FACTORS AFFECTING THE PLANTING DISTANCE OF TEA

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1. Introduction

Recent progress in replanting and new planting of tea with clonal material and on the contour system, focuses attention on an important point, namely spacing. A question frequently asked is what optimum spacing is required for a clone with regard to its vigour and spreading habit. It was thought, therefore, that it would be useful to review the information available from Indonesia, India and Ceylon on this subject.

In this connection also aspects which have an indirect bearing on spacing, *e.g.* those concerned with the growth of the individual bush in the field, will be reported.

2. Yield in relation to bush zones

The habit of the tea plant is to grow into a tree under natural conditions. It is, however, artificially modified by pruning to form a bush of height and width best suited for the purpose of plucking. It is a matter of practical interest, to know how such modification affects the growth of the bush in the field with respect to its centre and periphery.

Two experiments, one carried out by De Haan in Indonesia and one at the Tea Research Institute, regarding the growth pattern of the bush will be described below. Also the preliminary data concerning a "pre-prune" experiment will be presented. In the latter experiment it was investigated how yield was affected by removal of the "sides" of the bushes towards the end of their pruning cycle.

2.1 Zonal plucking: experimental

Investigations in both Indonesia and Ceylon were done on individual bushes. De Haan divided the plucking table of his bushes into a central and peripheral zone of equal surface with the help of concentric rings. In the experiment at St. Coombs the plucking tables of 5 clonal bushes were divided into 3 zones. The rings placed on the bushes at each plucking had a radius of 6", 12" and 18" from the centre of the bush, dividing the bushes into circular areas, namely 0-6", 6"-12" and 12"-18" from the centre. Accordingly, the inner zone occupied 1/9th, the intermediate zone 3/9ths and the outer zone 5/9ths of the bush surface.

The plucking system adopted in Indonesia and Ceylon was a bud + 2 leaves, leaving a foliage leaf above the fish leaf. Tender banji shoots were plucked, also leaving a leaf above the fish leaf. Flush and banji shoots were counted and weighed separately.

In the experiment at St. Coombs a further modification was introduced. Plucking, namely, was also done below the table in order to study the occurrence of the different crop shoots in each of the 3 zones *above*, *level with*, and *below* the normal plucking level respectively.

In De Haan's experiment records were kept over 28 plucks spread over a period of one year (2/1/1940-30/1/1941), while the experiment at St. Coombs ran over two years (9/2/54-7/2/56) giving records over 104 plucks at weekly intervals.

2.2 Zonal plucking: results

The findings of DE HAAN, summarised in table 1, demonstrate the difference between the central and peripheral zones. The former yields appreciably more and produces less banji shoots than the latter

Table 1 *Shoot production of the centre and periphery of the bush* (DE HAAN)

	Production of centre				Production of periphery			
	No. of shoots	Wgt. in g.	Number of		No. of shoots	Wgt. in g.	Number of	
			Flush	Banji			Flush	Banji
Total	755	651	414	341	591	453	261	329
Average per pluck	26.9	23.25	14.7	12.2	21.0	16.20	9.3	11.7

In this experiment the central part of the bush ($\frac{1}{3}$ of the bush surface) yielded 60 per cent of the total yield.

The results obtained at St. Coombs are given in table 2. In this table the two inner zones have been taken together and the results present the averages computed from the records over two years.

Table 2 *The average production of shoots of centre and periphery plucked above, level with, and below the plucking table for 5 bushes*

1	2	3	4	5	6	7
Position of shoots in plucking table	Central zones (4/9th of surface = 452 sq. inch)			Peripheral zone (5/9th of surface = 565 sq. inch)		
	Average No./pluck		Average per 100 sq. inch	Average No./pluck		Average per 100 sq. inch
	All shoots	Banji		All shoots	Banji	
I Above	36.1	8.4 (23.3)	7.8	24.2	5.3 (22.0)	4.3
II Level	21.5	7.6 (35.3)	4.8	18.2	5.9 (32.2)	3.2
III Below	43.1	30.8 (71.5)	9.5	77.3	50.3 (65.0)	13.7
IV Total	100.7	46.8	22.1	119.7	61.5	21.2

N.B. *Figures in parenthesis denote % of banji*

It can be derived from table 2, that the periphery of the bush yielded almost as much per unit area as the centre if total shoots are taken into account (compare column 4 and 7, row IV). However, if only shoots plucked above and level with

the normal plucking table are considered, it appears that the centre yielded significantly more than the periphery (columns 4 and 7; rows I, II). The periphery, though producing considerably more shoots below the plucking table, produces less shoots above and level with the table.

