SOME OBSERVATIONS ON THE DORMANCY OF THE TEA BUSH

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The term "dormancy" refers to the temporary suspension of visible growth especially in seeds and buds. We shall here be concerned with only the latter. When the dormancy of buds is brought about by the onset of external conditions unfavourable to growth—*e.g.* low temperatures, particular day-lengths, shortage of water supply, *etc.* it is sometimes referred to as "quiescence". This distinguishes it from the type of dormancy—referred to as "rest"—which is the suspension of growth even under conditions which are favourable. In such cases the cessation (or in reality, slowing) of growth is apparently governed by certain internal causes. In certain perennial, evergreen plants, dormancy occurs as a regularly recurring interruption of growth. Such is the case with tea.

If one examines the shoots of a tea bush, they fall into one of two classes, depending upon the condition of the growing tip or apex. When the youngest unfolded leaf is of full size and the shoot itself well formed, we refer to the shoot as an active flush. When the unfolded leaf and bud are obviously depressed in their growth and the shoot itself shows evidence of depressed growth, we refer to the shoot as a "banji". The production of banji is thus the manifestation of suspension of growth, or dormancy in the tea bush. Banji shoots range in appearance from being light green and "soft" to dark green and "hard" with increasing maturity.

There are two features of immediate interest about the production of banji in tea. Firstly, an active flush shoot if left unplucked will, after a time pass into the dormant banji phase and back again into the active state. Because of this alternation of periods of active growth and dormancy, the type of growth shown by tea shoots is sometimes referred to as "cyclic growth". If a shoot is allowed to grow unplucked, groups of a number of normal-sized foliage leaves will be seen to alternate with (usually two or three) reduced scale leaves. The position of the small scale leaves along the stem mark the banji cycles.

The second important feature is that in a tea bush, at any given time not all of the buds are either active or dormant—there being certain numbers of each type. It thus seems that the growth cycles for all buds are not completely synchronous but somewhat out of step. The factors that lead to the production of banji are thus (*a*) cyclic and (*b*) localised.

To gain some idea of the numbers of apices that may be dormant in apparently normal, healthy tea, we picked and separated out into hard banji, soft banji and flush, all of the recognisable growing points from twelve bushes, selected at random. Table 1 presents the general picture.

TABLE 1.—*Separation into active flush, soft banji and hard banji, of all shoot tips plucked off twelve mature seedling bushes in the final year of their pruning cycle.*

Bush No.	Active Flush	Soft Banji	Hard Banji	Total
1	71	134	247	452
2	113	108	396	617
3	135	103	484	722
4	146	117	475	738
5	98	118	269	485
6	94	105	314	513
7	195	167	376	738
8	122	176	344	642
9	188	292	354	834
10	155	218	452	825
11	141	159	315	615
12	35	187	588	810
Mean No.	124	157	385	666
Mean %	18.6	23.6	57.8	100

In the bushes we happened to have sampled therefore, one may immediately discount about 60% of the shoots as making no contribution to crop. Most of these are hard, dark green banjis below the plucking table and therefore probably never will be plucked. A large proportion of the second category comprise banjis which will also not be tolerated in a pluck by the average superintendent. We may therefore fairly estimate that only about 25% of the total number of shoots in the bushes comprise cropping shoots while 75% or so do not.

For purposes of general study however, an estimation of the proportion of banji shoots in samples drawn from a normal pluck should perhaps give a fair measure of the changes in degree of dormancy of the bushes. The sorting and counting of banjis in a large sample is tediously time-consuming. The minimum efficient sample size was therefore determined by plotting "coefficient of variation" against "sample size".

