TEA CLONES AND SEEDS — AN APPRAISAL

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HISTORICAL OUTLINE

Plants raised from seed remained the favoured planting material on commercial tea plantations in Sri Lanka until the mid-fifties, even though clonal selection was started as early as 1937 and the pioneering work on the vegetative propagation of tea described by Tubbs in 1939. It was only in 1955 that the use of vegetatively propagated high-yielding clones was recommended for replanting and new planting on estates (Portsmouth, 1955). With the introduction of a Tea Replanting Subsidy Scheme by the Government in 1958, the extent of clonal tea expanded gradually and interest in seed tea diminished. Consequently, tea seed production decreased and seed gardens were abandoned or neglected. There has been a recent revival of interest in seed tea, especially by tea planters from drought-prone areas. It is well to kindle and foster such interest since the production of tea seed in sufficient quantities and the raising of plants from seed are essential for the progress of a tea breeding programme. To this end, an appraisal of the relative merits of tea propagated from seed and by cuttings and some notes on the need for seed tea and the establishment and maintenance of the clonal seed gardens seem timely.

SOME CHARACTERISTICS OF SEED TEA

The most striking feature about a field planted with tea raised from seed is the enormous variation observed. Since tea is generally cross-fertilized, seed tea is extremely heterogeneous with great diversity in growth, vigour and morphological characters. Differences in growth rate often cause the height of the plucking table to vary from bush to bush, resulting in an unevenness of plucking surface in a field which makes plucking more difficult. Further, the bushes in a field may not all need pruning at the same time, pruning methods may have to be adapted, depending on whether the bush is of the Assam or China type and rates of recovery from pruning may be different. Response to fertilizers may also vary, with individual bushes having different requirements. Since the bushes in a field of seed tea are treated uniformly to facilitate management, the individual requirements of each bush cannot always be met.

Another characteristic of seed tea is that it is quite unpredictable. It is not possible to predict, with any degree of certainty, the yield to be expected from any lot of seed. The crop harvested from individual bushes in a field of seed tea may vary up to 500 per cent between the lowest and the highest yielding bush (Bezbaruah, 1974). In some instances, most of the crop is produced by only about a third of the bushes in the field (Visser & Kehl, 1958). In general, the average yield of a field planted with commercial seed is much lower than one planted with proven high-yielding clonal material.

Tolerance to drought is also not predictable in a field of seed tea. A few drought tolerant types may be interspersed amongst several drought susceptible plants and there will, of course, be natural selection. There is a widespread belief that seed tea, by virtue of its taproot, is able to withstand drought better than vegetatively propagated tea. However, this belief seems quite unjustified and there is much evidence to the contrary. It has been reported that suitable clonal material can be established without difficulty under Uva conditions (Portsmouth, 1955) and clones have been found to stand up to drought conditions as well as, and sometimes better than, seed tea in Uva and Dimbula (Tubbs, 1946) and in the low country (Bean, 1956). Seed tea bushes do not always possess intact taproots. While bushes grown from seed-at-stake may generally possess undamaged taproots, those transplanted from a nursery would have the taproot damaged in the process of transplanting and its function taken over by laterals arising from the seedling taproot. Tubbs (1946), in a comparative study of the root systems of clonal and seed tea, found that clonal tea bushes had a tendency to develop a spreading root system within the fertile upper layer of soil but the roots descended, although not vertically, to a similar depth as the roots descending from seedling rootstocks. Further, although some of the lateral roots produced by seedlings transplanted from a nursery grow vertically downward, the bulk of the root system in these bushes is concentrated in the upper layers of the soil. He concluded that certain of the lateral roots may descend as deeply as the taproot or its substitute in both clonal and seed tea bushes and the function of the taproot is often taken over by lateral roots with no loss of efficiency. Thus, although the taproot is of value if it exists, it is not an essential requirement for tiding over drought. Old seed tea may sometimes appear to do better than clonal tea during periods of stress; this would depend, to a large extent, on the type of clonal tea used in such a comparison. A field of mixed seed tea is bound to contain at least some bushes which can stand up to the drought and may appear superior to a field planted with a clone which has been selected for some character other than drought tolerance. Furthermore, seed tea may sometimes appear to fare better than clonal tea during drought if it was planted in virgin soil or if it is much older than the clonal tea and therefore well established. In conclusion, clonal tea can be established without difficulty and survive, at least as well as seed tea, in droughty conditions provided sufficient care is taken in the selection of drought tolerant clones and in the early stages of establishment.

