THE BREEDING, SELECTION AND PROPAGATION OF TEA*

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Tea was introduced into Ceylon and grown with success since the eighteen-seventies when the coffee industry which was the mainstay of the Island's economy collapsed because of the ravages of the Coffee Rust disease. From a meagre ten acres in 1867, the extent under tea had risen to 14,226 acres in 1880, and 305,000 acres in the next fifteen years. The total extent in 1965 was 594,308 acres and is expected to increase to 600,000 acres in the next few years with the planting of more land in tea in highland colonization schemes, and by the Ceylon State Plantations Corporation.

The total tea production has also shown a spectacular increase with an all time high-yield record of 503,200,000 lb in 1965 and the average yield per acre has risen from 503 lb in 1945 to 748 lb in 1960, 824 lb in 1963 and 848 lb in 1965. Unfavourable weather conditions in 1964 caused a drop in yield to 481,700,000 lb with an average of 814 lb per acre compared to 484,600,000 lb in 1963. Nevertheless the target for 1965 of nearly five hundred million pounds, which is about half the production target of India, the world's largest tea producer with 825,700 acres under tea (*World Coffee and Tea*, July 1965) was exceeded by 3,200,000 lb.

Ceylon's economy is primarily dependent on the foreign exchange earnings from the export of tea, which in 1965, amounted to Rs. 1,210,000,000 representing 62% of the total foreign exchange earnings of the country. With the increase in world demand for quality tea there is little doubt that Ceylon tea which has a reputation for its quality and flavour will continue to occupy a pre-eminent position as the major export crop of the Island.

Breeding of Tea

Tea is almost completely self sterile and requires cross-pollination for the satisfactory setting of viable seed. According to the most recent botanical classification of tea (Barua 1965) there are three kinds of cultivated tea indigenous to the three different geographical regions of South East Asia, namely, Assam, China and Indo-China of which the first two are distinct species, *Camellia assamica* Masters and *Camellia sinensis* L. while the third which is known as the " Southern " form or the Tran-ninh plant is regarded as a sub-species of the Assam plant and named *Camellia assamica* sub sp *lasiocalyx* (Planch M.S.) by Wight (1962). A species of wild tea *Camellia irrawadiensis* P.K. Barua which does not contain caffeine like the cultivated tea has also been described, its native habitat being Upper Burma. Most of the high-grown tea in Ceylon and in North East India consists of natural hybrids between Assam and China tea, and some of these have also the characteristics of the Southern form of tea. According to Barua (1965) there is reason to believe that complex hybrids of these three kinds of tea and one or more of the wild species of *Camellia* occur in the cultivated tea populations particularly in the Darjeeling district of NE India which is famous for the distinctive quality and flavour of its tea.

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Until recently when some large companies became interested in the production of vegetatively propagated (VP) tea the most popular method of growing tea in India was from seed, and for that purpose commercial seed gardens known locally as seed *baries* were established mostly in Upper Assam. Mass selection was the method practised for tea improvement by some growers for over 50 years. It was successful to some extent in improving the indigenous Assam tea probably because of the presence of desirable genetically linked morphological characters that breed true to type. It failed, however, to produce a hardier kind of tea with acceptable cup characters and morphological uniformity which could adapt itself to conditions in other regions. The tea breeding programme which was initiated at the Tocklai Experimental Station in 1939, but which came into full operation only after the war years in 1946, has, therefore, as its objective the improvement of the existing standard of tea by the line breeding technique in order to achieve uniformity within and diversity between types of progenies from which selections could be made for the different regions (Barua 1963). Seeds are initially produced by controlled hand pollination between selected pairs of bushes and the resulting seedling progenies are put out in replicated test plots along with a popular commercial jat as control for observations on vigour of growth, morphological uniformity, leaf quality and yield. The two bushes whose seedling progeny shows promise are then multiplied vegetatively and planted as generative clones in alternate rows in isolated seed gardens to produce seed by natural cross-pollination. The number of plants of each clone need not be the same if one is a better seed producer than the other. The biclonal progenies from the resulting seed are tested at Tocklai and other districts. The final selection of each pair of generative clones is made on the performance of their biclonal progeny. It may take as many as seven years to assess fully the manufacturing quality, yield capacity, *etc* of one generation of biclonal seedlings, and it is estimated that to effect reasonable improvement it may take as many as three generations, although with some clones satisfactory results may be achieved in one generation. Out of hundreds of crosses made at Tocklai up to 1963, only six pairs of generative clones have been selected and planted out in isolated seed gardens and these have yet to prove their worth (Barua 1963). Nevertheless the use of a " combiner " clone which according to Wight (1961) transmits its morphological features to the progeny resulting from cross-pollination with another clone merits consideration if remarkable uniformity in growth and other characteristics could be achieved thereby. The precise conditions under which the combiner clones can be put to practical use and the suitable clonal combinations have yet to be worked out. Selection for pubescence or hairiness of the first fully opened leaf below the bud which was recommended earlier as being correlated with quality has now been found to result in production of tippy tea in orthodox manufacture. With the CTC method of manufacture high degree of pubescence results in production of tea " saw dust like " in appearance.

