CURRENT TRENDS IN PHYSIOLOGICAL INQUIRY

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I wish to make use of the opportunity that this brief talk affords me, of giving you some idea of our activities and thinking, since the last Conference in 1964. At the same time, I hope it will serve as an introduction to what you will see of our experimental activities on the Institute's estates, during this Conference.

Agronomic studies of immediate practical relevance necessarily constitute the main part of our work. We strive concurrently, to probe somewhat deeply in an attempt to understand treatment responses in terms of the basic functioning of the tea bush. This often takes us close to studies of a more fundamental nature. Within the next few minutes I hope to give you a glimpse of our activities, achievements and aims by selecting a few areas within which our recent efforts have been concentrated.

Pruning

By far the bulk of our studies have been concerned with one aspect or another of pruning. Such studies have the ultimate aim of minimizing dieback and ensuring the most rapid and satisfactory return to a maximum cropping level.

Suitable weather conditions are of primary importance in good recovery from pruning. Pruning into prolonged dry weather is hazardous. Likewise, cold and over-wet weather slows down recovery. There are many reports of good recovery when pruning is done at the end of a period of slow growth in dry weather and consequently, the normal rush of growth which follows rain after such a spell, is utilized in post-pruning recovery. Where despite satisfactory weather, poor recovery results, other causes should be suspect. Certain clones prune worse than others and there is more than a suspicion that at certain critical stages, young tea is extra susceptible to damage from pruning.

Carbohydrate reserves in tea roots have loomed largely in considerations of pruning. We can fairly claim that in tea, the problem could not have been studied elsewhere more comprehensively than has been done by us. Tea roots contain surprisingly high amounts of reserves — particularly starch. Soon after pruning there is a rapid decline of such reserves — strong evidence of their utilization in recovery. One puzzling feature however, is that a great part of this decline occurs before bud-break on the frames — and hence must be used for purposes other than merely for tissue-building in the new sprouts. Establishing with certainty the fate of these disappearing stores will be a major challenge to us. In analyses of many clones, we have concluded that no correlation exists between reserve levels and yield. The practice of resting before pruning, builds up reserves but does not necessarily improve recovery. In fact, evidence suggests that long periods of rest may actually result in poorer recovery. The removal of complete rings of bark (ring-barking) is a technique for isolating portions of plants from receiving elaborated food materials. Similar isolation of sections of pruned frames, so presumably depriving them of materials moving up from the roots, although slowing recovery, does not prevent it altogether. Mention has already been made of the rapid decline of reserves following pruning. No correlation could be established between initial reserves or mobilised amounts and recovery as measured by the weights of all new buds stripped off the

frames. Further, by successive strippings of buds at a stage when they would have used root reserves but had not yet commenced to contribute towards them, it was possible to depress root reserves to levels which would normally be considered dangerously low. Recovery was not necessarily impaired.

Whatever the importance of carbohydrate reserves themselves in recovery, it is clear that lungs often help to reduce casualties and dieback. The exact role of lungs has thus been studied. They appear to mobilize root carbohydrates immediately after pruning. They may also function as sinks for deleterious materials coming either from within or without the bush. Some evidence would support this role. Lungs normally grow on top, but do not permit buds to sprout and grow freely along the length of their branches. If, however, a lung is ring-barked, growth on top ceases and buds below the ring grow out. A plausible explanation is that the ring has confined a growth inhibitory principle within the lung and so stopped its growth, while releasing buds distal to the ring. Leaves on the lung naturally suggest themselves as the source. Chromatographic and bio-assay analyses of leaves confirm that the hypothesis is attractive. Lungs also speed up the commencement of recovery (bud break) and also encourage the new shoots to grow rapidly. But, they reduce the numbers of new buds arising. Thus, although lung-pruned bushes have greater tipping weights than clean-pruned ones, the numbers of tipped shoots is less. Also, the retention of lungs for too long impairs recovery and increases the risk of dieback on the lung branches themselves, when they are eventually pruned away.

The new buds which commence growth after pruning must awaken themselves from a very long period of quiescence — perhaps ranging from three years to many more. The process of this activation must be remarkable. In a practical approach, various substances known to affect growth were sprayed onto pruned frames. Some enhanced, a few impaired, and others had no effect on bud-break.

Circumstantial, analytical and direct observational evidence seems to strongly suggest a possible influence of fertilizer practices on recovery from pruning. The problem is evidently complex and complete resolution may well involve considerations of soil and plant chemistry, climate, fertilizer composition, level and time of application and many other factors besides. The problem of unsatisfactory recovery is however serious, apparently on the increase and thus warrants immediate concern. Before the fullest explanation is forthcoming, it will clearly be necessary to suggest palliative measures which are necessarily of a somewhat empirical nature. This has in fact been already done.

