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Selection and Testing Field Performance of Tea Clones of *Soktim* and *Kanyam* Tea Estates in Nepal

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Abstract

Nepal has a very long history of tea cultivation, dating back to 1862, when the Ilam Tea Estate was established. Thereafter, *Soktim* and *Kanyam* tea estates were established, where we can find several seed-grown tea plantations. This paper has been prepared after a thorough review of the early efforts by experts in Nepal to select desirable tea clones from the natural variability in the selected tea estates. Moreover, it has also described the procedures and criteria for selecting elite clones. Likewise, it also highlights the genetic and morphological differences between seed and clone plantations and their complementarity as planting materials. Based on the review and descriptions, it is suggested to conserve valuable tea germplasm present in the existing old seed-grown plantation. The risk of new clonal plantations' genetic vulnerability is emphasized, as using a small number of well-liked clones narrows their genetic base.

Keywords: camellia, seed, clone, germplasm, selection procedure, cultivar

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Introduction

Junga Bahadur Rana, the ex-prime minister of Nepal, brought tea seeds to Nepal for the first time. He provided some seeds to his son-in-law, Mr. Gajaraj Singh Thapa, the then colonel of Ilam district. The first tea plantation was done by Gajaraj Singh Thapa in 1862 in the Ilam Tea Estate. Then, after, the Shoktim tea estate was established in 1864. Thus, these two tea gardens are known as the historical tea gardens of Nepal, where we can find genetically and morphologically distinct varieties of tea bushes still producing good quality leaves.

The quality of tea leaves and their liquor is so exotic and unique in character. However, conservation of these tea varieties has been given less priority by the Government. With the intention of producing Nepal's own tea clone, Mr. S. K. Pradhan, for the first time in 2010–2011, chose some good varieties from the Ilam and *Kanyam* tea estates. However, his research activities efforts were not carried out by the state authority, and it became obsolete after his death. In 2021, the National Tea and Coffee Development Board (NTCBD) and National Agriculture Research Council (NARC) agreed through an MoU to conduct research on tea. Thereafter, the selection and clone development activities have been started. These tea species, growing side by side, crossed freely among themselves and thus produced highly heterogeneous early populations.

Difference between Tea Seed and Tea Clone

According to Barua (1963), adaptability is the primary distinction between clone and seed offspring “a seed population composed of a large number of genetically distinct units is elastic and can be fitted into a wide range of cultural and environmental conditions without much change in its overall performance.

On the other hand, thousands of bushes of a clone widely separated in space and time behave, in most ways, as a single bush. Consequently, a clone lacks elasticity which makes it more selective of environment and cultural treatment" (Barua, 1963). In light of this, it is anticipated that a clone will be more susceptible to a change in soil and climate than a seed population. According to the aforementioned distinctions, plant improvement in"Science and Practices in Tea Culture", (Barua, 1989) describes numerous benefits and drawbacks of seed vs. clone, as well as vice versa. Numerous factors will determine how they are grown for commercial use. Since they typically complement one another, there is no need to choose between them. Three to five clones should be used, according to (Wight, 1956), to plant one-fifth of an estate. Later, it was suggested that clones and seeds should be planted in an estate at a ratio of 1:1 as a long-term strategy. A single clone shouldn't take up more than 10% of the total estate space(Bezbaurah & Singh, 1980).

Complementarity between Clone and Seed

Elite clones are selected from either artificially developed or naturally occurring genetic variations. Their commercial multiplication is accomplished through vegetative propagation. The result of sexual reproduction, a fundamental aspect of evolution, is called a seed. This characteristic of the seed gives the opportunity to choose among different clones. The decision of tea growers to use seed or clone depends on a variety of factors, as indicated above, but the race to develop seed and clone types that complement one another will continue (Barua,1963). Visser (1969) emphasizes the significance of breeding for the general genetic advancement of tea while acknowledging the limitations of clonal selection from existing tea fields. The development of a seed or a clonal variety depends on various factors like its time requirement, location, climate, and the environment of that region. It will depend on the stage of the improvement program, the targets, the evaluation technique, the selection criteria, the growth environment, and the level of urgency. Total replacement of seed by vegetative clones can potentially be ruled out utilizing recent advancements in tea. The

simultaneous creation of seed variants and clone selection is both more likely and preferable.