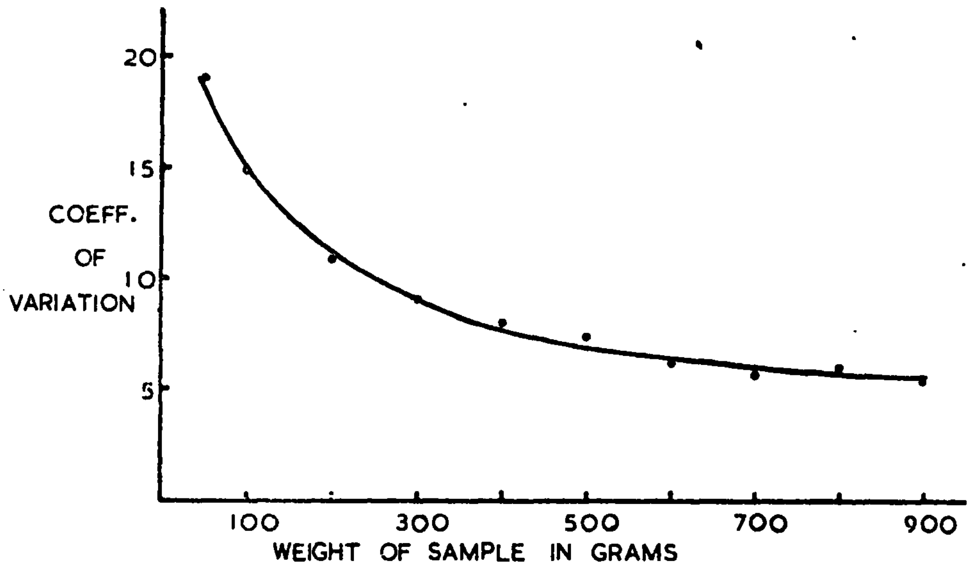

Figure 1—Determination of "minimum efficient sample size" for the estimation of banji percentage in samples drawn from a pluck. Above a sample size of 300 gm. the coefficient of variation is less than 10%

It thus appears that samples larger than 300 gm. give a statistically reliable assessment of banji which in turn gives a picture of the growth status of the bulk. When the total pluck falls below this weight, the whole amount is counted in estimating the percentage of banji.

At this stage I would like to digress somewhat to explain one mechanism that has been suggested as governing the dormancy of buds. If we consider a growing shoot of a plant, it is evident that active growth occurs mainly in the terminal or apical bud. Rudimentary buds placed in the angles made by leaves with the stem (or in the axils of the leaves) generally remain in a dormant state—growing only occasionally to produce new shoots or branches. If the top-most bud is removed however, (as in plucking a tea shoot), then one or more axillary buds will begin to grow out. It is thus evident that some influence exerted by the terminal bud has suppressed those lower down along the stem. Its removal releases them from this influence and permits their growth. This phenomenon has been termed "apical dominance".

Among the ideas proposed for explaining this dormancy of axillary buds induced by the apex—or "apical dominance" is one involving the activity of a compound or class of compounds called the plant growth hormones or auxins. These compounds are produced predominantly in the extreme tips of shoots and roots and in leaves They move through the plant (according to a specific set of observed rules) and are able, in infinitely small amounts, to exert various influences on the plant—notably in regard to growth.

Figure 2 illustrates the effect of applied auxin (commonly indole acetic acid or IAA) on the growth of three types of organ—root, bud and shoot. It would be noted that both too high and too low a quantity of auxin is able to retard growth of buds; that is to induce dormancy.