On the basis of yield per unit area and excluding shoots plucked below the table, it can be calculated that the centre half produced 65 per cent of the yield as against 35 per cent produced by the peripheral half of the bush.

It is also worthy of note that plucking below the table more than doubled the total yield of the bush. Namely, if the shoots plucked below are included, the total yield amounted to 220 shoots/pluck/5 bushes as against 100 shoots per pluck for normal plucking (only above and level with plucking table). If plucking below the table is confined to the periphery only, the comparable figures are 177 and 100 shoots.

With regard to banji (columns 3, 6), the table shows that there is little difference between centre and periphery, in fact the former produced a slightly greater percentage of banji than the latter. It is also worthy of note that the percentage of banji for shoots plucked below the table is 2 to 3 times higher than that for shoots above and level with the plucking table.

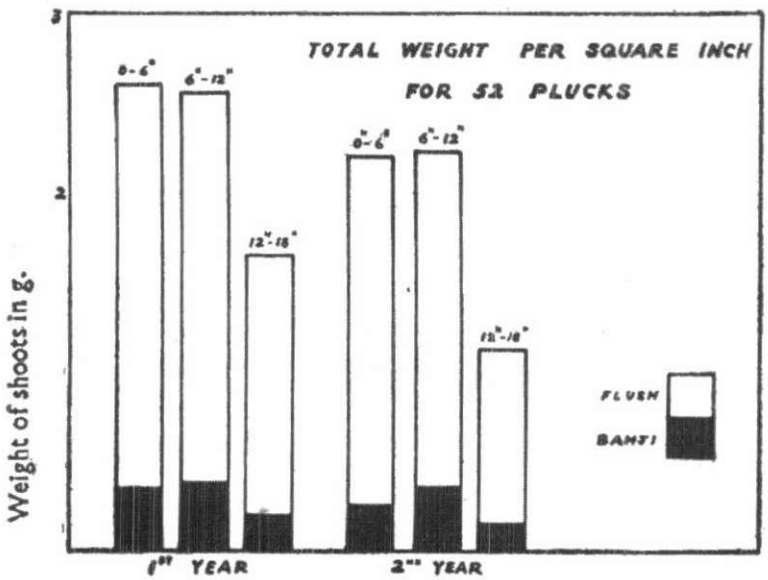

Figure 1. *Shoot production in g. per sq. inch. (exclusive of shoots grown below plucking table) for the different zones of the bush.*

In figure 1 the weight of shoots plucked above and level with the plucking table are given for all 3 zones. This figure illustrates again the greater yield of the central area as compared with the periphery in both years.

2.3. Side-pruning: experimental

In a field at St. Coombs which had run nearly 4 years, the bushes of a number of plots were "side-pruned" in order to investigate a new method of pruning (prepruning); that is to say, about 1/6th of the bush on each side along the row was removed. Thus, in total about 1/3rd of the plucking surface was taken away along the periphery.

In one treatment the bushes were side-pruned high (pruning height 3-4" above last pruning cut); in the other the sides were pruned low (pruning height ½-1" above last pruning cut). The subsequent yield of the plots treated as above was compared with the yield of non-pruned plots. Each treatment was replicated 6 times: plot-size 1/20th per acre.

At the time of side-pruning the bushes (spacing about 3' × 4') touched each other giving a complete cover of tea.

2.4. Side-pruning: results

Figure 2 graphically illustrates the trend in yield per pluck following side-pruning in comparison with the non-pruned controls.