Selection of Clones

Genetic Variability

The exploitation of wide genetic variability present in the early tea populations due to free hybridization among cultivated tea species was adopted as one of the early strategies for tea improvement. Early improvement of tea was based primarily on mass selection, line breeding, and clonal selections. Mass selection (Wight, 1956) failed to produce desired results. Hence, it was replaced later on by line breeding, where every selection was maintained separately to establish a new seed *bari (*bank) from which further selections were made. It was further extended to produce bi-clonal seed varieties.

Selection Criteria for yield

Mature bush yield

Many selection criteria have been established and used widely in selecting elite clones. Some of these are described below:

Size or Surface Area. (Visser, Some aspects of the propagation of tea cuttings, 1961) suggested using the bush's size or surface area to estimate yield. Surface area that has been pruned or removed and yield of specific bushes have been found to be positively correlated .

Leafiness. A bush's leafiness or total leaf area could be used as a criterion for its ability to produce more yield. (Barua D. , 1963 a) asserts that since young shoots harvested as crop develop primarily at the expense of food produced by the maintenance foliage, and that its reduction results in a proportional loss of crop, there can be expected to be a positive correlation between yield and area of mature leaf on a bush. According to (Visser, 1969), there is a substantial positive correlation between the yield of shoots harvested from two groups of clones and the total leaf area per bush.

Leaf size. A yield criterion has been developed based on leaf size, which is connected to the size and weight of the shoot. According to studies conducted

in the USSR (, South India (Satyanarayana & Sharma, 1982) leaf size, leaf number and yield in Japan (Toyao, 1966) and length of growing shoots and yield (Amma, 1975), there is a positive correlation between the size of the leaf and the yield of tea. These associations, however, were only discovered in bushes with a sparse population of China – and China-hybrid leaf species. There were no such relationships in large leafed shrubs. Given that a bush with large leaves and a large shoot provides a benefit other than yield, namely a lower plucking cost, weightage may be given to bushes with large leaves in clonal selection, provided that other criteria permit.

Plucking Point Density. One of the most crucial criteria for quickly evaluating mother bushes by eye judgment is plucking point density. It estimates how many shoots were really plucked from a shrub.

According to Barua and Dutta (1971), a tea bush's center has the highest density of plucking points, and the number of shoots decreases steadily as it moves outward. Regardless of the vigor of the bushes, it was discovered to be true in all of them. (Barua D. N., 1965)had also discovered that the following morphological characteristics of a tea bush contributed favorably to the high density of plucking points:

a) Thickness and distribution of pruned sticks

b) Bud break per pruning stick

c) Evenness of flush

Pruning Weight. Visser (1969) and Satyanarayana and Sharma (1982) found that the weight of the pruning, among other growth parameters, such as the number of plucking points, the number of pruning sticks, the weight of tipping, and the number of primaries tipped, was a fairly reliable criterion for bush yield.