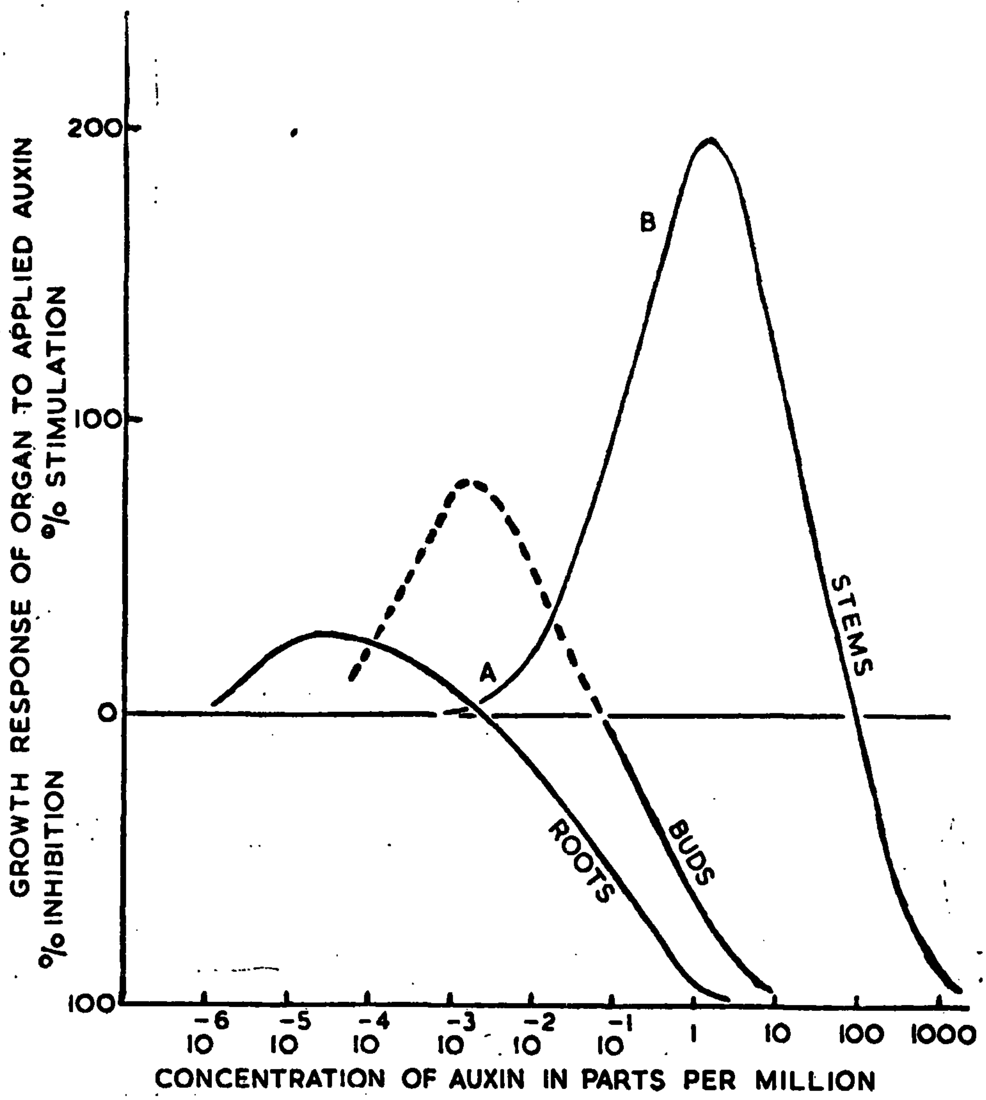

Figure 2.—Curves showing the growth responses of roots, buds and stems to auxins applied from outside. Growth stimulation or retardation is plotted against auxin concentrations (expressed as equivalents of indole acetic acid)

(After Audus; "Plant Growth Substances" 1959)

In regard to "apical dominance", it is believed that auxin diffusing downwards from the terminal bud keeps the axillary buds lower down in check. On removal of this source of production, the axillary buds are freed from this check and begin growth. The first bud below the apex is the first to be released. It grows out and the auxin that it begins to produce prevents the growth of buds below. The new branch thus assumes dominance. If removal of the apex is followed by application of a suitably heavy dose of synthetic IAA to the wound, it is capable of assuming the same dominace that the apex exerted and the axillary buds are again prevented from growing out.

At this point I would like to draw attention to two observations suggestive of hormonal action in causing banji. Firstly, as a banji cycle is approached, there is a progressive shortening of internodes and a gradual restitution of normal internode lengths after the banji period is over. This is presented in Figure 3 where mean internode lengths from a large number of shoots are plotted against internode number.