Maintenance foliage

Leaves are absolutely essential organs on account of their photosynthetic activities. If a bush is defoliated it would be expected that growth and therefore crop would be proportionately reduced. Much to our surprise therefore, in experiments on reducing maintenance foliage, relatively trivial (6%) depressions of crop resulted from severe defoliation (over 80%). Using C^{14} as a tracer, it has been shown that even the oldest maintenance leaves on a bush are potentially efficient synthesizers of food. That their removal does not result in drastic crop reduction must mean that they also produce substances which may be antagonistic to growth and to flush shoot production. Analyses have once again shown that such material inhibitory principles are present in extracts of fresh tea leaf and preliminary efforts are being made at isolation and identification.

A further interesting finding was that if half of a bush was pruned away, then the remaining half bush yields considerably more than 50% of the crop from unpruned bushes. Likewise, the pruned half, once it comes back into crop, yields much less than half the yield of bushes which were completely pruned at the same time. There obviously exist regulatory influences within the parts of a bush.

Shade and shelter

Two trials in which tea was shaded by plastic screens letting in controlled amounts of light disappointed by the lack of conclusive results. Certain trends were suggestive of a mildly beneficial effect by light shading. Subsequent investigations suggested the possibility of confusion arising from sheltering effects. Shade slightly dulled the response to increased nitrogen. The effects of shading suggested a varying trend at different ages from pruning. Removal of the screens has not given the spectacular jumps in crop normally expected when previously shaded tea is suddenly exposed to full sunlight.

Artificial screens are doubtless a far cry from shade trees growing among tea. We must therefore await the results of our several extension trials before taking up a final attitude on the good or ill-effects of shade trees.

The probable importance of the provision of shelter has prompted us to protect areas with *Hakea saligna* and unplucked tea rows for observation and yield and wind measurement.

Shade trees provide mulch which may have important effects on the moisture and nutritional status of the soil. A trial is in progress in which various types of mulches are brought into an area of unshaded tea from elsewhere and are applied to plots receiving different levels of fertilizer. All mulches tried — tea, dadap, *Grevillea* and Mana — have given yields superior to the controls kept free of all mulch.

Plucking

As a start on the complicated business of experimentation on plucking, the two variables which are least difficult to control – plucking frequency and the size of plucked shoot — are being tested out in various combinations for effects on both yield and made tea characteristics. Increased frequency and increased size make for greater crop. Calculation of crop on a " per pluck " basis suggests certain time trends whose interpretation will only become clearer with much more experimental experience.

A very large amount of work has been done on the growth of individual crop shoots and much information has been gathered. Lack of time precludes their discussion. We have discovered a rather spectacular means of inducing banji rapidly and have hopes that this ability will be a valuable aid in resolving this fascinating problem of dormancy in tea. The recipe is very intense shading. Alternate shading and exposure stimulates growth to an extent which goes far beyond accountability on photosynthetic considerations alone.

In order to achieve optimum crop exploitation which, while avoiding the disadvantages of excessive cropping, will equally ensure that no crop is left ungathered, the patterns of dry matter accumulation and partitioning into bush components, are under study. Growth analysis techniques are being employed on free growing controls in comparison with plants of similar age subjected to bringing-into-bearing and plucking practices. Preliminary estimates are that under normal plucking on seven-day rounds, some 15% of the total growth in the early stages is taken as flush. Bending slightly checks normal growth of leaf, stem and roots.

Bringing-into-bearing

Bending plants into a highly arched loop has had the very desirable effect of achieving a quick ground cover and vigorous flushing. Certain doubts on the possibility of the frames being inconveniently high have been completely dispelled in test prunings carried out.

Rehabilitation

Mana and Guatemala have displayed no great difference in their influence as rehabilitation grasses. There are locational differences in the growth of the two grasses. They both provide large amounts of mulch (about 50 tons per acre per annum green matter at Kottawa and an average of 5 tons of roots per acre for Guatemala and 1.5 tons for Mana). The effect on the organic matter content of the soil is however not detectable by analyses.

Tea plants in sand culture

As a prelude to the study of several nutritional problems, we have, after initial teething troubles, evolved sand culture techniques for tea which are outstandingly successful. One of the first points we shall study is the claim that tea preferentially utilizes the ammonium ion rather than the nitrate.

New methods and techniques

One of our constant interests is to devise means to measure functions and factors which are of physiological interest. The main achievements to date have been the devising of a ' leaf area grid ' for the non-destructive estimation of leaf areas of tea. The device has proved very convenient, rapid, accurate and versatile. A strong positive correlation between basal stem girth and dry matter of young free growing tea plants has been worked out. Initial steps have been taken to develop a " dry weight " method for measuring photosynthesis in leaf discs. Attempts are being made to evolve satisfactory means of studying root growth and behaviour in standing tea in the field. A suitable method for assessing post-pruning dieback and measuring the adequacy of recovery is a pressing need.

I hope that this brief account has given you some idea of the main lines of inquiry and thought on the physiology of tea. I look forward to more detailed discussion and amplification when we have the privilege of meeting you on the field visits to St Coombs.