Susceptibility to nematodes, insect pests and diseases would unpredictable but variable in seed tea. Hence resistance or tolerance to the pests and pathogens prevalent in an area is not assured when seed tea is planted. However, this variation could be advantageous when there are sudden outbreaks of hitherto unencountered pests or diseases since it is unlikely that all the plants raised from mixed seed would succumb to such an epidemic due to the difference in susceptibility among the individual bushes and there would be natural selection for resistant types.

Several of the disadvantages associated with tea raised from seed are overcome by planting clones.

ADVANTAGES OF CLONAL TEA

Plants propagated vegetatively from one original plant are collectively known as clones; they are genetic copies of the single parent plant and may be considered as all parts of one individual. The main differences among such plants will be due to the environment because they are genetically identical. The plants of a clone are, therefore, remarkably uniform when grown under the same conditions and clonal planting gives rise to several advantages such as the following:

1. Superior material, retaining many of the desirable characters of the parent plant, may be produced in large quantities. Thus, planting material may be chosen according to the needs of the area to be planted. For instance, selected drought tolerant clones may be planted in drought prone areas and material tolerant or resistant to the pests and diseases prevalent in an area may be chosen for planting.

2. Yield is predictable. At present, a proven high-yielding clone produces nearly three times as much crop as most existing seed tea on the same area. Clonal tea is generally brought into production more quickly because the selected genotypes usually have a rapid growth rate (Portsmouth, 1955).

3. It may be possible to raise the quality of the tea produced on an estate by planting selected clones (Kane, 1958). There are also some advantages, due to uniformity, in the processing of clonal tea.

4. Similarity of growth rate and response within a clone results in ease of plucking and facilitates the planning of pruning schedules and fertilizer programmes.

DISADVANTAGES OF CLONAL TEA

In spite of the popularity of clonal tea, it is not without certain disadvantages.

For example:

(1) Uniformity results in the same susceptibilities to pests and diseases; this enhances the rapid spread of pests and pathogens so that large expanses of tea may be wiped out with the outbreak of a new pest or disease.

(2) Continued asexual propagation through cuttings may lead to a clone suffering from age effects such as debility and reduced resistance to diseases because peculiarities associated with senescence of the parent plant may be transmitted to the progeny through the cuttings. This has not been reported for tea, possibly because clonal tea has been planted on a large scale only during the last 25 years, but is known in other vegetatively propagated crops such as vines (Molisch, 1938) and grasses (Valentine & Charles, 1975).

(3) Large scale planting with a limited number of clones narrows the gene pool and reduces variability. It is important to shift the population values in the desired direction while maintaining, as far as possible, the variability which is the source of further improvement.

THE NEED FOR NEW CLONES

It is important to have available adequate numbers of genetically distinct clones to meet the demands of the industry. It is possible that even the best clone may prove susceptible to a new disease or suddenly display hitherto unsuspected shortcomings. Such was the case with TRI 2024, once the most popular clone at the higher elevations but which, due to its susceptibility to eelworm and Phomopsis and its uncertain recovery from pruning, lost its place to TRI 2025 (Richards, 1967). The continuous production of new clonal material is essential to ensure that in such an event, there is a choice of clones available for use as replacements.

SOURCES OF CLONAL MATERIAL

There are three possible conventional sources of new clones:

1. Introductions: Perhaps the quickest method of obtain-

ing new clones is to introduce proven material from abroad. However, it would be necessary to re-test this material in clonal proving trials locally due to the presence of genotype x environment interactions and the effect of environment on clonal adaptation and performance which have been clearly demonstrated for tea (Wickramaratne, 1981). Besides, this method would be hampered by import/export restrictions and untold difficulties due to rivalry; it will, therefore, not be considered further.

2. Existing seed tea populations: Selection of mother bushes from amongst already existing seed tea populations for the purpose of cloning is limited to the isolation of the best already present. There is no new creation of variability but rather, the exploitation of that which is already available. Most fields of seed tea in Sri Lanka are predominantly low jat, have passed their prime and are low yielding. An average field of seed tea yields only about 1000 kg ha^{-1} while a good seed tea field may yield about 1800 kg ha^{-1} with some individual bushes yielding more. Hence, selection from fields of seed tea should preferably be carried out in high yielding fields unless selections are sought for characters other than yield.