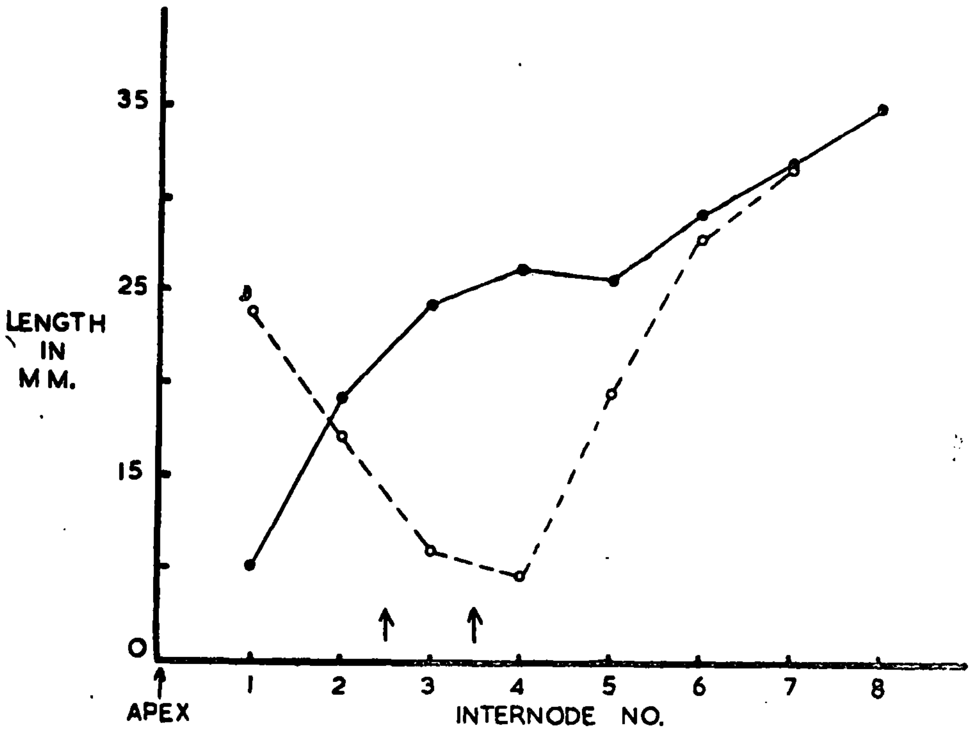

Figure 3.—Comparison between mean internode lengths attained by shoots which have passed through a banji cycle (broken line) and shoots which have grown continuously (unbroken line). (Note that internode number is strictly applicable only to the latter curve. In the case of banji shoots, the two scales have been arbitrarily assigned nodal positions 2 & 3, as indicated by the small arrows).

Secondly, there is often an interesting positional relationship between banji cycles and branching. One particular clone—TRI 2043 showed, in a large number of shoots examined, that in over 90% cases, the two nodes immediately behind the scale leaves marking a banji period show pronounced axillary development. We may thus deduce that at the time the apex goes banji, its physiology must so alter as to result in the loss of "apical dominance". It must therefore either cease for a period to be a source of growth hormone, or be flooded with some inhibitory substance which nullifies the effect of the hormones that it does produce.

Further, work in Nyasaland has shown a strong relationship between banji cycles and the rooting of cuttings. With the known role of hormones as agents inducing the rooting of cuttings, the results may well be amplified to establish a relationship between the banji cycle and concurrent alterations in hormonal levels.

I shall now briefly deal with some of the salient points we have noted about the production of banji in tea.

1. **Banji and the age from pruning:**—As early as the 1937 Conference, Tubbs presented evidence to show that banji increases as the cycle advances. Kehl and Piyasena (1956) made similar observations.

In Figure 4 are represented banji percentages to cover all plucks representing first, second and third years of a three year cycle. The experiment was so arranged that the pruning operations were staggered over the preceding three years so that bushes in their first, second and third years were available at each pluck. Each point represents the mean banji percentage for 28 clones represented in the trial.

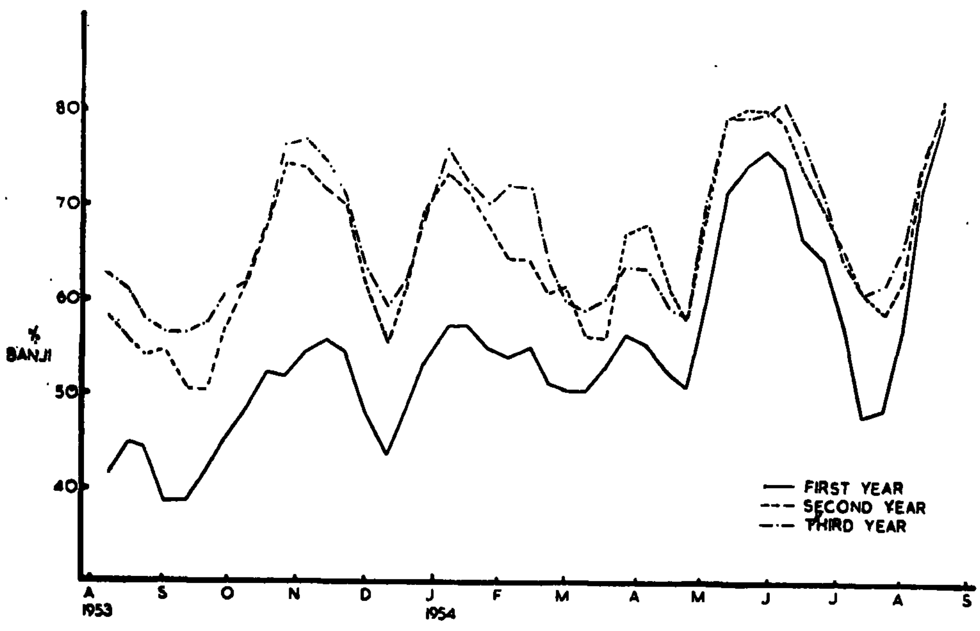

Figure 4.—Mean banji percentages for bushes in the first, second and third years of a pruning cycle. Each curve represents the mean for 28 clones, Running means of successive pairs of estimations have been employed in this and succeeding figures.

The points to note are:—

(*a*) The close agreement between the large periodic fluctuations shown by all three curves.

(*b*) There is markedly less banji in the first year while the second and third year curves are indistinguishable one from the other.

