplings
(a) S S S S ...	4409 (100.0)	4025 (100.0)	11775 (100.0)	568 (100.0)
(b) S S F F ...	5671 (128.6)	3325 (82.4)	9275 (78.8)	614 (108.1)
(c) S F F F/R ...	5756 (130.6)	5050 (125.5)	8125 (68.9)	553 (97.4)
(d) S F F F/S ...	5960 (135.2)	3850 (95.7)	8125 (68.9)	605 (106.5)
Sign. diff. ...	227 ( 5.1)	750 ( 18.6)	2000 ( 17.0)	57 ( 10.0)

It can be seen from Table 6 that fish-leaf plucking preceded by 1 or 2 years single-leaf plucking gave between 1,260 lb. and 1,550 lb. of tea per acre per cycle more than single-leaf plucking throughout. The amount of maintenance foliage at the time of pruning was for plots (b), fish-leaf plucked for 2 years, significantly lower, and for plots (c), rested at the end of cycle, significantly higher than that of the control (a); the foliage of bushes on plots (d), single-leaf plucked at the end of the cycle, was approximately the same as in the control.

As regards wood growth, fish-leaf plucking during part of the cycle had a significant depressing effect which was greater, the longer the period of fish-leaf plucking (Table 6).

However, when comparing the depressing effects of limited and perennial plucking (after one cycle), it is clear that limited fish-leaf plucking has been much less harmful to the bush than perennial (Table 7).

TABLE 7.—*Relative effect of perennial and limited fish-leaf plucking on foliage and wood production (in terms of prunings) after the 1st cycle of 4 years*

Fish-leaf plucking	Foliage <sup>3</sup>	Wood <sup>3</sup>
Limited <sup>1</sup> ...	80	79
Perennial <sup>2</sup> ...	37	54

1. Two years normal and 2 years fish-leaf plucking.
2. Figures obtained from Eden (1949).
3. Foliage and wood expressed in percentages of that of single-leaf-plucked bushes.

Bushes where fish-leaf plucking was preceded by normal plucking carried more than twice as much maintenance foliage by the end of the pruning cycle as did bushes fish-leaf-plucked throughout. As it can be assumed that, during the fish-leaf plucking stage, not much foliage is added, it would appear that a considerable

part, if not the greater part, of the foliage present at the time of pruning must have been formed two years previously when the bushes were plucked to the single leaf. With respect to bushes plucked continuously to the fish-leaf (1st cycle), Eden (1947) remarked that the foliage remained almost static from the time of tipping. This means that the maintenance leaves on fish-leaf-plucked bushes are subject to a very much lower abscission rate than those on normally plucked bushes, as a result of the better light conditions in the plucking table.

**RECOVERY AND STARCH RESERVES.**—Judging by the recovery of the bushes, which in terms of tipping weights (Table 6) was approximately the same for all treatments, fish-leaf plucking during part of the cycle does not seem to have impaired the health of the bushes.

Further information about the condition of the bushes was sought by determining the starch content of roots of certain treatments at the time of pruning, at the end of 4 years plucking, and about 4 months later when the bushes had reached the tipping stage (Table 8).

TABLE 8.—*Starch contents (in % of dry weight) of roots of bushes continuously single-leaf plucked or fish-leaf plucked during part of the cycle*

Type of plucking		1st Sample Sept. 1959	2nd Sample Jan. 1960
(a) S S S S	...	22.7	12.4
(c) S F F F/R	...	21.6	9.4
(b) S S F F	...	19.9	—
Sign. diff. at P=0.05	a/b a/c	1.7 2.9	2.7

It follows from Table 8 that roots of bushes plucked to the fish-leaf during the 2nd half of the cycle (S S F F) contained at the time of pruning significantly less starch than roots of continuously single-leaf-plucked bushes. Resting for half a year before pruning enhanced the starch reserves; the starch content of the fish-leaf-plucked and rested bushes (S F F F/R) did not significantly differ from that of the control.

The second sampling done at tipping time shows a marked depletion of reserves following recovery after pruning. The starch reserves of the fish-leaf-plucked and rested bushes were significantly lower than those of the control. This does not necessarily mean that the health of the former bushes was impaired; it may in fact point to a quicker mobilisation of reserves (see comments on Table 4, page 42).

