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Variability in fruit physico-chemical characteristics of litchi (*Litchi chinensis*) in Tripura and Asom

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ABSTRACT

Litchi (*Litchi chinensis*) improvement has been sought mainly through the selection of improved clones and very little work has been done in planned breeding programmes. The economic importance of litchi has led to the selection and breeding over thousands of years, which resulted in relatively few genotypes because of narrow genetic base and restricted germplasm variability. The present day need in litchi is to have cultivars with high fruit weight, high pulp content and small/chicken-tongued seeds coupled with prolonged shelf-life. Therefore, surveys to select the desirable clones of litchi were conducted in the litchi growing areas of Asom and Tripura during the fruiting season of 2007-08 to 2011-12. The superior clones differing in fruit maturity period, with heavy bearing were selected and characterized. The fruit characteristics were studied in the selected clones, which have exhibited a wide range of variation. Based on the characterization of various physico-chemical parameters in fruits, thirty-nine clones were identified. The important clones identified for different characteristics having (i) higher fruit weight A26 (22.29g/fruit), A1l (21.75g/fruit) and A15 (21.21g/fruit), (ii) high TSS (T9 (20.88°Brix), A23 (20.16°Brix) and T5 (19.88°Brix), (iii) small seeds (A26 (1.18g/seed), A25 (1.37g/seed) and A27 (1.95g/seed) and (iv) high pulp percentage/edible portion A26 (72.96%), T15 (69.83%) and T14 (68.63%) were identified. Two clones, viz. A10-1 and A25, having five or more of the desirable fruit quality attributes and fourteen clones having four desirable fruit quality characteristics were propagated vegetatively for detailed evaluation. It was concluded from the present study that there is ample scope for selection of the desirable clones from the existing variability in the litchi orchards of Tripura and Asom.

Key words: Asom, Characteristics, India, Litchi, Physico-chemical, Tripura, Variability

All over the world, the genetic improvement of litchi (*Litchi chinensis* Sonn.) has been carried out by means of selection of open-pollinated seedling trees. The cultivated varieties being grown presently appear to have been selected for characteristics like fruit size, quality and period of maturity, however, the qualitative fruit characters, precocity, dwarfness and regularity of bearing, wider adaptability and resistance to physiological disorders are of vital importance and must be utilized for the development of cultivars for improving the productivity per unit area.

Practically, no breeding work has been carried out for the varietal improvement and to evolve an ideal litchi cultivar. Opportunities exist for improving the productivity by breeding new selections with the emphasis on traditional breeding (Bose 2001). Almost all of the litchi cultivars have arisen as a result of clonal propagation of high performing parents. No genetic characteristic has been observed to be controlled by segregation and no experiment appears to have been conducted on the heritability of desirable and undesirable characteristics (Galan Sauco 1989). Fruit and seed weight have strong positive correlations with total sugars, ascorbic acid, protein and tryptophan contents, but a significant negative correlation with acidity and phenol content. Thus, the selection for two characters (fruit and seed weight) can produce nutritionally superior genotypes (Singh *et al*. 1987). A negative partial correlation between embryo and aril and a direct repressive effect of the former on the later may be taken into account while breeding varieties less prone to cracking. Keeping these objectives in view, the present exploration was carried out to identify the variability and to select the superior clones of litchi for increasing the genetic base, expanding the harvesting season and for improving the fruit quality.

MATERIALS AND METHODS

The present investigation was carried out from 2007-08 to 2011-12 during the fruiting season in the litchi growing areas of Tripura and Asom. Extensive field surveys were conducted to select the desirable clones of litchi and to evaluate the litchi variability present in these states. In Tripura, West Tripura district, having maximum litchi plantation, was covered, whereas in Asom, Kamroop and Tejpur areas were undertaken for the study. During the

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exploration, ninety-seven orchards were surveyed comprising more than 4 000 plants of litchi. The heavy bearing plants, exhibiting superior fruit characteristics like early or late maturity, dark red or red rind colour, large fruit size, smooth-skinned fruits with uniform distribution of fruits inside the plant's canopy, were identified and characterized. In total, thirty nine clones, having different visible fruit characteristics were identified and the results are reported here. A sample of thirty fruits was collected randomly from all the sides of the plant (Das and Vishal Nath 2006) and analyzed for fruit physico-chemical characteristics in the laboratory. The characters studied included the colour, weight, length and breadth of the fruit, total soluble solids (TSS°Brix), rind and seed weight, acidity and presence of seed borer in the fruit.Fruit colour was recorded visually. Fruit length and breadth were recorded with a Vernier Caliper. Fruit rind, seed and pulp weight were recorded with an electronic balance. TSS was recorded