(*c*) The first year curve shows a gradually increasing trend, resulting, as the year comes to a close, in all three curves tending to merge.

Tubbs attributed this progressive increase of banji to increasing internal competition between the different shoots for nutrients. While not ruling out the probable importance of nutritive status in determining whether an apex would continue in active growth or become dormant, the role of growth promoting or inhibiting substances may also be of importance.

2. Seasonal fluctuations in banji percentage:—I have commented on the striking periodicity in banji levels. The pattern seems remarkably similar for the successive pruning years, provided plucking is done on the same occasion. There is therefore a strong possibility that external, climatic and other factors are responsible.

However, on examining data from a number of experiments, we have been unable to correlate banji production with rainfall, sunshine or manurial level. Reduction of light intensity however, does seem to result in somewhat less of banji. There is also no apparent definite relationship between banji and yield.

I have already indicated that the age from pruning could be one of the internal factors of relevance in determining banji. Data collected from all the fields on St Coombs showed clearly that age of the field alone does not account for the pattern of fluctuation. In Figure 5 we have selected single fields representing the three years of a pruning cycle and it would be seen that the patterns are not in close agreement.

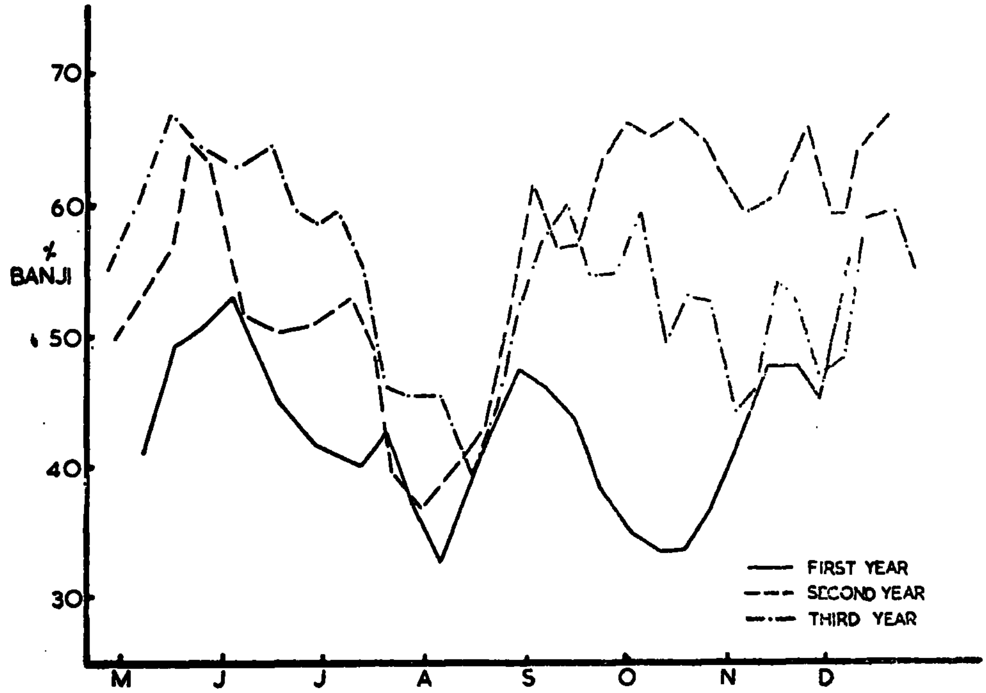

Figure 5.—Banji percentages for three selected seedling fields at St Coombs in their first, second and third years of a pruning cycle.

Thus the age from pruning and known changes in external factors do not seem to entirely account for the rhythm of banji changes. Figure 6, representing the behaviour of two clones TRI 1114 and TRI 1294 in their first, second and third years from pruning, confirms clearly enough the common view that clones differ in their tendency to go banji.