**MANURIAL RESPONSE.**—With respect to differences in response to manuring at the 8 and 12 lb. N ratio, it appears that the higher ratio increased flush production by 15 to 21%; there was no interaction between manuring and plucking treatment. The increased rate of manuring (per 100 lb. tea) increased the weight of prunings of single-leaf-plucked bushes by 6%, but was accompanied by an average decrease of 12% with bushes fish-leaf-plucked for part of the cycle.

A similar phenomenon was observed in the trial at Endane (see page 47). It seems quite likely that the fish-leaf-plucked bushes treated at the higher ratio were slightly over manured, because they received about 20% more manure *per acre* while producing less growth (flush + foliage + wood) than single-leaf-plucked

bushes. Growth may have been adversely affected, either directly by such an overdose (or possibly that of one of the components of the mixture) or indirectly if the overdose limited the uptake of other elements.

As an increase in nitrogen or potash application *only* had a favourable effect in the long-standing plucking experiment it may be that too much phosphate was given per acre.

**FLUSH AND BANJI FORMATION.**—At every alternate plucking round, random samples were taken of each plot in order to determine both the proportions of flush and banji shoots in the crop and their individual weights. Table 9 gives the averages of 7 alternate plucking rounds recorded in the 2nd, 3rd and 4th years after pruning (in August, 1956) for two treatments.

TABLE 9.—*Flush and banji shoot weights as affected by time after pruning and by plucking method (fresh weights in mg.)*

Period	Flush weight		Banji weight		Average weight*		% Banji	
	S	F	S	F	S	F	S	F
10/56 — 1/57 ...	586	475	495	444	542	468	48.0	41.5
10/57 .. 1/58 ...	527	443	448	415	488	430	50.5	54.4
10/58 — 1/59 ...	430	393	424	366	430	377	52.7	58.5

S = continuous single-leaf plucking. F = fish-leaf preceded by normal plucking for one year.

\*Based on total weight and total number of shoots of 7 samples.

Table 9 shows that the weights of flush and of banji shoots decrease and the percentage banji increases with time after pruning for both fish-leaf-plucked and single-leaf-plucked bushes. Pluckable shoots from the former were on average 13% lighter than from the latter treatment (average weight 425 and 487 mg.). These observations conform with those of Tubbs (1937) made in a study on shoot growth in relation to time after pruning. The fish-leaf-plucked bushes formed initially less banji shoots, probably due to a stimulating effect following the change over to harder plucking (August, 1956), but later produced more banjis than single-leaf-plucked bushes.

### 3.2 The Endane Experiment.

**EXPERIMENTAL.**—The purpose of this trial was mainly to test pruning cycles of different lengths, comparing at the same time the effect of two manuring ratios and the effect of continuous single-leaf plucking in comparison with limited fish-leaf plucking (Visser, 1957). In the latter case, fish-leaf plucking (preceded by about 6 months single-leaf plucking) commenced 9 months after pruning. The two manuring rates were, as in the St. Coombs experiment, 8 and 12 lb. N per 100 lb. tea, with a mixture of which the proportions were N:P:K = 8:4:5.

The experiment completed a 3-year cycle in September, 1959; the main results—as regards the effect of pruning-cycle length—have been reported elsewhere (Visser, 1960).

**EFFECT OF PLUCKING METHODS.**—Table 10 summarizes the data with respect to the two plucking treatments (of plots pruned every 1½ and 3 years).

TABLE 10.—*The effect of 3 years continuous single-leaf and limited fish-leaf plucking on growth in terms of flush, prunings, tippings, and dieback, in lb. per acre*

Type of plucking	Flush (DW)	Prunings (FW)	Tippings (DW)	Dieback (FW)
Single leaf	4235 (100.0)	20014 (100.0)	169 (100.0)	665 (100.0)
Fish leaf	4858 (114.7)	18102 (90.4)	174 (103.0)	695 (104.5)
Sign. diff. at P=0.05	159 (3.8)	590 (2.9)	Difference not sign.	Difference not sign.

N.B. Figures within parentheses are yields in percentages of control.

DW=dry weight. FW=fresh weight.

It can be seen from Table 10 that limited fish-leaf plucking significantly increased flush yield by about 15% and decreased growth in terms of prunings by about 10%. Bushes fish-leaf plucked for part of the cycle showed recovery which was no different from that of single-leaf-plucked bushes, as can be seen from the fact that tipping and die-back weights recorded after pruning were the same for both treatments.