Table 1 Characterization of litchi clones from Tripura and Asom*

Clone	Fruit colour	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Length: Breadth (L:B)	TSS (°Brix)	Rind weight (g)	Seed weight (g)	Edible portion (%)	Presence of fruit borer (%)
T_1	7.00^{b}	18.96^{cdefg}	3.60^{bcdefgh}	3.14^{efghi}	1.15^{bcdefgh}	18.96^{bcdef}	2.18^{nop}	4.22^{ab}	66.08bcdefg	0.40
T_2	7.00^{b}	15.18^{lmnop}	3.46^{fghijkl}	2.94^{jk}	1.18^{bcde}	17.56^{efghijk}	2.02^{op}	3.26^{fghijk}	65.45bcdefg	0.60
T_3	7.00^{b}	14.76^{mnop}	3.44^{ghijkl}	2.88^{jkl}	1.19^{bcd}	17.24^{fghijkl}	1.90^{p}	3.94^{abcdefg}	59.86ghijkl	0.80
T_5	6.00^{c}	17.26^{ghijk}	3.48^{fghijk}	3.20^{efgh}	1.09^{ghi}	19.88^{abc}	2.70^{ijklm}	3.48^{cdefghijk}	64.04bcdefgh	0.00
T_6	6.80^{bc}	15.60^{klmno}	3.46^{fghijkl}	3.02^{i}	1.15^{bcdefgh}	19.44^{abcd}	1.84^{pq}	3.42^{cdefghijk}	66.26bcdefg	0.00
T_7	7.00^{b}	15.96^{jklmno}	3.40^{hijkl}	3.08^{ghi}	1.10^{fghi}	19.60^{abc}	2.68^{jklm}	3.90^{abcdefgh}	58.51hijkl	0.00
T_8	1.40^{ef}	12.38^{qr}	3.18^{m}	2.84^{jkl}	1.12^{defghi}	18.32^{cdefgh}	2.62^{klm}	3.38^{defghijk}	51.55mn	0.20
T_9	7.00^{b}	17.72^{ghi}	3.70^{abcde}	3.14^{efghi}	1.18^{bcde}	20.88^{a}	3.30^{cdef}	3.36^{efghijk}	62.46defghij	0.00
T_{11}	3.00^{d}	10.14s	3.32^{jklm}	2.66^{m}	1.25^{a}	15.76^{kl}	3.10^{efghij}	2.76^{klm}	42.03o	0.40
T_{13}	7.00^{b}	18.16^{fghi}	3.58^{bcdrfghi}	3.42^{bc}	1.01^{j}	17.00^{ghijkl}	2.56^{klmn}	3.42^{cdefghijk}	64.08bcdefgh	0.60
T_{14}	6.60^{bc}	13.44^{pq}	3.28^{klm}	2.72^{lm}	1.22^{b}	19.12^{abcde}	1.42^{q}	2.80^{klm}	68.63abc	0.00
T_{15}	6.20^{bc}	19.86^{bcdef}	3.74^{abc}	3.44^{b}	1.09^{ghi}	18.44^{bcdefgh}	2.60^{klmn}	3.40^{cdefghijk}	69.83ab	0.00
T_{16}	4.80^{d}	17.22^{ghijkl}	3.66^{bcdef}	3.14^{efghi}	1.16^{bcdefg}	19.20^{abcde}	2.90^{fghijk}	2.98^{ijkl}	65.96bcdef	0.00
T_{17}	1.00^{f}	12.70^{q}	3.66^{bcdef}	3.00^{ij}	1.22^{b}	18.60^{bcdefh}	3.36^{gde}	3.08^{ijkl}	48.56n	0.20
T_{18}	7.00^{b}	16.10^{jklm}	3.48^{fghijk}	3.10^{fghi}	1.12^{defghi}	18.40^{bcdefgh}	2.10^{op}	3.14^{ijkl}	67.15abcdef	0.20
A_1	7.00^{b}	20.28^{abcde}	3.74^{abc}	3.36^{bcdef}	1.11^{efghi}	18.64^{bcdefg}	2.86^{ghijklm}	4.12^{abc}	65.15bcdefg	0.60
A_2	4.00^{d}	12.71^{q}	3.66^{bcdef}	2.78^{kl}	1.32^{a}	16.92^{ghijkl}	3.12^{defghi}	3.68^{abcdefghi}	46.52no	0.20
A_3	6.40^{bc}	17.89^{fghi}	3.54^{cdefghi}	3.22^{defg}	1.10^{fgh}	18.64^{bcdefg}	2.44^{mno}	4.10^{abcd}	63.45cdefghi	0.80
A_4	1.00^{f}	10.51^{rs}	3.26^{lm}	2.80^{klm}	1.17^{bcdef}	12.34^{m}	3.10^{efghij}	3.65^{abcdefghi}	35.76p	0.00