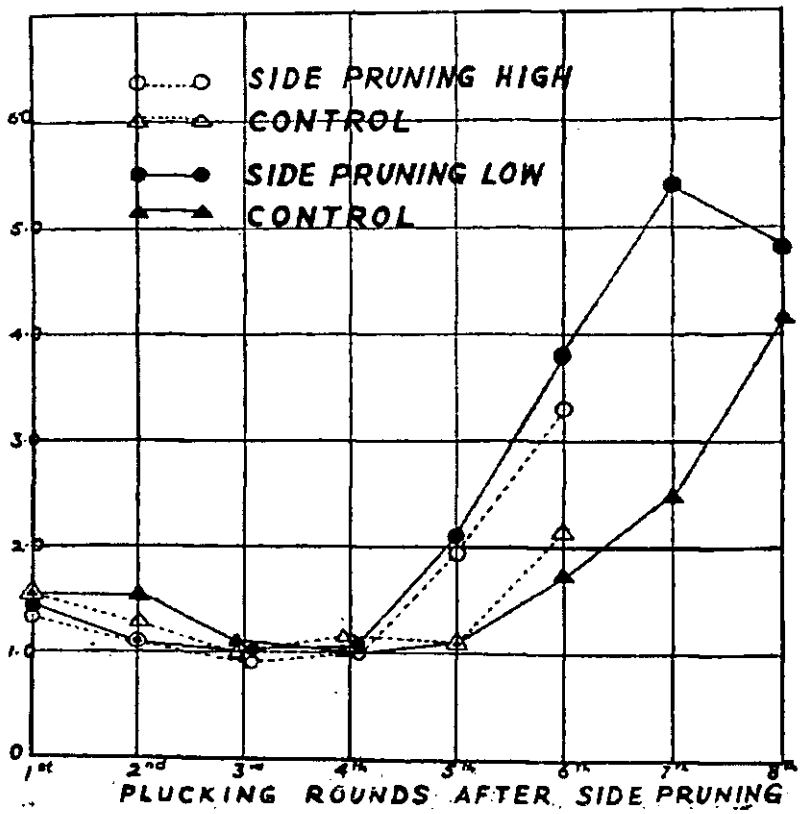

Figure 2. *The effect of side-pruning on yield of full grown bushes.*

It can be seen from this figure that the yield of the side-pruned bushes is initially somewhat less, but later, markedly higher than that of the control, irrespective of whether the bushes were side-pruned high or low. The side-pruned (high) bushes yielded over the first 4 plucks 19 per cent less, but over the subsequent 4 plucking rounds 68 per cent more than the non-pruned bushes.

It is clear from the two ring-plucking experiments and the side-pruning experiment that the centre of the bush produces the greater portion of the yield.

Apparently, towards the periphery of the bush the yield per unit area gradually decreases (if shoots below the table are not plucked!).

This is undoubtedly partly explainable on account of the natural habit of the bush to grow upright rather than to spread. On the other hand, the enhanced yield recorded after side-pruning points to the fact that the decreased yielding capacity of the periphery is also due to competition for light and air. This tendency is likely to become more noticeable with increasing age of the bush after pruning and smaller spacing. In fact, in another experiment where the bushes were less intergrown the effect of side-pruning was less pronounced.

3. Yield in relation to spacing

Since no field experiments have been laid down in Ceylon till now to investigate the optimum spacing of tea, the work done on this subject in Indonesia (3, 4) and India (1) will be reviewed.

3.1. Experimental

In the *Indonesian* experiment seed was planted at stake in January 1927 and was brought into plucking in 1930. The experiment was discontinued in May 1942. The elevation was approximately 5,000 ft.

The following planting distances were compared:—

I	Hedge	— 4′ × 1′ × 3′	: 6,695 bushes counted/acre
II	Rectangular	— 4′ × 3′	: 3,644 ,, ,, ,,
III	,,	— 3′ × 5′	: 2,953 ,, ,, ,,
IV	,,	— 4′ × 5′	: 2,270 ,, ,, ,,
V	Square	— 5′ × 5′	: 1,820 ,, ,, ,,
VI	,,	— 6′ × 6′	: 1,262 ,, ,, ,,

Treatments II, III, IV and V were replicated 5 times, while treatments I and VI were replicated twice; plot size was 1 ha (2.47 acres). The yields were recorded as fresh weights, but are here converted into terms of weight of made tea by assuming that the dry matter percentage of green leaf was 22.5 per cent.

In the experiment carried out by *Tocklai Experimental Station*, two year old seedlings of a light leaf Assam jat were used. These seedlings were planted in April 1949 and came into bearing in 1950.

The planting distances tried out were the following:

A	Rectangular	— 4′ × 2′	: 5,460 bushes calculated/acre
B	Hedge	— 5′ × 2½′ × 2½′	: 4,590 ,, ,, ,,
C	Rectangular	— 5′ × 2½′	: 3,440 ,, ,, ,,
D	Square	— 4′ × 4′	: 2,700 ,, ,, ,,

The four treatments were randomized in 3 replicates, with plot size 0.02 acre.

3.2. Observations

A summary of the results obtained in Indonesia and in Tocklai is given in table 3.