The increase in yield by limited fish-leaf plucking was approximately half of that obtained at St. Coombs. It is possible that this is due to the lower starch reserves of bushes growing at a low altitude and loss of maintenance foliage as a result of Shot-hole Borer and *Cercospora*.

MANURIAL RESPONSE.—Manuring at a higher rate (12 lb. N/100 lb. tea) had little effect on flush production, resulting in only 4% more crop compared with manuring at the lower rate (8 lb. N). Neither tippings nor die-back weights were significantly affected by increased manuring. The effect on the weight of the prunings depended on the plucking treatments; pruning weight of the single-leaf-plucked bushes increased by 5%, that of fish-leaf-plucked bushes decreased by 5%. The same phenomenon was noticed in the experiment at St. Coombs, possibly indicating over-manuring in the case of fish-leaf-plucked bushes manured at the 12 lb. ratio (see page 45).

#### 4. Discussion and Conclusions

There are several reasons why fish-leaf plucking markedly increases yield

The first factor is that less time is required to form a flush shoot with two leaves and a bud (or an equivalent banji shoot) than to form a shoot with three leaves. The average time it takes to unfold a new leaf on a shoot was found to be 6.3 days by Tubbs (1939), 7.7 days by Visser (1958) and 9.0 days by Portsmouth (1957) or say about a week. It is known (Portsmouth, 1957; Visser, 1958) that development of an axillary bud into a pluckable shoot (of which the single leaf is left when plucked) takes an average of about 77 days up-country (St. Coombs). Accordingly, one may assume that about 10% of the yield increase by fish-leaf plucking is accounted for by the shorter period that the shoot is left on the bush. This is possibly an underestimate, as the growth rate of shoots on fish-leaf-plucked bushes may be higher.

The second and main factor is that fish-leaf plucking very markedly increases the number of plucking points. At St. Coombs where the average yield over the 2nd and 3rd year was about 60% higher (Visser, 1960) and the shoots 13%

lighter, fish-leaf-plucked bushes must have had on the average about 80% more plucking points than single-leaf-plucked bushes. This increase is not due to a greater number of primary shoots, but due to "multiple" shoot growth. That is to say, the axil of a fish-leaf often produces two shoots, while normally only one shoot is formed in the axil of a single leaf. Furthermore, it also happens that dormant buds on the sides of fish leaves previously formed (often abscised at that time) develop into pluckable shoots (in that case, the axil of the apical fish-leaf usually carries only one shoot). The latter rarely happens on single-leaf-plucked shoots, probably partly because single leaves previously formed are already under the plucking table, where light conditions are no longer favourable for photosynthesis, thus impeding bud activity.

On the other hand, maintenance leaves (and fish leaves) of fish-leaf-plucked bushes enjoy good light conditions for a long time because the height of the plucking table increases only slowly. The unimpaired yield capacity of fish-leaf-plucked bushes is undoubtedly partly the result of the enhanced efficiency of the foliage and fish leaves in synthesizing carbohydrates because of the better light conditions. This is also borne out by the fact that starch reserves of roots from fish-leaf-plucked bushes are not much lower, though their foliage is less, than those of single-leaf-plucked bushes. Since its abscission rate is much lower, the foliage of fish-leaf-plucked bushes also remains active longer than that of bushes plucked to the single-leaf.

Last but not least, mention must be made of the fact that fish-leaf plucking stimulates leaf growth at the expense of wood growth. In a sense, hard plucking resembles hard pruning, in so far as it leaves less wood but stimulates the activity of buds which would otherwise remain dormant.

The long-term plucking experiment showed that *continuous fish-leaf-plucking* can be done over many years without losing crop (increase over 18 years was 8%). However, it was abundantly clear that it greatly weakened the bushes and almost certainly must also have been detrimental to soil conditions. Continuous fish-leaf plucking causes a considerable loss in organic material in terms of diminished wood (and root) growth and leaf droppings. The latter loss is estimated to be of the order of 80% as compared with normally plucked bushes (Visser, 1960a). Further, the less dense soil cover provided by fish-leaf-plucked bushes is an unfavourable factor. Accordingly, perennial fish-leaf plucking must stand condemned as a normal estate practice.

*Fish-leaf plucking in alternate cycles* proved to be less harmful, for the bushes all but recovered from the after-effects of fish-leaf plucking in the first cycle in which they were plucked normally. This system of plucking led to a 19% increase in yield over 12 years. The disadvantages are again that the soil cover and the supply of organic material become inadequate in the fish-leaf-plucking cycle.

