Indian J. Genet., 72(2): 143-147 (2012)

Variability in fruit physico-chemical characters of litchi (*Litchi chinensis* Sonn.): an index for selection of improved clones for processing and value addition

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Abstract

Survey to select the desirable clones of litchi (*Litchi chemensis* Sonn.) was conducted in the litchi growing areas of Bihar, Jharkhand, Assam and Tripura during the fruiting season of 2007-08 to 2010-11. The fruit characteristics were studied in the selected clones, which have exhibited a wide range of variation. On the basis of variability in fruit characteristics, ninety-seven clones were identified and studied for various physico-chemical parameters. The important clones from value addition and processing point of view were those having (i) higher fruit weight (ASL-95 (29.92g/fruit), ASl-85 (21.75g/fruit) and ASL-97 (21.13g/fruit)), (ii) high TSS (ASL-65 (20.88^{o}Brix) and ASL-92 (20.16^{o}Brix)), (iii) small seeds (ASL-97 (0.52g/seed) and ASL-95 (1.18g/seed)) and (iv) high pulp percentage (ASL-97 (83.65%) and ASL-95 (79.78%) were identified. Four clones *viz*., ASL-97, ASL-95, ASL-96 and ASL-89 were having most of desirable attributes for fresh fruit consumption as well as for processing/value addition and have been finally selected and propagated vegetatively. Further, there is ample scope for selection of the desirable clones from the existing variability in the litchi orchards. The correlation studies for fruit weight with pulp weight, fruit weight with seed size, pulp weight with TSS, TSS with acidity and fruit colour with TSS and acidity, etc. can be established for screening of large populations of the identified litchi clones.

Key words: Variability, processing, value addition, *Litchi chinensis*

Introduction

Litchi (*Litchi chinensis* Sonn.) is a subtropical tree of the Sapindaceae family, indigenous to Southern China. The cultivation spread over the years through neighbouring areas of south-eastern Asia and offshore islands and now one of the important fruit trees growing in the tropics and subtropics [1]. Litchi has traditionally been of economic importance and can offer interesting options for farmers as cash crop with high export potential both as fresh and processed fruit [2]. The Chinese claim that the litchi is highly variable under different cultural and soil conditions. There is much variation in fruit shape (round, egg-shaped or heart-shaped), skin colour and texture, the fragrance and flavour and even the colour of the flesh and the amount of rag in the seed cavity, and the size and form of the seed. Litchi has a very narrow genetic base owing to continuous vegetative propagation. This needs to be widened through selection of genotypes from the existing population under different ecological conditions. There is a need for identification and evaluation of local clones, which are regular, early bearers and which produce fruits with small seeds [3]. At present, there is a demand for high quality early and late season cultivars [4]. There is also a need for the varieties, which are suitable for processing, because, besides ecological compatibility, sustainable fruit production and processing systems imply profitable production and distribution of safe products with high nutritive value at all levels of food chain to assert the position on domestic and international markets [2].

Despite an enormous wealth of litchi cultivars, an ideal litchi cultivar for modern conditions is lacking, which leads to adoption of various crop improvement tools. Worldwide, genetic improvement in litchi has been carried out by means of selection among open-pollinated seedling trees of known cultivars. The existing old cultivars appear to have been selected for characters 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 in fruits are of vital importance.

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Published by Indian Society of Genetics & Plant Breeding, F2, First Floor, NASC Complex, PB#11312, IARI, New Delhi 110 012
Online management by indianjournals.com

A highly valued character of litchi under intensive culture is the immaturity of seed, which results in seedless fruits, popularly called as chicken-tongued seeds. This character is present in cultivars like Early and Late Seedless of Indian origin, No Mai Tsz and Kwei Sei of the Chinese origin and Brewster, a seedling selection of Chen Family Purple of Fukien at Florida, USA. Similarly, attractive coloured peel and fleshy aromatic aril characters are also limited to few cultivars, e.g. Rose-Scented, Kwai Mi and Heung Lai.