Table 3. *Summarised results of spacing experiments carried out in Indonesia (Pengalengan) 1927-1942 and India (Borbhetta) 1950-1955.*

1	2	3	4	5	6	7
Spacing of Bushes	Number of Bushes per acre	Relative space per Bush	Yield in green leaf per bush in 6th year	Annual Average Yield in lb. made tea per acre		
				Over first 6 years	Over last 3½ years	Over Total 12½ years
INDONESIAN EXPERIMENT						
I 4′ × 1′ × 3′	6695	100	**0.750** (100)	912 (107.9)	1512 (110.0)	1234 (109.2)
II 4′ × 3′	3644	184	1.332 (177)	**876** (100.0)	**1375** (100.0)	**1130** (100.0)
III 3′ × 5′	2953	227	1.752 (234)	891 (101.7)	1441 (104.8)	1171 (103.6)
IV 4′ × 5′	2270	295	2.014 (269)	765 (87.3)	1399 (101.7)	1083 (96.3)
V 5′ × 5′	1820	368	2.273 (303)	688 (78.5)	1394 (101.4)	1051 (93.0)
IV 6′ × 6′	1262	531	3.530 (471)	597 (58.2)	1204 (87.6)	850 (75.2)
TOCKLAI EXPERIMENT						
A 4′ × 2′	5460	100	**0.843** (100)	745 (111.8)	—	—
B 5′ × 2½′ × 2½′	4590	119	0.941 (112)	703 (105.5)	—	—
C 5′ × 2½′	3440	159	1.133 (134)	**667** (100.0)	—	—
D 4′ × 4′	2700	202	1.475 (175)	656 (98.4)	—	—

N.B. *Figures in parenthesis denote the yield in % of the yield of the closest spacing (column 4) or in % of the yield of about 3,500 bushes per acre (columns 5, 6, 7).*

The following remarks can be made:

(*a*) Both experiments indicate that the yield per bush (column 4) becomes greater when the available space per bush increases (column 3). In the Indonesian experiment the increase in production per bush in the 6th year is almost the same as the increase in space per bush for the first 4 treatments (I to IV). In the Tocklai experiment the increase in bush space with wider planting is not entirely matched by an increase in yield ber bush (A to D).

(*b*) In both experiments the annual yield over the first 6 years (column 5) was greater with a greater number of bushes per acre. Spacings giving less than 2,300 bushes per acre were considerably behind in the Indonesian experiment. It appears that when the number of bushes per acre is in the neighbourhood of 3,500 a difference of 700 bushes less has little effect on the yield per ac re over the first period of 6 years (compare: II and III, C and D, column 5.)

(*c*) In the last 3½ years of the Indonesian experiment (column 6), that is from the 10th year, the fields having 1,800-3,600 bushes per acre produced about the same yield, while the narrow spacing (6,695 bushes per acre) yielded more and the wide spacing (1,262 bushes per acre) yielded considerably less.

It is worthy of note that the annual yields of fields with less than 2,270 bushes per acre had increased markedly from the 10th year in comparison with the yields over the first 6 years.

(*d*) The average annual yield over the entire period of 12½ years (column 7) shows that the yield was greater as the spacing of the bushes was narrower. It can be calculated that the narrow planting I, yielded over this period in total 1,387 lbs. tea per acre more than the average of II, III, IV and V, and 4,800 lbs. more than the widest spacing VI.

(*e*) In the Indonesian experiment differences in effect of drought or severity of diseases between treatments were not significant, except for the widest spacing. In the latter case yield decreased during drought and sharp winds and these conditions were usually accompanied by more severe attacks of orange mite than in the other treatments. Similar observations were made in Tocklai.

4. Practical considerations with regard to spacing

The experiments carried out in Indonesia and at Tocklai on spacing showed that the closest planted fields (5,500-6,700 bushes per acre) gave the highest yield, especially during the first years. With time, as the bushes cover the available space, the yield of the less closely planted fields catches up. However, it might take as long as 10 to 12 years from the time the bushes start bearing, before *e.g.* 1,800 bushes per acre (5′ × 5′) yield annually as much as 3,600 bushes per acre (4′ × 3′). Hedge planting at a rate of 5,000 bushes or more might be expected to yield over such a period at least 5-10 per cent more than the latter.

Therefore, the advantage of close spacing, whether or not as hedge planting, with regard to yield is clear. Initial costs of planting will be higher, but maintenance costs will be lower, because resupplying will be little or unnecessary as neighbouring bushes will be quickly filling the vacant spaces occurring in the hedge. Also pruning will be simpler. Apart from this, closely planted bushes will also cover the soil more quickly and completely, thus diminishing erosion both after planting and after each pruning, while the yield will be sooner economic.