A_5	7.00^{b}	21.11^{ab}	3.64^{bcdefg}	3.42^{bc}	1.07^{ij}	18.40^{bcdefgh}	3.51^{cde}	4.32^{a}	62.83cdefghi	0.00
A_6	6.00^{c}	13.99^{nopq}	3.50^{efghij}	2.92^{ijk}	1.20^{bc}	16.36^{ijkl}	3.08^{efghij}	3.21^{hijk}	54.82lm	0.60
$A_{6\text{-}1}$	6.00^{c}	20.54^{abcd}	3.74^{abc}	3.38^{bcd}	1.11^{efghi}	16.68^{hijkl}	3.39^{cde}	4.06^{abcde}	63.57cdefghi	0.20
A_7	4.00^{d}	14.83^{mnop}	3.52^{defghij}	3.02^{i}	1.17^{bcdef}	17.72^{defghi}	3.24^{cdefg}	3.22^{ghijk}	56.60jklm	0.00
A_8	6.60^{bc}	18.95^{cdefg}	3.72^{abcd}	3.28^{bcde}	1.13^{cdrfghi}	18.84^{bcdef}	3.66^{c}	3.07^{ijkl}	63.85cdefgh	0.60
A_9	7.00^{b}	16.03^{jklmn}	3.40^{hijkl}	3.12^{efghi}	1.09^{ghi}	19.68^{abc}	2.45^{lmno}	3.08^{ijkl}	64.35bcdefgh	0.60
A_{10}	3.00^{d}	15.97^{jklmno}	3.58^{bcdefghi}	3.00^{ij}	1.19^{bcd}	15.64^{l}	2.88^{fghijkl}	3.96^{abcdef}	57.26jklm	0.40
$A_{10\text{-}1}$	7.00^{b}	18.35^{efghi}	3.50^{fghij}	3.24^{defg}	1.08^{hij}	17.56^{efghijk}	2.45^{lmno}	3.61^{abcdefghi}	67.06abcdef	0.60
A_{11}	6.60^{bc}	21.75^{ab}	3.88^{abc}	3.38^{bcd}	1.15^{bcdefgh}	15.96^{jkl}	3.54^{cd}	4.23^{ab}	63.74cdefgh	0.40
A_{12}	7.00^{b}	16.44^{ijklm}	3.64^{bcdefg}	3.42^{bc}	1.06^{ij}	16.96^{ghijkl}	4.29^{b}	2.81^{jklm}	56.42klm	0.40
A_{13}	3.00^{d}	16.56^{hijklm}	3.76^{abc}	3.26^{cdef}	1.15^{bcdefgh}	16.28^{ijkl}	4.49^{ab}	2.42^{lmn}	57.68ijkl	0.60
A_{14}	3.00^{d}	13.95^{opq}	3.30^{klm}	3.10^{fghi}	1.06^{i}	16.12^{ijkl}	3.20^{defgh}	1.73^{nop}	64.50bcdefg	0.00
A_{15}	2.00^{e}	21.21^{ab}	3.50^{efghij}	3.76^{a}	0.93^{k}	17.20^{fghijkl}	4.92^{a}	2.09^{mn}	66.81bcdef	0.00
A_{18}	8.00^{a}	18.59^{defgh}	3.64^{bddefg}	3.26^{cdef}	1.12^{defghi}	19.48^{abcd}	3.13^{defghi}	4.03^{abcde}	61.37fghijk	0.00
A_{22}	8.00^{a}	16.69^{hijklm}	3.64^{bcdefg}	3.04^{hi}	1.20^{bc}	18.24^{cdefgh}	2.77^{hijklm}	3.53^{bcdefghij}	62.27efghijk	0.60
A_{23}	8.00^{a}	18.22^{fghi}	3.62^{bcdefg}	3.14^{efghi}	1.15^{bcdefgh}	20.16^{ab}	2.44^{mno}	3.48^{cdefghijk}	67.38abcde	0.20
A_{24}	8.00^{a}	17.95^{fghij}	3.56^{bcdefghi}	3.20^{efgh}	1.11^{efghi}	19.28^{abcde}	2.79^{hijklm}	3.47^{defghijk}	65.00bcdefg	0.00
A_{25}	7.00^{b}	14.94^{mnop}	3.44^{ghijkl}	3.08^{ghi}	1.00^{efghi}	18.24^{cdefgh}	3.51^{gde}	1.37^{op}	67.43abcde	0.00
A_{26}	6.00^{c}	22.29^{a}	3.46^{fghijkl}	3.70^{a}	0.93^{k}	17.68^{defghij}	4.87^{a}	1.18^{p}	72.96a	0.00
A_{27}	6.00^{c}	20.71^{abc}	3.38^{ijklm}	3.68^{a}	0.92^{k}	18.40^{bcdefgh}	4.64^{ab}	1.95^{no}	68.23abcde	0.00
CD (P=0.05)	0.833	2.045	0.205	0.169	0.073	1.808	0.430	0.720	5.907	0.484