3. Hybridisation: A survey of clonal selection in Sri Lanka since 1937 shows the hybridisation of selected parental material to be the most promising source of new clones. Hybridisation creates genetic variability which can be exploited. If clones known to have certain desired traits are chosen as parents, the chance of obtaining plants with the required combinations of characters may be increased. Knowledge of the mode of inheritance of desired traits, presently lacking and in urgent need, would help in the choice of parents. The production of clones from hybridisation requires the setting up of clonal seed gardens and the planting of the resulting seed on an experimental scale from which promising new material may be selected. The greatest obstacle again is the lack of reliable selection criteria.

THE CASE FOR CLONAL SEED

It is clear from the above discourse that the main difference between seed tea and clonal tea lies in the great variability in seed tea as opposed to the uniformity of clonal tea. The replanting of seed tea fields with clones results in greater uniformity which, although it helps management and results in higher yields, makes the fields genetically more vulnerable to epidemics. However, the large scale planting of mixed seed tea would not be a sound proposition; it may, however, be useful to plant limited areas with proven 'clonal seed' which, although not true to type, would be less heterogeneous than mixed seed tea. Fields planted with good biclonal seed have been known to give yields approaching 2500 kg ha^{-1} and therefore comparable to the yield from proven clones. Such areas would help maintain the genetic diversity so necessary for a successful breeding programme leading to the selection of superior clones. Thus, although seemingly a step backward, the production and planting of proven clonal seed would lead to the development of more and improved planting material and facilitate the expansion of the area under clonal tea. Admittedly, plants raised from clonal seed would frequently possess many objectionable features in addition to some desirable ones but it should be possible to eliminate these qualities by skilful breeding!

Areas planted with clonal seed would, in addition, be of great use for experimental purposes. They would provide seedling populations from which new selections may be made and would also provide families of individuals which are necessary for the study of the mode of inheritance of desired characters. Such knowledge would be extremely useful for the choice of suitable parents for interclonal hybridisation.

Once the need for clonal seed is realised and the use of interclonal hybridisation as a source of new selections appreciated, the question of where to obtain a supply of clonal seed and how to set up clonal seed gardens is apt to arise. Some practical considerations regarding the establishment and maintenance of clonal seed gardens are outlined in the next section.

THE ESTABLISHMENT AND MAINTENANCE OF CLONAL SEED GARDENS

It would be advisable to set up some clonal seed gardens in the various tea growing districts of the country in order to study the performance of the seed so obtained in the different ecological regimes.

1. Types of clonal seed gardens: Seed gardens may be biclonal, where only two different clones are used as parent or generative clones or polyclonal where many different clones may be planted in an area, any pair of which may be the parents of each resulting seed. In biclonal seed, the tree from which the seed is collected is the maternal parent and the other clone is assumed to be the pollen parent, since tea is usually self-incompatible. In order to increase the likelihood of such an assumption being correct, it is important to have the biclonal area isolated from tea fields so that contamination by pollen from tea bushes in the field is not possible. Biclonal seeds are of known pedigree and are therefore extremely useful in genetic studies. In polyclonal seed, the tree from which the seed is collected is again the maternal parent and any one of the other clones in the garden may be the pollen parent. Many plant breeding activities require detailed knowledge about the genetic relationships among seed and it is therefore preferable that these gardens are also isolated to reduce the chances of contamination with other tea pollen. However, since there is less certainty regarding the male parent of polyclonal seed, if there is a shortage of isolated areas it is perhaps best to reserve them for biclonal seed gardens.

2. Planting material: The choice of the combination of generative clones to be used in a clonal seed garden should be based upon the results of experimental breeding. Clones should be carefully chosen after considering the flowering patterns, compatibility relations, fruit bearing ability and desired characteristics of possible plant breeding significance. Breeding experiments have not advanced sufficiently to justify a final choice of material but studies are in progress. Until such time as the required information is available, it is best to plant polyclonal gardens, using 5 to 7 different clones with 3 or 4 trees of each, per garden. Each clone would then have 4 to 6 other clones in the garden with which to interbreed, of which it is hoped that at least some would be compatible and have synchronous flowering.

