THE PRESENT POSITION OF TEA SELECTION IN JAVA

(REVIEW)*

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To a certain extent it is true to say that selection has been practised in an empirical fashion for as long as tea has been cultivated, whether in Java or elsewhere, but it was not until the beginning of the present century that a definite programme involving rational methods of selection was laid down. The first step was the establishment of a selected seed garden in Tjinjiroean in 1905. This work was extended in 1910 in co-operation with the Proefstation voor Thee and with the appointment of Cohen Stuart as the first tea selectionist. In these early days, the main object was selection for type or jât of the seed bearers, and it was not until 1920 that Cohen Stuart began selection with the definite aim of improving yield. Selection work with a perennial crop involves, sooner or later, the need for a method of vegetative propagation by which the selected material can be multiplied and its characteristic properties maintained. In Ceylon, the emphasis from the start has been on propagation by cuttings, while the Dutch workers have concentrated on grafting and budding methods, similar to those which are widely employed in fruit growing. At first, the "crown grafting" method was in vogue, and the early expansion of the selection work was impeded by the precarious and inadequate success obtained by this process.

A great step forward was made with the re-introduction of budding in 1932. Budding had already been employed on a small scale as early as 1917, but for some reason its real value had escaped attention. When once a reliable method of vegetative propagation was available there was every inducement to proceed with mother tree selection on a large scale, and in the relatively short period since 1932, the Java workers have selected some 2,000 bushes from which already more than 1,750 clones have been tested, both in plucking and as seed bearers.

* This article is based on and in part freely translated from recent papers by S. J. Wellensiek and I. J. H. van Emden respectively, in *De Bergcultures*, Vol. 14, pp. 223-6 (1940), and Vol. 15, pp. 118-24 (1941).

CLONE TESTING

The clone testing experiments, which are now more or less complete, form the peak of the selection programme and deserve to be described in some detail.

Why Clone Testing is Necessary.—A clone is the progeny raised by vegetative means from a selected bush, the so-called mother tree, which, in so far as its hereditary constitution is concerned, is reproduced exactly in each member of the clone (assuming the absence of vegetative mutations or "sports"). Scientifically speaking, a clone, however large or however widespread, is a single individual. It is the realisation of this fact that is apt to create difficulties in the way of appreciating the need for clone testing. The fact that successful results may sometimes be obtained without clone testing does not affect the general position. The aim of selection in these experiments is the improvement of yield, and there are abundant data to prove that the yield of a clone need not, and in fact often does not run parallel with the yield of the mother tree.

A tea plant develops — like any other organism — under the influence of two sets of factors, hereditary and environmental. That the latter may exert a predominant influence may be seen from the marked response of an estate to different levels of cultivation. ***In considering a certain bush which it is desired to select as a mother tree, we cannot foresee how far the properties which have attracted our attention are inherent in the genotype, and how far they are the result of local environmental influence. To form an opinion it is necessary to propagate the given plant vegetatively, and to grow on the progeny in such a way that the influence of external factors can be eliminated or recognised.*** This is the essence of clone testing.

The figures in Table I, which are selected from a Tjinjiroean experiment, indicate the importance of external conditions in determining the yield of a bush on the estate. In the Table, the productivity of the mother trees is expressed as a productive index, which is the ratio of the yield of the mother trees to the general average yield of the estate from which it was selected. The yield of the clones is expressed in grams per plant per plucking. It is obvious at a glance that the clones with the highest productive index do not always give the highest yield and *vice-versa.* In fact the correlation coefficient between the two sets of figures is only **0.1804 + 0.1232,** whereas a much higher value, approaching unity, would have been obtained if genetic constitution and not external conditions, had been the chief determining factor for yield. The need for clone testing is amply demonstrated by these figures.

TABLE I

Productivity of Mother Trees and of Clones derived from them.

Clone	Productive index (of mother tree)	Yield in grams fresh weight per plant per pluck (of progeny)	Clone	Productive index (of mother tree)	Yield in grams fresh weight per plant per pluck (of progeny)
a	1.9	69.5	p	2.8	56.7
b	6.5	68.3	q	1.9	56.2
c	5.7	66.5	r	2.3	56.1
d	6.1	62.3	s	1.8	55.7
e	4.8	62.3	t	2.2	55.4
f	2.3	61.6	u	2.2	54.9
g	2.0	60.4	v	8 9	53.9
h	3.7	60.0	w	4.1	52.7
i	2.0	59.1	x	2.3	52.0
j	2.2	58 8	y	4.4	52.0
k	4.0	58.8	z	1.9	51.2
l	3.8	57.4	a′	4.5	51.1
m	3.9	57.3	b′	4.0	50.5
n	7.3	57.1	c′	1.8	50.2
o	1.9	56.9	d′	3.1	49.9

How the Testing is done.—It has already been stated that the aim of clone-testing is to grow the clones on in such a way that the influence of external conditions can be eliminated or at any rate recognised (and allowed for). In order to obtain this object, a degree of replication of the experiment is necessary.