Selection Criteria for Quality

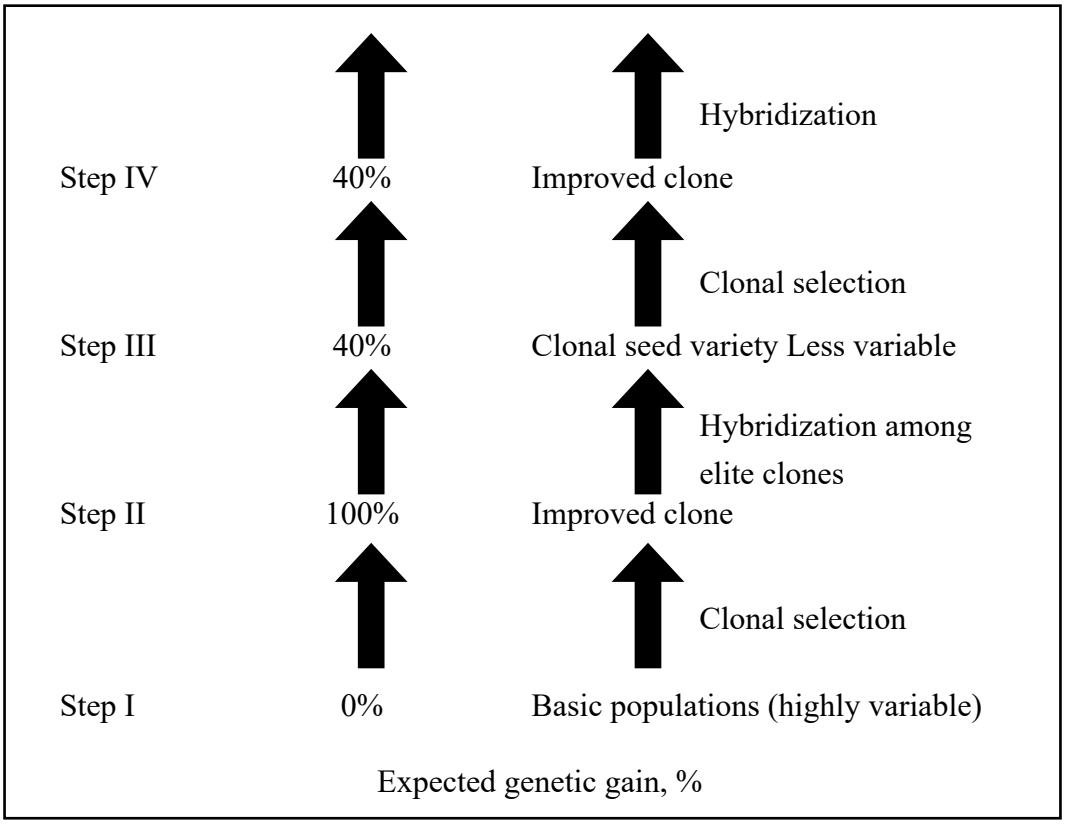
Pubescence

Pubescence, or the hairs on the underside of the leaf, has been linked positively to quality (Wight & Barua, 1954) (Wight & Gilchrist, 1961)(Wight,

Gilchrist, & Wight, 1963) (Venkataramani, 1964). Quality is not causally related to hairs themselves (Wight & Gilchrist, 1961). Orthodox tea is usually manufactured by collecting tips. Pubescence, however, did not correlate with quality in the tea manufacturing industry (Annual report, 1964).

Figure 1

A schematic diagram of the "clone-seed cycle" of tea improvement



Color of Leaf

Assam tea varieties with light green leaves produced higher-quality tea than those with green leaves (Wallensiek, 1947; Venkataramani, 1964; Wight, Gilchrist, & Wight, 1963) had established an ideal level of greenness for superiority. The palest green, as well as the darkest green foliage, produced inferior products compared to those from medium green. The findings presented here clearly

demonstrate that a leaf's color cannot be taken as a sign of quality.

Pubescence, phloem index, and vascular index were found by (Wight & Barua, 1954) to be favorably connected with the quality and strength. However, there are significant phenotypic or environmental variables that affect these characteristics (Visser, 1961)

Chloroform Test

This test, which was created to assess the fermentation of black tea, is frequently employed in various nations to evaluate the fermentability of the bushes (Sanderson, 1963)(Toyao, Katsau, Kayumi, Matsushita, & Amma, 1971) (Ellis, 1964) (Richards, 1967). The leaf in this experiment turns from green to brown. The speed of color changes suggests greater fermentability.

Selection Procedure

The technique of choosing clones is time-consuming and laborious. Before a clone is made available for commercial planting, it typically takes 7–10 years (Barua, 1963a; Bezbaurah, 1969; Singh, 1996). Figure 2 outlines the selection process in detail (Singh, 1996). The initial decision is primarily based on visual assessment of bush size, frame, and plucking point density; the second decision is based on rooting response, yield, and quality (Barua, 1965; Sinfg, 1996). Later, a streamlined method for clone selection was developed and implemented, based on the vigor of the mother bush and its young in the nursery (Bezbaurah H. P., 1984). Clones are evaluated for yield and cup quality, as well as their resistance to pests, diseases, and water stress.