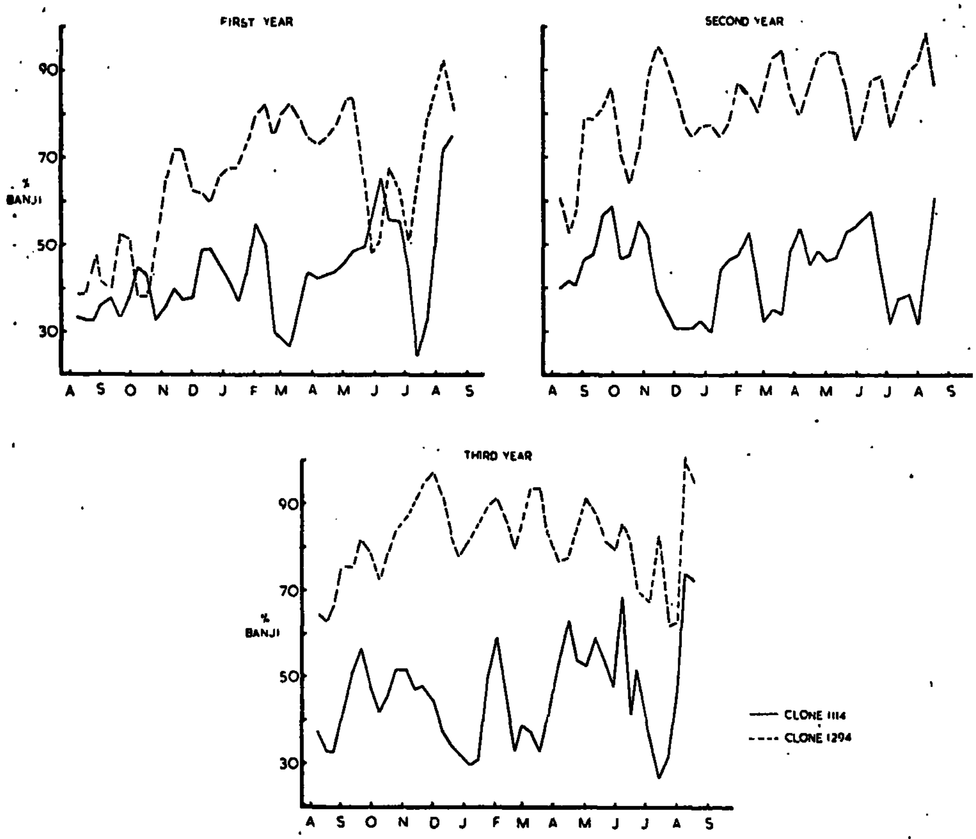

Figure 6—Banji percentages for bushes of clones TRI 1114 and TRI 1294 in the first, second and third years of a pruning cycle.

3. Localised nature of the banji stimulus:—As mentioned earlier, certain apices of a bush are dormant at a time when others in the same bush are in quite an active state of growth. This would mean that whatever influence brings about banji is probably restricted to particular apices or particular shoots.

Observations on labelled banji and active shoots brought out the following points:—

(*a*) Banji shoots produce new leaves at a greatly retarded rate.

(*b*) Banji shoots when plucked, have a greater tendency to produce new banji shoots than flush shoots. Likewise, plucked flush shoots tend to produce new active flush more frequently than banji.

(*c*) Where a shoot is destined to become banji, it takes somewhat longer to grow up to a pluckable state. It appears that the growth status of the newly produced shoot is a more dominant influence in determining rate of growth than the type of shoot plucked.

These features are indicated in Table 2.

TABLE 2.—*The influence of the type of shoot plucked (banji or active) on the type of new shoot produced and its rate of growth. The data were obtained from a shade trial and are based on observations on 494 flush and 457 labelled banji shoots.*

Shoot Plucked	Shoot Produced	Percentage of each type				Days to produce Pluckable shoot			
		Light Intensity			Mean	Light Intensity			Mean
		40	60	100		40	60	100	
Flush	Flush	83.0	85.1	58.4	75.5	63.1	62.1	61.5	62.2
	Banji	17.0	14.9	41.6	24.5	69.6	69.5	63.4	67.5
Banji	Flush	48.6	40.5	22.6	37.2	63.7	62.8	61.7	62.7
	Banji	51.4	59.5	77.4	62.8	70.7	67.5	63.6	67.3

These results are from a shade trial. You may note that reduced light intensity while reducing growth rate also seems to favour the active condition of the buds.

Although far from conclusive, the results do seem to suggest that the banji producing conditions occur in whole shoots at the time when the apex is in a dormant state. The growth rate of a shoot is reduced when it has entered, or is about to enter, a banji state.

4. **Growth inhibitors as agents bringing about dormancy:**—There is very strong recent evidence from a number of perennial plants which suggests that specific growth inhibiting substances are responsible for bringing about dormancy. A whole range of both synthetic and naturally occurring substances have been shown to induce dormancy. Some of them exert their effect by nullifying the activity of growth hormones, and their effect may therefore be counteracted by spraying on growth-promoting hormones. Leaves have been shown in some cases to be the sites of production of these growth depressants. (Eagle & Wareing, 1963).