*The values denoted by the same letters are not statistically different from each other.

with a hand-held refractometer and acidity was measured by the titration method (AOAC 1970). The edible portion was calculated by dividing pulp weight with total fruit weight and the length: breadth (L:B) ratio was calculated by dividing fruit length with its breadth. The fruit infestation by seed and fruit borer was recorded at the time of fruit analysis by observing each and every fruit.

The data were analyzed in a completely randomized design with five replications. The best clones were identified based on these characteristics. The clones were divided into various groups depending upon the superiority of characteristic/characteristics by them. After the selection of the clones on the basis of different characteristics, the superior litchi clones were identified and propagated in the nursery for detailed evaluation in replicated field trials.

RESULTS AND DISCUSSION

The development of better cultivars is very slow in litchi because it takes several years for most seedlings to bear fruits. When they do fruit, less than one per cent of the seedlings are found to be worthy of selection. It was estimated that about 40 years are taken to develop a new cultivar in litchi by following the traditional breeding techniques (Zhang *et al*. 2001). In the present investigation, clonal selection survey was undertaken in the litchi growing areas of Tripura and Asom states of India, because the litchi was first introduced in the north-east part of the country, and most probably, there may be existence of seedling populations of litchi in these areas. As litchi is strictly a cross-pollinated fruit crop, there may be existence of variation in the natural population of litchi. The high-yielding clones were characterized on the basis of fruit maturity period, yield and fruit physico-chemical characteristics. The maturity in general was ten days earlier in Tripura and Asom as compared to the Bihar state.

Variability in fruit physico-chemical characteristics among the selected clones

A wide range of variation was observed for the fruit physico-chemical characteristics amongst the selected clones (Table 1). The fruit colour varied from green to dark red depending on the genotype and also the fruit colour is a good indicator for the fruit maturity.It was earlier reported that in litchi fruit colour varies depending upon the cultivars and is also influenced by growing conditions. Kumar *et al*. (1998) have also recorded variation in phenotypic characters of litchi fruits (colour, shape and number of tubercles). Differences in fruit colour of litchi cultivars have also been reported by many other workers (Froneman 1999, Wong 1999 and Yuan and Zhu 2001). The clones A_{18}, A_{22}, A_{23} and A_{24} were having dark red coloured fruits, whereas completely green fruits were observed in T_{17}, A_{14} and T_8 clones. Fruit weight was maximum in A_{26} (22.29g) followed by A_{11} (21.75g), A_{15} (21.21g) and A_5 (21.11g), whereas, it was minimum in T_{11} (10.14g), A_{14} (10.51g) and T_8 (12.38g). Fruit size was reported to be a genetic characteristic of the cultivars and is also used for identification of cultivars (Singh *et al*. 1999), although, it is also affected by cultural practices and the prevailing climatic conditions. Li *et al*. (2002) found that the differences in fruit size between large and small-fruited litchi cultivars were related to both size and activity of the sink.