Due to variations in the types of tea processed, the bushes grown, and the soil-climatic conditions, a rigid selection process cannot be applied across all locations. For instance, the criteria for manufacturing orthodox tea will differ somewhat from those for manufacturing CTC tea. Selection will be completely different for a particular tea quality. Similarly, in certain locations, taste is the primary criterion for selection, whereas in others, resistance to disease and pests is the primary criterion. Therefore, the selection methods recommended below for clonal selection in mature fields and seedling progenies should only be viewed as

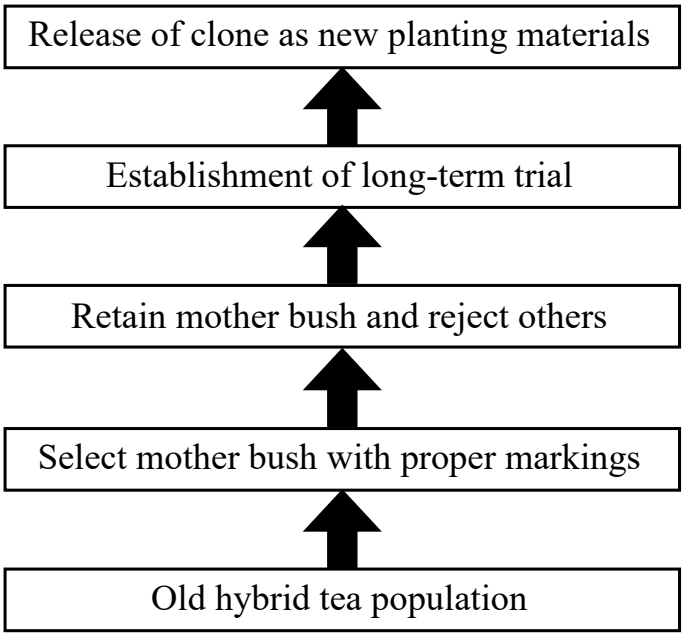
general recommendations that may need to be adjusted to meet local conditions.

Selection of Clones in a Mature Field

For the purpose of selecting elite clones, use hybrid populations developed from old seed. Highly varied populations are more likely to produce exceptional clones than areas with more physically homogeneous bushes.

It is recommended to choose fields in phases, applying one rejection criterion at a time. Using the standards suited for that stage of growth, it might be started at any time of the year. When the plucking table is fully utilized, it is preferable to begin the selection process by screening for the density of plucking points. If the pruning cycle is longer, it should be postponed until the second or third year after pruning to give enough time for the entire plucking table to be filled. At the end of the plucking season, selection should be made for annual prune bushes (Barua D. , 1989).

Bushes should be chosen based on a number of factors that have already been mentioned. The sequential steps taken up until the release are given in Figure 2.



A. Fig. 2: ***Procedure of clonal selection in tea*** Selection criteria for the mother bush with proper markings

Health, vigor, flushing behavior and duration, free from diseases and pests, plucking point density, distribution of plucking points, leaf size-medium, leaf color – intermediate, least presence of root suckers, preferably compact frame, erect or semi-erect leaves, medium position, intermediate shoot size, higher pubescence, and least flowering.

B. Retain mother bushes and reject others

Maintain a crop record for each bush individually in every plucking round, and convert the total crop to yield per unit area for each bush.

- Allow the plant to grow undisturbed.
- Prune and clean the bush frame properly.
- Plant cuttings bush-wise and record the number of cuttings per bush.
- Compare growth records with control(s).
- Process green leaf in miniature manufacture and assess for quality.
- Compare rooting ability with control(s).

C. Establishment of long-term trial

- Bring up the young plants per recommended practices, viz., mulching, centering, re-centering, etc.
- Guard against weeds, pests, and diseases.
- Maintain crop records clone-wise and repeat-wise for 3 consecutive years starting from the 2nd year and compare with control(s).
- Arrange manufacture and quality assessment of each clone separately and compare with control(s).
- Record the weighing of pruning litters clone-wise and repeat-wise at the end of the 3rd year and compare with the control(s)
- Observe and record resistance to drought, diseases, and pests.
- Record morphological characters of each clone.
- Ascertain the promising clones on the basis of the above observations and trials.

The selection and its field trial performance during 2011, conducted by the National Tea Coffee Development Board, Nepal, at *Kanyam* and Ilam Tea Estates, are given below:

D. Bush Selections

Out of 30 selections initially, 10 selections were made as per the given criteria:

- Shoot size
- Shoot weight
- Length of internodes
- Disease pest resistance
- Flushing pattern
- Plucking point density

The nodal cuttings of 10 selected bushes were planted in the nursery of various geo location of NTCDB units.