One-year-old clonal plants from the nursery may be used but two-year-old plants grown in pots in the nursery are preferable, if available. The latter, being older, would produce a crop of seed in less time.

3. Location and terrain: The area should be suitable for tea growing but isolated from tea fields by at least 0.4 km. The ground should be gently sloping and well-drained with plenty of light and air circulation and sufficient numbers of pollinating insects (files and bees) in the area. An ideal site would be one with a gentle slope toward the East, North-east or South-east so that the trees get the maximum amount of sunshine. An extent of fertile land 20 m by 20 m would be sufficient to plant 16 seed bearing trees.

4. Preparation of land: The land should be thoroughly deep-forked and all roots above pencil thickness removed. It would be useful to fumigate the soil, if possible. Sufficient organic matter should be incorporated before planting the seed bearers.

5. Planting arrangement: It has been customary to plant in clonal rows but this does not allow for optimum pollination. The main insectpollinators of tea in Sri Lanka are flies and bees (Wickramaratne, in preparation). Bees work methodically, moving from flower to flower on a single tree and then visiting the neighbouring tree, often moving down the row. When the entire row is planted with a single clone, a bee moving down the row would not effect any cross-pollination. In order to exploit bee activity and maximise the chances of cross-pollination, it is important to have each clone surrounded by different clones which are possible pollen parents. Alternate planting for biclonal gardens and planned mixed planting for polyclonal gardens (for example, square planting or double triangle planting as is used in Indonesia, S. Sandanam, *pers.comm.*) are therefore recommended and are illustrated in Figure 1.

6. Spacing: The need for sufficient space per tree cannot be over-emphasized. Too close spacing leads to congestion, dampness and high humidity, depriving parts of the tree of sunlight and fresh air; this would dispose the trees to disease and encourage fungal attack on the developing fruit, resulting in premature fruit drop and

a consequent reduction in seed yield.

Recommended planting distances are about 5 m between trees.

7. Ground cover and shade: Quick-growing ground cover must be planted to prevent soil erosion during the early stages but removed when the trees begin to bear, to reduce competing blossom which might attract pollinating insects away from the tea flowers and to facilitate the collection of seeds.

The young clonal trees should be interplanted with quick-growing intermediate shade trees such as Gliricidia or Dadaps which should be removed as soon as they begin to interfere with the growth of the seed bearers.

8. Wind breaks: Protection against strong blasts of wind is necessary as wind may cause blossom drop and premature fruit drop and may also affect insect populations. In order to reduce the possibility of insect pollinators being diverted to blossom on the trees planted as wind breaks, it may be worthwhile using rows of tea trees planted at a closer spacing as wind breaks. If clones, such as DT1, which are good pollen parents are used as wind breaks they could act as pollen donors too.

9. Fertilizer: Newly planted tea seed bearers should be given T 200 at the following rates of application, forking in the fertilizer around individual trees:

1st year - 14 g per plant in 6 applications/year;

2nd year - 21 g per plant in 6 applications/year;

3rd year - 42 g per plant in 6 applications/year.

Subsequently, T 530 may be used, applied at 4-6 monthly intervals at not less than 300 kg ha^{-1} per application. Higher application rates may be required where large crops of seed are obtained.

Fertilizer may be applied in 2 or 3 equal doses during the year with one application at the start of the monsoon and another just before the period of maximum flowering. Although tea trees flower throughout the year in Sri Lanka, there are definite periods of maximum flowering which vary with the clone (Wickramaratne, in preparation). If the flowering patterns of the clones are known, fertilizer should be applied about a month before the peak flowering period to assist the set of fruit. If the flowering patterns of the clones to be used have not been studied, application of fertilizer in three equal doses at suitable times may serve the purpose as several of the clones studied have their peak flowering periods about January to March or June to August.

10. Pruning: Ideally, a tea seed bearer should have a shrub-like habit with 4 to 5 main stems. Tree formation should be attempted at the early stages of growth and is best initiated by thumbnailing in the nursery. Lower branches which trail on the ground should be removed and the upper branches may be thinned but cuts should be reduced to a minimum. However, if there are too many branches it may be necessary to remove some in order to keep the centre of the tree sufficiently open to let in sun and air. The tree should not be permitted to grow so tall as to be out of reach, even with the aid of a ladder. All prune cuts should be treated with bitumastic and antifungal compounds such as TB 192 or Santar A. Once the ideal tree form has been achieved, no further pruning is required.