Polyclonal combinations involving the use of more than two generative clones in a seed garden have also been tried out at Tocklai, but the results are said to be more unpredictable than those from biclonal matings. The use of polyclonal seed gardens with about ten selected clones is recommended as an interim measure for quick results in Nyasaland and Rhodesia by Ellis (1964). It is claimed that the polyclonal progeny is likely to have a higher level of tea making quality and uniformity than the progeny of ordinary unselected commercial seed. Biclonal seed gardens are, however, better but it takes more time for the clonal pairs to be thoroughly tested to make certain that they combine satisfactorily and produce large quantities of good viable seed.

In the Soviet Union where a tea breeding programme was initiated in 1930 at the Experiment Station, Georgia, new high yielding varieties with increased tannin content and appreciable resistance to frost were evolved by artificial pollination with pollen mixtures taken from Indian, Chinese and Japanese varieties of tea with the desired characteristics. No less than 20 hybrid tea varieties have since been developed, and of these Selection No 8 known as Severny is grown in areas where the ground is covered by a blanket of snow in winter and the temperature drops to –25°C. The success of the methods employed in tea breedng is claimed to be due primarily to the use of a population of tea rather than individual bushes as initial breeding material (Konstantin 1965).

In Ceylon a programme of tea breeding was initiated about four years ago at the Tea Research Institute. The results of experiments on controlled hand pollination confirmed the existence of self sterility in tea. The few seeds that set either failed to germinate, or produced seedlings which lacked vigour. A large number of successful crosses have been effected between clones noted for their high yield potential such as TRI 2024, TRI 2025, TRI 1114, *etc* and clones of high quality such as TRI 777, DT 1 *etc*. Clones tolerant to eelworm and Blister Blight have also been included in the hybridization programme with a view to combining the desirable characteristics of high yield, high quality and pest and disease resistance in the seedling progeny. The next step was to select the most promising hybrid seedlings on their vigour and habit of growth, morphological characteristics, uniformity and fermenting ability as determined by the chloroform test and multiply them vegetatively from cuttings for further field trials. Preliminary observations indicate that the progeny of the cross TRI 1114 × TRI 2024 are comparatively vigorous growers with bigger leaves while the progeny of crosses with DT 1 which appears to be a poor combiner clone are generally slow growers and consist mostly of small leaved types. Several hundreds of seedlings from open pollinated seed of approved TRI and estate clones are also under observation in the field. In Java, Wellensiek (1940) has shown that rapid growth of seedlings both at an early age and at a later stage can be considered as a genetical characteristic related to yield.

Production of biclonal seed has also been undertaken by the private sector at Lansdowne and Rambukkande estates in the Ratnapura district using the two TRI clones 2023 and 2026 which have proved successful as high yielders giving over 5000 lb of made tea per acre in the low country. The biclonal seedlings appear to be more vigorous and uniform with a high proportion of large leaved types than seedlings from unselected commercial tea seed.

The programme of tea breeding has a two-fold objective—the production of generative clones which give rise to vigorous and uniform seedling progenies with all the desired characteristics, and the selection of the so-called "golden bushes" with high yield potential, leaf quality, pest and disease resistance, *etc*, which could be multiplied as clones. With a highly heterozygous plant like tea which shows great variability in its seedling progeny there is considerable scope for improvement by selection.