This has encouraged us to look upon maintenance foliage as a possible source of similar inhibiting substances in tea. The most obvious function of leaves is photosynthesis. They could also be the source of substances which retard growth and so result in loss of crop in the case of tea.

Hadfield at Tocklai has suggested that leaves at or below 3–10% of sunlight are not photosynthetically profitable to the bush. Especially towards the end of a pruning cycle, it may be that a large proportion of the leaves carried may fall into this category due to self-shading. This could perhaps account for the observed yield decline at this period and the excessive production of banji.

Some results do suggest that the loss of maintenance foliage does not always result in a proportionate reduction of crop. Tubbs in 1932 observed that complete defoliation of bushes by hand, depressed the yield over six months of plucking by only 20–40% with indications that even this surprisingly narrow gap would be soon bridged. Visser (1959) noted that removal of an estimated 50% of the maintenance leaf, reduced yield by only 5%. He also found (1961) that pruning of a large proportion of the bush along the sides, only depressed yields relatively slightly and in at least some cases, actually enhanced yield.

In an experiment on continuous fish-leaf plucking over 18 years, it was found that although maintenance foliage is reduced to 1/3rd and pruning wood to 1/4th the controls,yet the fish leaf plucked bushes yielded more than the controls (108%).

In preliminary trials on the control of maintenance leaf fall in the low-country, the indications are that while spraying appears to reduce leaf-fall from the bushes, yield seems little affected.

These results seem to suggest that the view of maintenance foliage merely as a source of photosynthetic products supporting growth may need to be modified to include it as the point of origin of influences whose effect is the depression of growth. While a certain amount of foliage is vital to provide material for growth and sustenance, too much may well check the full growth potential of the bush.

Attempts to locate a banji-stimulus within labelled banji shoots, by removal of combinations of successive leaves along the shoot were frustrated by the natural growth rhythm of these shoots—banji shoots becoming active and *vice versa*. Studies of this type could be of prime interest and means of inducing continued dormancy at the apex are awaited as a prelude to renewed attempts to locate the source of any dormancy inducing substances. Suitable alteration of environmental conditions or the use of chemicals may help in achieving this.

Perhaps a relevant feature borne out by our trials and also a matter of common observation, is that "high cut-across" pruning which results in a removal of the younger foliage and retention of older leaves results in increased banji in the crop and fitful growth, at least in the early plucks after pruning.

When we examined the banji percentages from the fish-leaf plucking trial, it was clear that fish leaf plucking results generally in more banji as shown in Figure 7.

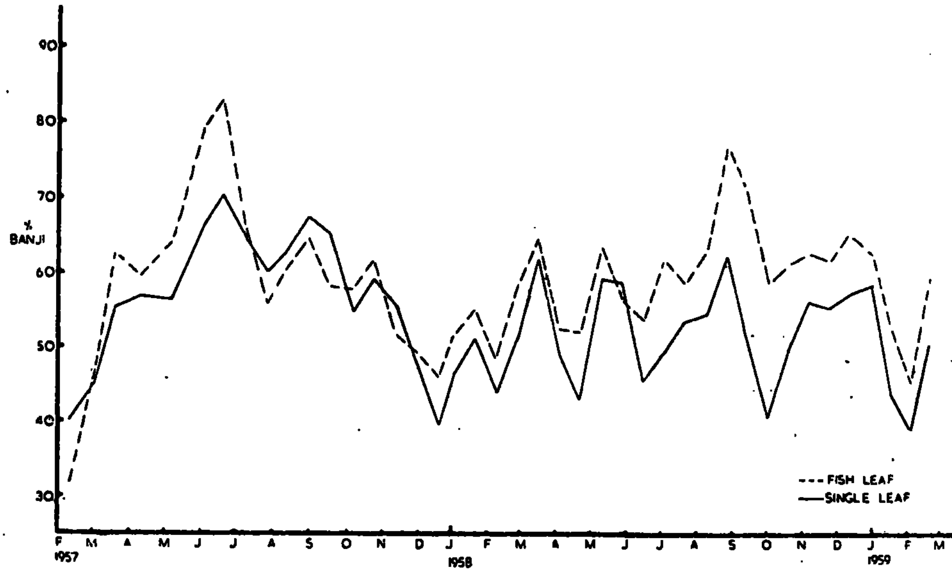

Figure 7.—The effect of "fish-leaf plucking" and "single-leaf plucking" on banji percentages as determined over a two-year period.

This appears in conflict with the possibility of old maintenance leaves being the source of a banji producing stimulus. However, it may be that fish-leaf plucking while drastically reducing the addition of younger maintenance leaves may lead to a longer retention of older leaves and this might account for the increased banji.