The simplest method of replication is to put out the budded plants at random and to determine the yield of each individual bush. By calculating the average yield for each clone and the standard error for the experiment one can obtain a significant estimate of the productivity of the clones and of the differences between them. This method has several disadvantages of which the most serious are the relatively small number of bushes to which it can be applied, the great practical difficulties in plucking, and the high errors in weighing compared with the actual weight of leaf obtained.

The next step was the introduction of the row-test method which is now used in all the Tjinjiroean experiments. This is a randomised block layout in which eight objects are compared, *e.g.*, eight clones, or seven and one control. Each clone is represented in each of four blocks by a row of eight plants, the row being treated as a unit for plucking and in weighing the produce. The plants are set at intervals of 125 cms. (about 4 feet) with the same distance between the rows. Thus each block of eight rows needs an area of 10 × 10 metres (32 ft. square) and the whole experiment of four blocks, 20 × 20 metres (64 ft. square).

The advantages of the row-test method are as follows: the number of bushes needed for each clone is relatively small compared with the accuracy of the results obtained, the layout is compact and utilises the ground to the best advantage, and the yield determinations are simple. Under favourable conditions, *i.e.*, with relatively uniform batches of planting material, and an area of ground free from excessive variations in fertility, the method will detect significant differences in yield of the order of 15-20 per cent. However, there are certain inherent difficulties which cannot be overcome by attention to homogeneity of the material or layout and the chief of these is that of the mutual influence of the clones. Thus a relatively slow-growing clone will be subjected to unfair competition from a relatively fast-growing clone in an adjacent row.

As an additional control to the row-test experiments, the tests may be repeated with double the number of blocks, (*i.e.*, 8 replications of 8 plants per clone), or, if adequate material is available for the large number of plants required, plot experiments may be set up in which the replications consist of whole plots or blocks of each clone.

It is important to realise that, necessary as clone testing is, there is no single experiment which will give an absolute measure of the productivity of different clones under all circumstances. The yield of a clone in a testing experiment is reckoned as the mean yield of the replications, while the standard error gives a measure of the variability of those means. However, this "error" applies only to the particular time and place of the experiment, and to none other. For instance, if in the test clone "A" gives 25 ± 5 grams more yield per plant than clone "B", it can be forecasted that under the conditions of the test there is a 95 per cent chance that the difference will lie between 15 and 35 grams. But no forecast can be made as to the relative behaviour of the two clones in a later occasion, perhaps on another estate, or in a different climate. There is even no guarantee that the yield of clone "A" will exceed that of clone "B" at all. It may be asked what is the value of testing, if the result is only valid for one place, in one season, for one age of the plant, or for one system of cultivation? The answer is that although these difficulties indeed exist and do provide an explanation for the peculiar discrepancies that are sometimes encountered, yet, on the whole, and provided that the extreme cases are omitted, it can be said that *most clones react in the same way to changes in their conditions of growth, and that the differences between them will therefore tend to persist.* They will, however, exhibit a much wider variation than could be forecasted from the standard error of a single experiment. In time of course the results of clone tests will be supplemented by the experience of all those planters to whom selected clones are distributed from growth on a field scale.

The results obtained.—The first impression of the clone tests results is disappointing, since the great majority of the clones have little more than average yield. *Usually only about 10 per cent of the clones is kept for further testing.* However, among these, certain clones are undoubtedly outstanding and in them the limit of improvement by selection would appear to have been reached. That this improvement is considerable is shown by the number of clones in the final selection yielding from 100 per cent to 150 per cent more than unselected material. By the use of these clones, therefore, *yields of at least double the present figures can be expected.*

The predominant influence of external factors on the performance of the mother trees is again emphasised by these results. Beyond the fact that clones from average, (*i.e.*, unselected) and from good mother trees are usually distinguishable in testing, there is no necessary relationship between the yield of a clone and the performance of the mother tree. It is therefore waste of time to spend too long on the selection of mother trees; clone testing is of paramount importance and as much time as possible should be left for this stage of the work. As the clones are inevitably tested at an early stage in their life, the mother trees should be selected from as young fields as possible, *i.e.*, under conditions more nearly approaching those of the clone test.

NURSERY SELECTION

Nursery selection is considered from two different aspects; that of the supply of young plants to put out (as in Ceylon) in the field, and that of the provision of stumps to serve as understocks for budded plants of selected clones.