In this connection it must be mentioned that the experiments in question were carried out with bushes grown from seed. Under Ceylon conditions much of the replanting or new planting is likely to be done with clonal material, especially selected for its vigour and spread.

It has been asked whether such clonal bushes, *e.g.* planted 5 × 2 ft., will not grow so vigorously that, 6-10 years after they have come into bearing, field operations will become difficult. Also whether competition for light and air, particularly along the periphery of the bush might not become so severe so as to constitute a limiting factor to yield. That such might happen can be derived from the ring-plucking and side-pruning experiments which indicated that the yield per unit area markedly decreases towards the periphery.

On the other hand, our observations on *side-pruning* suggested that this operation might partly overcome the possible drawbacks of close planting. That is

to say, when in due time and towards the end of the pruning cycle the rows between the bushes become too much intergrown, side-pruning might be resorted to. Not only that such a practice would facilitate subsequent plucking, but it is also likely that the yield will not much decrease or even increase after side-pruning.

Furthermore, attention might be drawn to *plucking below the plucking* table. Such plucking when carried out along the periphery between the rows will retard the side growth of the bushes, while at the same time the yield obtained will be probably considerably higher. From the ring-plucking experiment on the clonal bushes it would seem that the yield can be considerably increased by plucking the periphery below the table during the first two years.

Eventually it can be said that both side-pruning and plucking below the table along the periphery provide measures to keep a closely spaced plantation in check. However, as our experiments were more or less preliminary ones, further information on the practical application and on the long term effects of these measures are desirable.

The above observations confirm the correctness of the system of contour planting in narrow spaced hedges, now compulsory by legislation, with regard to yield and soil conservation. A few remarks may be made on this subject.

Contour planting will mean that with time the tea fields will gradually tend to get levelled out into a series of contour platforms. It has been remarked that this might be disadvantageous to the root growth of the bush, as the "down-slope" roots will have to originate from a lower point at the stem than the "up-slope" roots. Though initially—during the time that the platforms are formed—some roots at the surface will be disturbed, there is no reason to assume that this would be more harmful to the bush than *e.g.* forking.

The distance between the contour hedges is also a point of consideration. The contour platform will have to be wide enough to make plucking, manuring, cultivation, etc., not too difficult during the second half of the pruning cycle. Depending on soil fertility, vigour and spreading habit of the clones planting up at a distance, *between the rows* of 4-5 ft., and *in the rows* at a distance of 2-2½ ft. can be recommended. That is to say, on a good soil with vigorously spreading clones planting at 5 × 2 ft. or 5×2½ ft. will be recommendable, on poorer soil or with clones which tend to grow more upright planting at 4 × 2 ft. or 4 ×2½ ft. might be preferable.

The distance between the rows will also depend on the slope of the field; on rather steep slopes they may have to be somewhat greater than recommended above. Otherwise, the distances—as measured along the slope—may be found too narrow for the unhindered carrying out of field operations.

5. Summary and conclusions

Data were reported and literature reviewed concerning the yield of the centre and periphery of the bush and with regard to planting distances, which can be summarised as follows:—

(1) The central region of the bush, its area depending on spreading habit and environmental conditions, yields more per unit area than the periphery.

(2) At the end of the pruning cycle, when the bushes touch each other, the periphery produces only a small proportion of the yield. Removal of 1/4th to 1/3rd of the surface along the periphery (between rows) at this time resulted in a 20 per cent decrease in yield over the first 4 plucking rounds, but increased the yield by nearly 70 per cent over the 4 subsequent rounds.

(3) Plucking below the plucking table along the periphery, while checking the side-growth of the bush, is likely to give a considerable increase in yield.

(4) The spacing experiments done in Indonesia and Tocklai show that the yield *per bush* increases with wider spacing. This increase is not equivalent to the available space per bush during the first years, so that yield per unit area decreases.

(5) With close planting a quicker cover is obtained resulting in higher yields. Planting at a rate of more than 5,000 bushes from seed per acre gave over periods of 12½ years and 6 years respectively approximately 10 per cent more yield than the planting of about 3,500 bushes per acre.

(6) Side-pruning and plucking below the table along the rows may provide measures to overcome the practical drawbacks of close planting.

(7) Contour planting is recommended at distances not closer than 4 to 5 ft. between rows and 2 to 2½ ft. in the rows, the distances depending on slope, soil fertility and characteristics of the clones used.

Acknowledgments

Our thanks are due to Mr. G. B. Portsmouth who initiated the ring plucking experiment at St. Coombs and to the staff of the Physiology Department for their co-operation in plucking and weighing.

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