Summary

The problem of banji or cyclic growth in tea appears to be a phenomenon of agricultural importance. It would be a factor both in preventing a bush from reaching its full cropping potential and also, when occurring in young nursery plants, of markedly setting back growth.

The appearance of banji shows a marked periodic rhythm although it cannot be related to any single factor of the environment.

Some inherent property of the bush and its age from pruning appear to be relevant both to the level of banji and the timing of the growth cycles.

Shading appears to depress its occurrence while adequate balanced manuring is believed to do the same.

It is not possible to correlate banji with immediate yield.

Two facts which any physiological explanation must account for are firstly, the localised nature of the banji stimulus. At any given time, some shoots on the bush are in a banji state while others are actively growing. The rate of unfolding of leaves and of extension growth seem to be reduced as a banji phase is approached. Secondly, an explanation must be found for the observed periodicity of banji cycles on any given shoot.

Drawing from the ideas put forward to explain dormancy phenomena in other perennial plants, it appears that hypotheses postulating the role of growth hormones and/or inhibitors might be applied to furnish an explanation for the banji phenomenon in tea.

As a beginning, we plan to explore the possibility of banji apices or shoots carrying within them, substances which may bring about dormancy. We also propose to investigate the possibility of inducing dormancy or the active state at will by suitably altering environmental conditions or by the use of chemicals shown to be effective on other plants.

If, as seems likely, some material stimulus is ultimately shown to be responsible for the onset of banji, the next step would be to locate and then eliminate the source of this substance. We are attracted by the possibility of old maintenance foliage being the site responsible.

Physiologically, the problem of banji is clearly an intriguing one. At the moment, there are so many apparently conflicting features about its occurrence that no simple explantion seems likely.

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ANSWERS TO QUESTIONS RAISED ON DR PETHIYAGODA'S PAPER

Question:—If the removal of banji encourages the development of more banji, would it not be preferable not to remove banji shoots? (Superintendent, Dankoluwa Estate).

Answer:—It would not be correct to say that the removal of banji "encourages the production of more banji". What our obesrvations do indicate is that when a banji shoot is plucked and its axillary buds thereby induced to grow out, the chances of the new shoots becoming banji by the time they reach a pluckable state, are considerably greater than their being flush shoots (63% as against 37%). Likewise flush shoots when plucked have produced new flush shoots in about 75% cases and banjis in 25%.

One should not overlook the fact that banjis may constitute an important proportion of the crop at certain times. If banji shoots were to be left unplucked, not only would this directly reduce crop, but also with time, the banji shoot may become progressively "harder". This means more plucking points completely out of production. If our results are generally applicable, by removal of a banji shoot, one may stand a chance of about 1 in 3 of obtaining new flush shoots. This would seem sufficiently encouraging and would certainly not appear to justify any recommendation for the avoidance of banji shoots during plucking.

Question:—Sunlight would seem to have a promoting effect on the production of active shoots. As the foliage of the bush itself in its third and fourth years prevents light from penetrating and producing active shoots, would you recommend a reduction of shade in the latter parts of a cycle? (Superintendent, Pettiagalla Estate).

Answer:—The results I presented would seem to suggest that at the particular intensities of shading that we employed, there is a progressive reduction of active shoots as the light increases. It needs to be stressed however that these particular results are of a preliminary nature and whether shading generally decreases banji would need to be investigated in greater detail.

We also have no data on the problem of "self shading" by tea bushes at different times in the pruning cycle. Further, shade as applied to tea cultivation is so complex in its effects that a single feature of this nature would not by itself justify a change in policy.

Question:—Your observations on banji growth seem to lead to a new trend in selection of cuttings for propagation. Are you in a position to state any observations on the frequency of banjis in cuttings taken successively after pruning? (Mr K. P. Abeywickrema, Tea Control Department).

Answer:—It has been shown that plants raised from cuttings successively removed from a mother bush after pruning, do tend to become progressively less satisfactory. One of the main problems would appear to be the tendency of such cuttings to produce flower buds and consequently to be reduced in vegetative vigour.

We are not in a position to state whether this is in any way related to the frequency of banjis in the shoots produced later. It might be relevant to state here, that there has been no observation of a consistent effect of the condition of the apex (whether active or banji) of the propagation shoot on the subsequent performance of single node cuttings.

In connection with observations on different clones, it appeared that some clones are more prone to the production of banji than others. However, in the absence of a direct relationship between this character and yield, it would not appear to be sufficient grounds for the rejection of any selection made on other bases of suitability.