*Limited fish-leaf plucking*—that is fish-leaf plucking preceded by plucking to the single leaf during the first part of the cycle—appeared to have practical possibilities at *up-country* elevations, as its effect on growth was not unduly detrimental. The best method would seem to be *fish-leaf plucking, preceded by single-leaf plucking for 10 months after tipping, and succeeded by 6 months resting at the end of the (4 years) cycle*: This system increased the yield by 30%. The advantage of resting prior to pruning is that it enhances the carbohydrate reserves which have been reduced by the preceding fish-leaf plucking.

The average starch contents of roots—from bushes in adjacent fields (Tables 4 & 8)—give a fair indication of starch reserves in relation to pruning (Table 11).

TABLE 11.—*Starch percentage of roots at various times after pruning*

Months after pruning	4 <sup>0*</sup> (tipping)	7½ <sup>*</sup>	13 <sup>**</sup>	48 <sup>*</sup> (pruning)
Starch %	10.9	14.6	19.7	21.4

\*August/September 1959.

\*\*January 1960.

They show (Table 11) that the starch reserves at tipping time had been reduced to about half the amount initially present and that at least one year elapses after pruning before the starch reserves of regularly plucked bushes have been built up again. These observations are in fair agreement with those of Tubbs (1935), who deduced from the close relation between variations in flush weight and in the weight of maintenance foliage following recovery that carbohydrate supplies are low for more than a year after tipping when the bush is regularly plucked. Presumably only after this period does the bush attain a sufficiently large leaf area to enable it to balance its reserves. This supports the desirability of allowing the bush to form sufficient maintenance foliage by single-leaf plucking first before fish-leaf plucking commences. Lack of sufficient foliage would also unfavourably affect the growth of the branches (Tubbs, 1932).

*Limited fish-leaf plucking under low-country conditions* led to a smaller increase in yield than up-country (15% increase versus 30%). This can probably be partly attributed to the shorter cycle and partly to the lower starch reserves, while depletion of the maintenance foliage by Shot-hole Borer and *Cercospora* may have played a part as well. However, limited fish-leaf plucking for 3 years did not appear to have harmed the bushes, judging by the facts that the weight of prunings decreased only a little, recovery was unimpaired, and dieback not significantly more than that of single-leaf-plucked bushes. Also, the yields of fish-leaf-plucked bushes showed no tendency to decrease over the 3 years of the experiment; bushes pruned every 1½ years produced in the 1st, 2nd and 3rd years of the trial respectively 5.5, 12.5 and 18.5% more crop than single-leaf-plucked bushes.

With respect to *manuring of high-yielding fish-leaf-plucked bushes*, indications were obtained that the application of a high ratio may be over manuring. The 12 lb. N ratio per 100 lb. tea, though it increased flush, was found to depress wood growth to some extent.

As regards the components of the mixture, phosphate rather than nitrogen or potash may be the depressing factor in our case, where both a high ratio per 100 lb. tea and a high rate per acre (because the yield was high) were applied. On the other hand, an indirect effect of the over-manuring resulting in decreasing the availability of other elements cannot be ruled out.

Estimations of organic material supplied by regularly plucked bushes (Visser, 1960a) showed that single-leaf plucking provided both in the low-country and at up-country altitudes about 1 ton of dry organic matter in the form of leaf droppings and 1 ton in terms of prunings per acre per year. Bushes plucked to the fish-leaf for part of the cycle produced about one quarter less than single-leaf-plucked bushes.

Regarding the effect of fish-leaf plucking on *quality*, it was observed that continuous fish-leaf plucking in the first cycle of the long-term experiment led to a very marked diminution (by 30%) of flush size (Eden, 1947). A preliminary trial (Lamb, 1945) indicated that the colour of teas made from this leaf increased, but strength and quality had declined. Shoot-weight determinations made in the 6th cycle of the older trial and in the first cycle of the newer trial showed that pluckable shoots from fish-leaf-plucked bushes were on the average 13 to 15% lighter than those of single-leaf-plucked bushes. The diminution in flush size, though significant, is much less marked than observed by Eden during the 1st cycle of the older trial, probably because of improved manuring practices since then and the

fact that in our case the bushes were fish-leaf plucked for part of the cycle only. As no tests have been carried out recently, it is not known whether the plucking system affected the made tea.