11. Cultural practices, pest and disease control: It is important to protect the seed bearers against shot-hole borer infestations because the presence of galleries in the branches cause them to snap, often resulting in loss of premature fruit. Shot-hole borer may be controlled in newly planted tea seed gardens, up to about the third year, by spraying with Dieldrex. The recommended dosage is 15 cc in 1 gallon of water. The trees should be sprayed thoroughly so that the entire frame including bark, younger wood, trunk and main branches are covered with a deposit. Spraying should be done on a dry day and the deposit should dry on before rain occurs. The base of each tree may be sprayed at ground level with the same mixture to prevent termite damage. When the trees being to produce flowers and fruit the use of insecticides should be reduced to an ablolute minimum, as the pollinating insects must not be disturbed or destroyed.

Care must be taken to prevent fungal attack. In addition to fungal growth on leaves, fungal infections have also been found in fruit at various stages of development resulting in premature fruit fall and rotting of seeds. Fungi may be controlled by the use of copper-based fungicides.

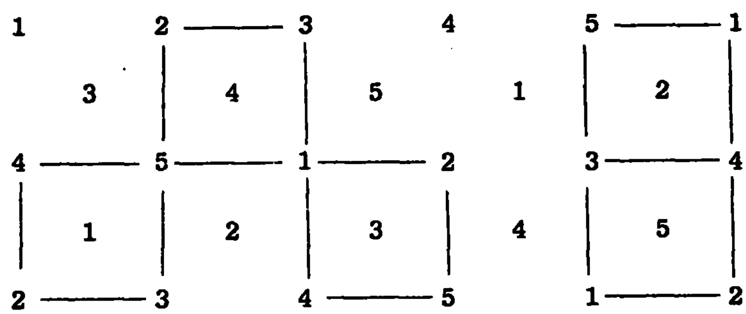
Other cultural practices include weed control. Weeds should be removed or at least slashed in order to reduce competing blossom which may attract the pollinating insects away from the tea flowers. Keeping the area weed free would also facilitate collection of seeds. Forking and the incorporation of green manure is recommended about once in five years. It would be useful to mulch the area between the trees during periods of drought in order to prevent water loss from the soil surface.

12. Seed yields: Tea seed bearers are said to have a useful life of about 30-40 years. The first crop of seed may be expected about 7 years from planting although if plants which have been planted in pots in the nursery for 2 years are used, seed production may begin within 3 years from planting.

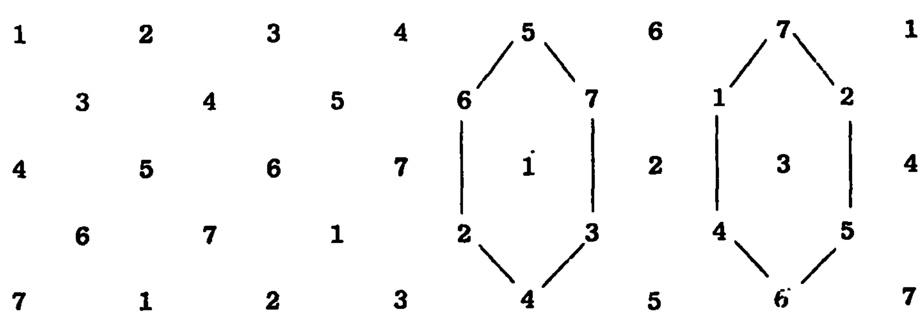
The development of mature fruit from pollinated flowers takes from about 9 to 18 months, depending on the clone. Yields may be in the region of 4-8 maunds per acre, one maund being equivalent to nearly 40 kg. It is best to collect the seed directly off the tree, just as the capsules are dehiscing. Seeds may also be collected off the ground but should not be left lying on the ground for too long, especially during wet weather.

1	2	1	2
2	1	2	1
1	2	1	2
2	1	2	1

(a) *Alternate planting*



(b) *Square planting*



(c) *Double triangle planting*

Figure 1.

Planting arrangements for clones in clonal seed gardens. (a) Alternate planting for two different clones, 1 and 2. (b) Square planting using five different clones, 1 to 5. (c) Double triangle planting using seven different clones, 1 to 7. The numbers represent different clones and indicate the position of each clone.