Table 1

Performance of selected bushes under different criteria at Ilam Tea Estate in 2011

SN	Bush No	Green leaf yield in cm from June to Oct 2010	Inter nodal length of 1st and 2nd leaf in cm	Plucking point density in 25cm2	Bush diameter in cm	Leaf style	Pubescence	100 Shoot size in gm	Quality	Peast disease Observation
1	3A/3(UP)	750	1.1	13	80	Semi-erect	Medium	32	Very good	Susceptible to mite/thrips
2	4A/1(LP)	1145	1.4	15	110	Semi-erect	Medium	31	Good	Highly susceptible to blister
3	4A/3(LP)	1900	1.8	18	110	Semi-erect	Medium	33	Average	Fairly resistant to mites
4	4A/5(LP)	805	1.6	11	90	Semi-erect	Medium	36	Very Good	Highly susceptible to thrips &blister
5	4A/6(LP)	1055	1.7	12	95	Semi-erect	Medium	32	Average	Highly susceptible to blister
6	4A/7(LP)	845	1.4	10	85	Semi-erect	Medium	30	Very Good	Fairly resistance to mites and blister
7	5B/1(UP)	1070	1.7	12	98	Semi-erect	Medium	34	Good	Susceptible
8	6B/1(UP)	2360	2.1	24	180	Semi-erect	High	35	Average	Fairly resistance

Table 2

Performance of selected bush to different criteria at Kanyam Tea Estate in 2011

SN	Bush No	Green leaf yield in cm from June to Oct 2010	Inter nodal length of 1st and 2nd leaf in cm	Plucking point density in 25cm2	Bush diameter in cm	Leaf style	Pubescence	100 Shoot size in gm	Quality	Pest disease observation
1	6A/3(UP)	895	1.7	10	95	Semi-erect	Medium	30	Very good	Susceptible to mite/ thrips
2	6A/5(UP)	1465	2.1	19	115	Semi-erect	Medium	32	Good	Fairly resistance to blister blight
3	7A/1(UP)	785	1.5	11	100	Semi-erect	Medium	31.5	Excellent	Susceptible to mites
4	7A/2(UP)	705	1.6	12	85	Semi-erect	High	31.0	Very Good	Fairly resistance to blister blight

Table 3

Taster reports on experimental tea samples of made tea from the Ilam Tea Estate in 2011

SN	Selected mother bush	Strength of liquor	Quality	Flavour
1	3A/3	Very good	Very good	Good
2	4A/1	Good	Good	Good
3	4A/3	Good	Fairly good	Good
4	4A/5	Very good	Very good	Very good
5	4A/6	Fairly good	Fairly good	Good
6	4A/7	Very good	Very good	Very good
7	5B/1	Fairly good	Good	Good
8	6B/1	Good	Fairly good	Fairly good

Table 4

Taster reports on experimental tea samples of made tea from the Kanyam Tea Estate in 2011

SN	Selected mother bush	Strength of liquor	Quality	Flavour
1	6A/3	Very good	Good	Very good
2	6A/5	Very good	Good	Good
3	7A/1	Very good	Very good	Very good
4	7A/2	Very good	Very good	Very good

Conclusion

The procedure of selection by the process of elimination at various stages is laborious, however, it has been quite effective in identifying elite clones. The modern techniques of biochemistry, physiology, and biotechnology may be used for early screening of selected clones. Selection of seedlings for yield and other attributes holds great potential and should be exploited for genetic improvement of tea. Genetic markers for identifying superior clones may be introduced.

Clonal plantings are gaining more popularity; however, this is leading to a narrowing of the genetic base of tea plantations. It needs to preserve interesting bushes in the old seed-grown plantation. Field selection techniques have to be improved so that the time duration of development can be reduced. The field trial conducted by the National Tea and Coffee Development Board has clearly shown some bushes suitable for multiplication, like 4A/5 and 4A/7 from Ilam tea estate and 7A/1 and 7A/2 from *Kanyam* tea estate. However, multiple experiments should be followed for them before registration. Limited financial support from both the Government of Nepal and international donor agencies is given for tea germplasm collection and its conservation. The focus and priority should be *given* to adequate funding so that our tea germplasm can be conserved before we lose it forever.

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