## 5. Practical Aspects

*Perennial fish-leaf-plucking*, being harmful to the bush, is *not* recommended, except when fields are to be uprooted. When uprooting is planned, continuous fish-leaf plucking is an advantageous practice, as the increased crop (possibly of the order of 50%) will contribute to the costs of replanting. The earlier the fields are earmarked for uprooting, the greater are the benefits that can be reaped.

*Limited fish-leaf plucking* gave, in both high and low country, results which warrant its trial on estates. Up country, an increase of the order of 30%—in our trial, equivalent to 330 lb. tea/acre/year—seems possible if fish-leaf plucking is preceded by 10 months of normal plucking and succeeded by 6 months of resting before pruning in a 4 year cycle. With a cycle of 3 years, more common in the mid-country, the same system could be applied; possibly the period of resting could be shortened to 4–5 months.

Under low-country conditions, fish-leaf plucking for the last 9 months of a 1½-year cycle and preceded by 6 to 7 months of single-leaf plucking after tipping can be expected to yield 10 to 15% more—in our trial equivalent to 200 lb. tea/acre/year more.

It is *essential* that fish-leaf plucking is applied only on mature and vigorous bushes; poor fields should not be subjected to it.

In the low country and the mid-country, where the bushes often suffer from Shot-hole Borer and *Cercospora*, depletion of maintenance foliage can more easily occur than up-country. As also starch reserves are lower, it is *most important* to avoid or correct undue depletion of the maintenance foliage. If this were to occur due to disease, pests, or drought, a few rounds of resting followed by 1 or 2 rounds of normal plucking should be resorted to before fish-leaf plucking is resumed.

Where our trials have shown that fish-leaf plucking for about half the cycle is not detrimental to the bush, then naturally fish-leaf plucking for a few months in the year is not likely to harm the bush either. In fact it is common practice on many estates to fish-leaf pluck during the rush season and pluck to the single leaf for the rest of the year.

It seems to me, however, that the reverse of this procedure would be advantageous under certain circumstances. Crop intake during the rush season is often already so high that it taxes the capacity of the factory; fish-leaf plucking then aggravates this problem. Instead, normal plucking during the rush season followed by fish-leaf plucking in the flavoury (dry) season would have the advantage that it would tend to reduce the crop when the yield is high and prices are low, and increase the crop when it is normally low but prices are better.

Fish-leaf plucking during the dry season may assist in counteracting the effects of drought by decreasing evaporation; it is in any case more profitable than stripping which is sometimes advocated during severe droughts.

Attention must also be drawn to *breaking-back* and *plucking below the table*. Both practices—which amount to harder plucking—have been found to increase yield substantially (Eden, 1945; Visser, 1960; Visser and Tillekeratne, 1958).

Plucking below the table should be applied with discrimination (healthy bushes only!) and tried out according to the following principles:—

- (a) plucking below the table only around the *periphery* during the first 14–16 months after tipping only, to restrict the size of the bush in fields which are densely planted or where bushes expand to such an extent that movement through the rows becomes difficult later in the cycle;

- (b) plucking below the table in the *centre* should *not* be applied during the first 10 to 14 months after tipping, because it is important that the bush forms a good canopy of foliage first;
- (c) plucking below the table should *not* be applied *at all* in fields which are to be fish-leaf plucked later.

Although plucking below the table is not normally done in Ceylon, it is noteworthy that pluckers on some estates in Indonesia were specifically trained to do so. On theoretical grounds the practice seems sensible, because shoots formed below the plucking table are not likely to contribute for long to the synthesis of carbohydrates, since light conditions will quickly become unfavourable there.

With respect to *manuring* of bushes fish-leaf plucked for part of the cycle, the application of the same ratio and mixture normally applied was found to give satisfactory results. Some indications were obtained that a rather high ratio— in our case 12 lb. N per 100 lb. tea— slightly depressed wood growth, possibly because too much phosphate is then applied. It should not be forgotten that when manuring is calculated as a ratio to crop, since fish-leaf plucking increases the yield, much more manure is applied *per acre*, although *total growth* (flush, foliage, wood) will tend to be less than that of normally plucked bushes.

Since conditions differ from place to place, planters, particularly in the mid-country, would be well advised first to try out the methods of plucking discussed here on one field, in order to assess the effects under their own conditions before applying them to large acreages. Practical trial is certainly worth while, for the rewards may be substantial.