Selection

The most popular TRI clones 2023, 2024, 2025 and 2026 which cover over 60% of the new clearings under the Tea Replanting Subsidy Scheme since it came into operation in 1959 are all selections made at the Tea Research Institute from about 15 seedlings raised from seed brought by Dr F. R. Tubbs in 1937 from a single open pollinated seed bearer at the Tocklai Experiment Station of the Indian Tea Association, New Jorhat, Assam. (Richards 1965). Estates have also not been slow in selecting in the field quite a few clones which are outstanding in leaf quality, tolerance to nematodes *etc*. Selection has to be made in a high yielding field of mature tea of about 15 to 30 years or more, and not from either young seedling clearings or very old tea which has passed its prime. The field should be reasonably large with about 40,000 bushes and the initial selection is made by eye on the following criteria after discarding all those bushes which are favourably situated in close proximity to drains, roads, foot-paths, ant-hills, springs or surrounded by vacancies :

1 — High density of plucking points per unit area of the surface—avoid bushes with open plucking table

2 — Strong spreading bush frame with healthy foliage—Weak frames with poor spread and unhealthy foliage should be discarded and so also strong frames with relatively few plucking points

3 — Evenness of flush—select bushes in which the buds grow evenly at about the same time and produce a crop of flush—Avoid bushes with poor and uneven bud growth

4 — Good size of leaf—bushes with large leaves generally produce heavier plucking shoots and give higher yields

5 — Reasonable length of internode—flush shoots with very short internodes are difficult to pluck and are less heavy

6 — Absence of tendency to free or precocious flowering—avoid bushes which produce flower buds at the expense of leaf buds

7 — Absence of tendency to produce *banji* frequently—this may be reflected in low yield

8 — Very high degree of tolerance or resistance to Blister Blight, *Phomopsis* and other diseases and to pests such as Shot-hole Borer, mites and nematodes

9 — Resistance to drought—this is of particular significance in areas subject to drought and strong desiccating winds

10 — Rate of fermentation as determined by the chloroform test—the test should be repeated under different weather conditions and all non-fermenters rejected.

Once the initial selection by eye has been completed the selected bushes should be marked with tall bamboo stakes. After the field is pruned further selection from amongst these marked bushes is made on the appearance of the frame, evenness and vigour of growth of the buds and the density of the plucking points. About 100 cuttings from each of the selected bushes are taken for rooting tests in the nursery before the bushes are brought into plucking.

The true yield potential of a seedling bush can only be judged from the performance of its clonal progeny and not merely from its performance as a single mother bush. Nevertheless individual yield records of selected mother bushes are useful for comparison with that of a standard clone if they cover both the peak flush periods as well as the off periods during the year. The final selection is made on the yield records of both the mother bush and its clonal progeny and the quality of the made tea from them as determined by the mincing machine technique described by Keegel (1935). The ability to strike root rapidly is also an important factor in large commercial scale propagation of tea, and unless a clone is exceptionally high-yielding, or of very high quality, it should not be selected if it is a poor rooter in the nursery.

Propagation

Tea is no longer propagated from seed in Ceylon except for supplying vacancies in old tea in small holdings and a few estates. All new clearings under the Tea Replanting Subsidy Scheme have to be planted with approved VP tea clones except in special cases where the Tea Controller may allow 50% of the area to be planted with seedling tea if soil and climatic conditions are not favourable for the success of VP tea.

The technique for raising VP tea is now well known although it took several years for it to be perfected by the pioneer workers, Dr F. R. Tubbs and Mr F. H. Kehl at the TRI and most estates have their own nurseries for the supply of VP plants. The stem of the cutting is generally an inch long and is inserted into polythene sleeves of three inches in diameter and nine inches in length containing a rooting medium consisting of friable soil of good structure taken from the jungle, patana or Guatemala Grass field or even subsoil with well rotted tea fluff compost, the pH of the rooting medium being about 4.0 to 5.0. Most estates prefer to strike the cuttings under low shade about three feet high provided by bracken fern or coir matting supported on metal hoops.

The following are the most important factors which influence rooting of cuttings :

1 — *Moisture*—Two or more applications of water have to be given daily depending on the soil and intensity of rainfall in order to keep the soil moist and the atmosphere above the cuttings saturated. Relatively heavy soils will require less moisture than light soils. Many of the casualties among nursery plants are generally due to over-watering which also causes abnormal callus formation that inhibits rooting or induces shallow rooting.

2 — *Light intensity*—Cuttings will fail to strike root if they are kept in the dark. They should receive about 25% light intensity at the start and once they are rooted more light should be allowed particularly in the mornings. Failure to provide adequate light intensity would result in a slowing down of growth and a high percentage of banji.