The ratio of fruit length: breadth was used as a measure of roundness/flatness of the fruit. The clones A_{25}, T_{13}, A_{12} and A_{14} produced almost round fruits. The fruits in the clones A_2, T_{11}, T_{14} and T_{17} were elongated, whereas, the clones A_{27}, A_{26} and A_{15} produced flattened fruits. These three clones produced fruits similar to Bedana/Seedless cv., a comparatively small-seeded cultivar of litchi.

Maximum TSS (20.88%) was recorded in the clone T_9 followed by A_{23} (20.16), T_5 (19.88) and A_9 (19.68), whereas, lowest TSS (12.34%) was recorded in A_4 followed by A_{10} (15.64%) and T_{11} (15.76%), however, there was a lot of variation for this characteristic. This characteristic is considered to be very good indicator for early or late maturity in the clones. Seed size was quite large in the clone A_5 (4.32g) followed by T_1 (4.22g), A_1 (4.12g) and A_{18} (4.03g), whereas, very small seeds were produced in A_{26} (1.18g), followed by A_{25} (1.37g), A_{14} (1.73g) and A_{27} (1.95g). The small seed size is a characteristic for the small seeded/ chicken-tongued clones. Maximum edible portion of the fruit was recorded in the clone A_{26} (72.96%) followed by T_{15} (69.83%), T_{14} (68.63%) and A_{27} (68.23%), whereas, minimum edible portion was recorded in A_4 (35.76%) followed by T_{11} (42.03%) and T_{17} (48.56%). The per cent edible portion is directly proportional to the rind thickness and seed size. The superiority of this characteristic may be either due to small seed size, thin rind or both of these characteristics.

There was quite a large variation for the attack of seed and fruit borer. As is evident from the Table 1, the borer attack was comparatively less in Tripura as compared to Asom and further varied amongst the selected clones within a state. The borer attack variation may be either due to inherent condition of clone or due to cultural operations and the climatic conditions. Further, it was very much clear that most of the small seeded clones (A_{25}, A_{24}, A_{27} and A_{14}) were comparatively free from the attack of the borer.

In general, the fruit characteristics were better in the litchi clones from Asom as compared to Tripura. The litchi in Asom was exhibiting more desirable variation and offers good scope for the selection of superior litchi clones.

Selection of superior clones for individual fruit characteristics

The clones were grouped for the characteristics possessed by them (Table 2 and Table 3). In Table 2, grouping of clones is evident based on these important characteristics and the clones with dark red fruits, fruit weight of >20 g/fruit, TSS of 19% or more, seed weight less than 2.25 g/seed, edible portion of more than 60% and fruit length: breadth ratio around one were considered superior. The clones were further grouped in the order of possession of number of superior fruit characteristics (Table 3). This

Table 2 Classification of litchi clones on the basis of individual fruit characteristics