Undoubtedly, problems of management will play a significant part and will have to be considered; can labour be trained and disciplined to do fish-leaf plucking today, and single-leaf plucking tomorrow? If they can anywhere, surely they can in Ceylon.

### Summary

1. By fish-leaf plucking is meant plucking the tea shoot as soon as it has two leaves and a bud; when the shoot is allowed to grow more, so that plucking two leaves and a bud leaves a young leaf behind, that is called normal or single-leaf plucking.

2. Fish-leaf plucking prevents the continuous addition to the maintenance foliage of young leaves, an addition that is characteristic of single-leaf plucking; in the long run, continuous fish-leaf plucking harms the bush, but it takes a long time to do so.

3. Fish-leaf plucking always gives a bigger crop.

4. If fish-leaf plucking is practised for one pruning cycle or less, normal treatment readily brings the bush into condition again. Such ill-effects as there are can be guarded against by normal plucking for some time after tipping, and by resting before pruning.

5. Fish-leaf plucking can be very profitable for two to four years up-rooting tea; it can be used to help to smooth out yield over the year by applying it in the dry season, plucking normally in the rush season; and, by careful management, it can be intermittently applied to increase crop.

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## References

- EDEN, T. (1942). Report of the Agricultural Chemist for 1941. *Bull. Tea Res. Inst. Ceylon*, no. 23: 56-57.
- EDEN, T. (1944). Report of the Agricultural Chemist for 1943. *Bull. Tea Res. Inst. Ceylon*, no. 25: 44-45.
- EDEN, T. (1945). Report of the Agricultural Chemist for 1944. *Bull. Tea Res. Inst. Ceylon*, no. 26: 42-43.
- EDEN, T. (1947). The effects of hard plucking (with special reference to Blister Blight). *Tea Quart.* 19: 105-109.
- EDEN, T. (1949). Work of the Agricultural Chemistry Department of the Institute, 1927-1948. *Tea Res. Inst. Ceylon, Monograph* no. 1: 25-27.
- KEHL, F. H. & PRYASENA, M. (1956). Report of the Plant Physiology Department for 1955. *Bull. Tea Res. Ceylon*, no. 37: 48-49.
- LAMB, J. (1945). Report of the Biochemist for 1944. *Bull. Tea Res. Inst. Ceylon*, no. 26: 62.
- PORTSMOUTH, G. B. (1950). Report of the Plant Physiologist for 1949. *Bull. Tea Res. Inst. Ceylon*, no. 31: 36-37.
- PORTSMOUTH, G. B. (1953). Report of the Plant Physiologist for 1952. *Bull. Tea Res. Inst. Ceylon*, no. 34: 38-39.
- PORTSMOUTH, G. B. & RAJIAH, E. S. (1957). Factors affecting shoot production in tea (*Camellia sinensis*) when grown as a plantation crop. III. The time factor and new shoot production. *Tea Quart.* 28: 21-29.
- TUBBS, F. R. (1932). Defoliation. II. The effect of defoliation on the yield of flush and on the thickness of the pruning wood. *Tea Quart.* 5: 148-153.
- TUBBS, F. R. (1935). Report of the Plant Physiologist for 1934. *Bull. Tea Res. Inst. Ceylon*, no. 16: 35-36.
- TUBBS, F. R. (1937). The length of the pruning cycle. *Tea Quart.* 10: 21-36.
- TUBBS, F. R. (1939). Report of the Plant Physiologist for 1938. *Bull. Tea Res. Inst. Ceylon*, no. 19: 50-55.
- VISSER, T. (1957). Report of the Plant Physiologist for 1956. *Bull. Tea Res. Inst. Ceylon*, no. 38: 43.
- VISSER, T. (1958). Growth rates and weights of flush and banji shoots of clones (*unpublished data*).
- VISSER, T., & TILLEKERATNE, L. M. DE WAAS (1958). Factors affecting planting distances of tea. *Tea Quart.* 29: 36-44.
- VISSER, T. (1959). Report of the Plant Physiologist for 1958. *Annu. Rep. Tea Res. Inst. Ceylon*, 58-59.
- VISSER, T. (1960). Report of the Plant Physiologist for 1959. *Annu. Rep. Tea Res. Inst. Ceylon for 1959 (in preparation for press)*.
- VISSER, T. (1960a). Estimation of organic matter supplied by regularly plucked tea bushes. (*in preparation*).