3 — *Soil acidity*—An optimum range of soil pH from about 4.0 to 5.0 has to be maintained if the cuttings are to strike root satisfactorily. Any pH higher than 5.5 is harmful and so is also a very low pH. Soils with high pH can be rendered more acid by mixing with sulphur or with aluminium sulphate solution at the correct dosage.

4 — *Soil texture*—Many failures in rooting of cuttings are due to the use of soils of poor texture which impedes drainage. A high proportion of silt and clay is harmful, neither should the soil be too light and sandy. It should not be rammed and made very compact in the polythene sleeves but only lightly pressed when the cuttings are inserted, to prevent occurrence of air pockets.

5 — *Soil fertility*—Cuttings do not strike root satisfactorily in soils which have received fertilizer recently. The best growth is made in jungle or Guatemala soil. Mixing of 1 to 2 oz of superphosphate per square yard of soil to a depth of 6" or 6 to 12 oz per cubic yard of bulked soil before filling the sleeves is beneficial.

Once the cuttings have rooted they should receive once every fortnight a soluble fertilizer mixture containing sulphate of ammonia (35 parts) sulphate of potash (10 parts) and Epsom salts (10 parts) at the rate of ½ oz per gallon per square yard for about 100 sleeves.

6 — *Pests and Diseases—Fumigation with methyl bromide or other suitable soil disinfectants is absolutely necessary as a routine measure in nurseries on estates 3000 ft and over in elevation where parasitic nematodes are likely to occur. Every care should be taken to prevent reinfestation through drainage water from any adjacent infested fields.* Spraying with copper fungicides is necessary against Blister Blight in wet or cloudy weather and with DDT against Tea Tortrix.

Clonal testing

The performances of tentatively selected clones have to be tested in the field to enable the final selections to be made. No less than 85 TRI and estate clones and three seedling progenies of which one is biclonal, have been included in the clonal testing experiments set down annually since 1961 at St Coombs (up-country) Hantane (wet mid-country), Passara (semi-dry mid-country) and Kottawa (low-country) using TRI 2024 as the standard clone for comparison in each experiment.

The design used for these experiments is the randomized block with split plots in four replicates of which two are under *Gliricidia* or dadap shade and two without shade, the number of bushes in each plot being 36 planted in 6 rows at a spacing of four feet between row and two feet in the rows with guard rows of a red pigmented clone TRI 26 or TRI 2043.

Table 1 shows the yield records of weekly pluckings for the two years in the 1961 experiment at St Coombs.

TABLE 1—*Mean yields of clones : St Coombs (lb per acre of made tea per year for two-year weekly plucking)*

Clone	*Yield*	*Clone*	*Yield*	*Clone*	*Yield*
TRI 2025	2817	CY 9	2324	K 136	1662
TRI 2023	2699	MT/BG	2273	NL 3/1	1638
TRI 2026	2583	CV 5/B1	2161	T 5/35	1584
TRI 2024	2521	UH 9/3	1917	TRI 777	1479
GMT 9	2501	SEED	1875	KEN 15/7	1444
TRI 2027	2475	K 150	1861	PO 26	1297
TK 48	2424	T 5/3	1783	NL 4/2	1289
TRI 2151	2411	PA 22	1780	EN 31	1116
KEN 16/3	2379	MT 18	1764	QT 1/5	1097
N	2367	DG 39	1696	CR 4	1020
DT 1	2357			CV 4/B1	1006

LSD at $P = 0.01 = 447$

The mean yield of all clones under shade was 1849 lb and under no shade 2000 lb of made tea per acre per year, the statistically significant difference being 112 lb ($P=0.01$). The clones which have done well not only at St Coombs but also at the other regional stations are the popular TRI clones 2023, 2024, 2025 and 2026. The seedlings used in the experiments are from seed of the same parent tree at Tocklai from which an earlier collection of seed gave the popular TRI clones and it is significant that all these selections have out-yielded the seedlings ; the best was clone TRI 2025 by nearly 1000 lb of made tea per acre.

Summary

A tea breeding programme has a two-fold objective, the production of generative clones whose seedling progeny is uniformly vigorous, high yielding and of high quality and the selection of vegetative clones which have all the desirable charactoristics. The criteria for selection of the "golden bush" are outlined and the methods of propagation are discussed.

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