Fruit characteristics	No. of Clones (Name of the clone)
Fruit weight (g)	
<1 1.00	3 (T_{11}, A_1, A_4)
11.01-14.00	6 (T_8, T_{14}, T_{17}, A_2, A_6, A_{14})
14.01-17.00	12 (T_2, T_3, T_6, T_7, T_{18}, A_7, A_9, A_{10}, A_{12}, A_{13}, A_{22}, A_{25})
17.01-20.00	12 (T_1, T_5, T_9, T_{13}, T_{15}, T_{16}, A_3, A_8, $A_{10\text{-}1}$, A_{18}, A_{23}, A_{24})
> 20.01	6 (A_5, $A_{6\text{-}1}$, A_{11}, A_{15}, A_{26}, A_{27})
Fruit colour	
Green	3 (T_8, T_{17}, A_4)
Light green	1 (A_{15})
Green red	4 (T_{11}, A_{10}, A_{13}, A_{14})
Red green	2 (A_2, A_7)
Pink	1 (T_{16})
Light red	8 (T_4, T_6, T_{15}, A_3, A_6, $A_{6\text{-}1}$, A_{26}, A_{27})
Red	16 (T_1, T_2, T_3, T_7, T_9, T_{13}, T_{14}, T_{18}, A_1, A_5, A_8, A_9, $A_{10\text{-}1}$, A_{11}, A_{12}, A_{25})
Dark red	4 (A_{18}, A_{22}, A_{23}, A_{24})
TSS (°Brix)	
<15.00	1 (A_4)
15.01-17.00	10 (T_{11}, T_{13}, A_2, A_6, $A_{6\text{-}1}$, A_{10}, A_{11}, A_{12}, A_{13}, A_{14})
17.01-19.00	18 (T_1, T_2, T_3, T_8, T_{15}, T_{17}, T_{18}, A_1, A_3, A_5, A_7, A_8, $A_{10\text{-}1}$, A_{15}, A_{22}, A_{25}, A_{26}, A_{27})
19.01-21.00	10 (T_5, T_6, T_7, T_9, T_{14}, T_{16}, A_9, A_{18}, A_{23}, A_{24})
Seed weight (g)	
< 1.50	2 (A_{25}, A_{26})
1.51-2.25	3 (A_{14}, A_{15}, A_{27})
2.26-3.00	5 (T_{11}, T_{14}, T_{16}, A_{12}, A_{13})
3.01-3.75	18 (T_2, T_5, T_6, T_8, T_9, T_{13}, T_{15}, T_{17}, T_{18}, A_2, A_4, A_6, A_7, A_8, A_9, A_{22}, A_{23}, A_{24})
>3.76	11 (T_1, T_3, T_7, A_1, A_3, A_5, $A_{6\text{-}1}$, A_{10}, A_{11}, A_{18})
Edible portion (%)	
<50.00	4 (T_{11}, T_{17}, A_2, A_4)
50.01-60.00	8 (T_3, T_7, T_8, A_6, A_7, A_{10}, A_{12}, A_{13})
60.01-70.00	26 (T_1, T_2, T_5, T_6, T_9, T_{13}, T_{14}, T_{15}, T_{16}, T_{18}, A_1, A_3, A_5, $A_{6\text{-}1}$, A_8, A_9, $A_{10\text{-}1}$, A_{11}, A_{14}, A_{15}, A_{18}, A_{22}, A_{23}, A_{24}, A_{25}, A_{27})
70.01-80.00	1 (A_{26})
Fruit length : Breadth ratio	
< 0.90	—
0.91-1.00	4 (A_{15}, A_{25}, A_{26}, A_{27})
1.01-1.10	10 (T_5, T_7, T_{13}, T_{15}, A_3, A_5, A_9, $A_{10\text{-}1}$, A_{12}, A_{14})
1.11-1.20	21 (T_1, T_2, T_3, T_6, T_8, T_9, T_{16}, T_{18}, A_1, A_4, A_6, $A_{6\text{-}1}$, A_7, A_8, A_{10}, A_{11}, A_{13}, A_{18}, A_{22}, A_{23}, A_{24})
>1.20	4 (T_{11}, T_{14}, T_{17}, A_2)

table indicated a larger variation amongst the selected clones for various fruit quality characteristics.

Further, the grouping was done on the number of desirable characteristics of the selected clones (Table 4). The clones $A_{10\text{-}1}$ and A_{25} possessed five superior characteristics (Table 4 and 5) and can be recommended for further testing. The fourteen clones exhibited four superior characteristics (Table 4) and can also be recommended for testing.

Table 3 Classification of litchi clones on the basis of superiority for different characteristics

Fruit character	Clone
Fruit size (>17.00 g)	T_1, T_5, T_9, T_{13}, T_{15}, T_{16}, A_3, A_8, $A_{10\text{-}1}$, A_{18}, A_{23}, A_{24}
Fruit colour (Red or dark red)	T_1, T_2, T_3, T_7, T_{13}, T_{14}, T_{18}, A_1, A_5, A_8, A_9, $A_{10\text{-}1}$, A_{11}, A_{12}, A_{25}, A_{18}, A_{22}, A_{23},A^{24}
TSS (>17.00%) (>60.00%)	T_1, T_2, T_3, T_8, T_{15}, T_{17}, T_{18}, A_1, A_3, A_5, A_7, A_8, $A_{10\text{-}1}$, A_{15}, A_{22}, A_{25}, A_{26}, A_{27}, T_5, T_6, T_7, T_9, T_{14}, T_{16}, A_9, A_{18}, A_{23}, A_{24}
Edible portion	T_1, T_2, T_5, T_6, T_9, T_{13}, T_{14}, T_{15}, T_{16}, T_{18}, A_1, A_3, A_5, $A_{6\text{-}1}$, A_8, A_9, $A_{10\text{-}1}$, A_{11}, A_{14}, A_{15}, A_{18}, A_{22}, A_{23}, A_{24}, A_{25}, A_{27}, A_{26}
Seed weight (<2.25g)	A_{25}, A_{26}, A_{14}, A_{15}, A_{27}
Fruit length: breadth ratio (0.91-1.10)	A_{15}, A_{25}, A_{26}, A_{27}, T_5, T_7, T_{13}, T_{15}, A_3, A_5, A_9, $A_{10\text{-}1}$, A_{12}, A_{14}