Selection in the nursery of plants to be grown on as supplies depends on the hypothesis put forward by Cohen Stuart in 1929, that the strongest seedlings, judged by weight of prunings or by the diameter or height of stem, would also be the best leaf producers. The question raised is analogous to that considered in relation to clone testing, namely, as to how far the differences between nursery plants are due to external circumstances of a fortuitous character, rather than to genetic factors controlling productivity. At least some appear to be hereditary as may be seen by comparing the subsequent growth respectively of plants taken from the edge and from the middle of the nursery beds. The average difference between the two groups disappears within two years of transplanting while the differences between plants within each group are partly maintained. The improvement of yield may be the declared aim of nursery selection of supplies, but it is questionable whether the improvement, when effected, is really of a lasting nature. In any case, the increases obtained, about 15-20 per cent of the average for unselected plants, are relatively slight compared with those obtained by clonal selection.

Nursery selection is of greater importance for the present day selection programme as a means of obtaining improved stocks for budded clones. In the interests of economy, the selection should be carried out as early as possible in the life of the plant. The seed should be selected simultaneously for size and specific gravity (by flotation in sugar solution) before planting. Selection for one of these characters alone may be prejudicial to the other. Very striking results have been obtained by selective thinning of closely planted seed beds. The thinning is done at a single operation, and up to 90 per cent of the plants can be removed. Obviously, these methods depend on each estate having access to a plentiful and cheap supply of seed.

The exact influence of the stock on the subsequent growth of the budded clone is still an open question. It has been shown by experiment that stocks showing great vigour of growth exert a favourable influence on the success of budding and on the growth subsequently produced. This, in fact, is the benefit derived from nursery selection of stocks. It is further established that the productive capacity of budded plants of a given clone can run to a certain extent parallel with the potential productive capacity of the stock. Nursery selection is again the only means available of making use of this fact. Further investigations are needed to determine whether the stock can influence the type (jât) of the budded clone, or the quality of the manufactured product. Nothing is known of possible stock influence on the behaviour of budded seed-bearers.

ESTABLISHMENT OF BUDDED PLANTS

Budding is a routine operation in which high percentages of success are obtained. Growth of the buds is slow however at high elevations and attempts have been made to evolve a method of propagation in which green shoots could be employed as scions and a more rapid development encouraged. Such a method, which appears to combine the properties of grafting and budding, and from which great advantages are expected has recently been published* — it may be described in English as "couple-grafting."

For the establishment of budded plants in the field there are four methods available: (a) Budding of nursery plants, which are planted out when the buds have swollen; this furnishes a less regular supply of plants which come into bearing no earlier than: (b) Budded stumps, which are budded in the nursery and planted out as stumps 1-1½ years after budding; this method is preferred in all circumstances: (c) Young plants can be budded *in situ* in the field, or: (d) Old plants can be budded on to the new shoots produced after collar pruning.

In the long run, the replacement of existing fields by a monoclone complex — an area of budded plants from a single clone — is aimed at. Normally seed-bearer plots will be maintained only as a source of plants to serve as stocks, and nursery selection will be sufficient to maintain the quality of these. Highly selected seed-bearers will however be established for the purpose of procuring seedling families which will be good enough to replace the best existing clones, and will serve as a source of material from which

* van Emden, I. J. H. (1940). *Arch. Theecult.* 14(1): 16-25.

new mother trees can be selected. The chief difficulty encountered in the establishment of seed gardens from clonal material is to provide a suitable combination of clones which will ensure adequate pollination and from which desirable progeny will be obtained. This is best determined by small scale experiments involving artificial hybridisation.

QUALITY TESTING

Much still needs to be done in this field of work, but the results obtained so far are encouraging. A micro-method of manufacture has been evolved, suitable for the produce of a single bush or a clone in a small scale testing experiment. *It is already established that pronounced clonal differences in quality exist*, particularly as regards flavour and aroma. In van Emden's paper, five clones are listed which are considered to be of outstanding merit in this connection.

CONCLUSION

As a rule in the selection of a perennial crop, vegetative and generative periods can be distinguished — periods in which primary importance is attached to vegetative or to generative selection. From about 1905 to 1930, tea selection was exclusively generative, *i.e.*, it was concerned with the selection of seedlings produced by (frequently) random hybridisation. The vegetative period commenced in 1932, and is approaching its climax with the completion of the clone-testing experiments.

For the future, research procedure will tend to diverge from the *practical application* of the results of selection. The former will doubtless involve an increasing number of hybridisation studies, while the latter will remain in the vegetative field and will lead to the use of budded clones for estate purposes. Since expansion is only possible to a limited degree, the use of budded clones must largely be restricted to the improvement of existing estates. As mentioned above, the best method for this will be complete and gradual replanting with budded stumps. Using properly tested clones, very uniform fields will result and an increasing degree of standardisation of factory procedure, with a corresponding improvement in quality, will become possible.