Table 4 Classification of litchi clones on the basis of number of desirable fruit characteristics

Clone	Desirable fruit characteristics
Clones with five or more desirable fruit characteristics	
$A_{10\text{-}1}$	Fruit size, fruit colour, TSS, edible fruit portion, length: breadth (L:B) ratio
A_{25}	Fruit colour, TSS, edible fruit portion, seed size, L:B ratio
Clones with four desirable fruit characteristics	
T_1	Fruit size, fruit colour, TSS, edible fruit portion
T_9	Fruit size, fruit colour, TSS, edible fruit portion
T_{13}	Fruit size, fruit colour, edible fruit portion, L:B ratio
T_{15}	Fruit size, fruit colour, edible fruit portion, L:B ratio
A_3	Fruit size, fruit colour, edible fruit portion, L:B ratio
A_5	Fruit colour, TSS, edible fruit portion, L:B ratio
A_8	Fruit size, fruit colour, TSS, edible fruit portion
A_9	Fruit colour, TSS, edible fruit portion, L:B ratio
A_{15}	TSS, edible fruit portion, Seed weight, L:B ratio
A_{18}	Fruit size, fruit colour, TSS, edible fruit portion
A_{23}	Fruit size, fruit colour, TSS, edible fruit portion
A_{24}	TSS, edible fruit portion, Seed size, L:B ratio
A_{26}	TSS, edible fruit portion, seed size, L:B ratio
A_{27}	TSS, edible fruit portion, seed size, L:B ratio

The clones $A_{10\text{-}1}$ and A_{25} are possessing maximum superior fruit quality traits and were considered most desirable. However, the clones mentioned in the Table 4b also deserve large scale testing for selecting superior clones of litchi. Earlier, it was reported that the clone 90-9 was the most promising of the group, with large fruits (38g), 81% seed abortion, 72% flesh recovery, 18% TSS and fruit maturity one week earlier than the standard Sanyuehong (Zhou 1995). Most of the present day litchi cultivars have been selected on the basis of fruit quality, with a preference

Table 5 Top 10 litchi accessions on the basis of higher fruit weight, edible portion/pulp content, lower seed content and roundness/flatness of the fruit

Fruit weight (g)		Edible portion/ pulp content (%)		Lower seed content (g)		Roundness/ flatness (L:B)	
Clone	Fruit weight	Clone	Pulp content	Clone	Seed weight	Clone	L:B
A_{26}	22.29	A_{26}	72.96	A_{26}	1.18	T_{13}	1.01
A_{11}	21.75	T_{15}	69.83	A_{25}	1.37	A_{12}	1.06
A_{15}	21.21	T_{14}	68.63	A_{14}	1.73	A_{14}	1.06
A_5	21.11	A_{27}	68.23	A_{27}	1.95	A_5	1.07
A_{27}	20.71	A_{25}	67.43	A_{15}	2.09	A_{15}	0.93
A_1	20.08	A_{23}	67.38	A_{13}	2.42	A_{26}	0.93
$A_{6\text{-}1}$	20.54	T_{18}	67.15	T_{11}	2.76	$A_{10\text{-}1}$	1.08
T_{15}	19.86	$A_{10\text{-}1}$	67.06	T_{14}	2.80	A_{27}	0.92
T_1	18.96	A_{15}	66.81	A_{12}	2.81	T_5	1.09
A_8	18.95	T_6	66.26	T_{16}	2.98	T_{15}	1.09

for large fruit having bright red rind colour, a small seed or seed abortion and sweet, crisp flesh (Menzel and Simpson 1990). Selection for these characteristics has been done at the expense of productivity (Menzel 2001). But in the present investigation, the clones were initially selected on the basis of fruit load and only then the fruit characteristics were analyzed.

From these studies, it is evident that a large variation exists for fruit physico-chemical characteristics in the litchi growing areas of Tripura and Asom. This variation can be exploited for the selection of superior litchi clones for expanding the short harvesting period and improving the fruit quality. The identified clones were propagated vegetatively for the detailed evaluation in the replicated trials.

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