Most of the present day cultivars have been originated from Chinese sources and the genetic base of commercial cultivars is relatively narrow. Almost all of these cultivars have arisen as the 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 heritability of desirable and undesirable characteristics [5]. Many litchi cultivars have been selected from the open-pollinated seedlings. Salathiel litchi cultivar was selected in Australia from the chance seedlings of No Mi Chi and has better quality of fruits than its parent [6]. Maguili cultivar of litchi originated as a chance seedling and was discovered in 1979 [7]. Since appropriate selection of raw material specification and options for integrated fruit processing, including the reduction of processing waste by adequate by-product utilization [2]. There is a need to identify varieties with higher shelf life and smaller seeds, which can increase the marketing season and also are suitable for processing [8]. Keeping this in view, the present investigation was carried out 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 during the years 2007-08 to 2011-12 in the fruiting season of litchi. Extensive survey was conducted to select the desirable clones of litchi in the North-East states, *viz*., Tripura and Assam and Eastern Indian states of Bihar and Jharkhand. In Tripura, West Tripura district was covered, whereas in Assam, Kamrup and the Tezpur areas were extensively surveyed. In Bihar, Muzaffarpur, Samastipur, Vaishali, Bhagalpur and Begusarai districts were surveyed during the period of study. In total 251 orchards, comprising more than 12000 plants were surveyed for various positive horticultural traits. The plants exhibiting superior characters for fruit like early/ late maturity, dark red rind colour, large fruit size, smooth-skinned fruits and heavy bearing with uniform distribution of fruits inside the plant's canopy were identified and selected. In total 97 clones, having different visible fruit characteristics were identified during 2006-07 to 2011-12, out of which, the results are reported for only 40 selected clones. A sample of 30 mature fruits from all the directions of tree canopy was collected randomly and analyzed for fruit physico-chemical characters. Fruit colour was recorded visually. Fruit length and breadth were recorded with the help of Vernier Caliper. Fruit rind, seed and pulp weight were recorded with an electronic balance. TSS was recorded with a hand refractometer and acidity was measured by the titration method [9]. Edible portion percentage of the fruit was calculated by dividing pulp weight with fruit weight. The fruit infestation by the seed and fruit borer was seen at the time of the analysis by observing each and every fruit used in analysis.

The data were analyzed in a completely randomized design with three replications. The best clones for the processing and value addition, possessing higher fruit weight, edible portion, TSS and lower seed weight were identified based on the analyzed fruit-physico-chemical characteristics.

Results and discussion

The development of better cultivars is very slow because it takes several years for most seedlings to bear fruit. When they do fruit, less than 1% of the seedlings are found to be worthy of selection. Zheng *et al*. [10] calculated that it took about 40 years to develop a new cultivar in litchi using traditional breeding methods. Plants for evaluation can be planted close together at a density of 2000-2500 trees/ha compared to standard densities of 70-280 trees/ha. In the present investigation, a clonal selection survey was undertaken in the litchi growing areas of Bihar, Jharkhand, Assam and Tripura for the selection of superior litchi clones. The clones were characterized based on fruit maturity period, yield, fruit physico-chemical characteristics. The maturity in Assam and Tripura was about 10 days earlier as compared to Bihar.

Variation in fruit physico-chemical characteristics

A wide variation was observed for the fruit physico-chemical characteristics studied among the selected clones (Table 1). The fruit colour in the selected clones varied from green to dark red depending on the genotype. The fruit colour is also a good indicator for the maturity period. In litchi, the colour of fruit varies depending upon the cultivars and is also influenced by

Table 1. Fruit physico-chemical characteristics in selected clones of litchi

Clone	Fruit colour	Fruit wt. (g)	Fruit length (cm)	Fruit width (cm)	L:B	TSS (%)	Rind wt. (g)	Seed wt. (g)	Pulp wt. (g)	% edible portion	Presence of fruit borer (%)
ASL-58	Red	18.96	3.60	3.14	1.15	18.86	2.18	4.22	12.56	66.08	40.0
ASL-59	Red	15.18	3.46	2.94	1.18	17.56	2.02	3.26	9.90	65.45	60.0
ASL-60	Red	14.76	3.44	2.88	1.19	17.24	1.90	3.94	8.92	59.86	80.0
ASL-61	Light red	17.26	3.48	3.20	1.09	19.88	2.70	3.48	11.08	64.04	0.0
ASL-62	Red	15.60	3.46	3.02	1.15	19.44	1.84	3.42	10.34	66.26	0.00
ASL-63	Red	15.96	3.40	3.08	1.10	19.60	2.68	3.90	9.38	58.51	0.00
ASL-64	Green	12.38	3.18	2.84	1.12	18.32	2.62	3.38	6.38	51.55	20.00
ASL-65	Red	17.72	3.70	3.14	1.18	20.88	3.30	3.36	11.06	62.46	0.00
ASL-66	Green	10.14	3.32	2.66	1.25	15.76	3.10	2.76	4.28	42.03	40.00
ASL-67	Red	18.03	3.57	3.33	1.01	16.80	2.53	3.20	11.68	64.08	60.00
ASL-68	Red	13.35	3.27	2.70	1.22	19.10	1.45	2.80	9.22	68.63	0.0
ASL-69	Light red	19.86	3.74	3.44	1.09	18.44	2.60	3.40	13.86	69.83	0.0
ASL-70	Red	17.22	3.66	3.14	1.16	19.20	2.90	2.98	11.34	65.96	0.0
ASL-71	Green	12.70	3.66	3.00	1.22	18.60	3.36	3.08	6.26	48.56	20.0
ASL-72	Red	16.10	3.48	3.10	1.12	18.40	2.10	3.14	10.86	67.15	20.0
ASL-73	Red	20.08	3.74	3.36	1.11	18.64	2.86	4.12	13.10	65.17	60.0
ASL-74	Red green	12.70	3.66	2.78	1.32	16.92	3.12	3.67	5.92	46.52	20.0
ASL-75	Red	17.89	3.54	3.22	1.10	18.84	2.44	4.12	11.35	63.45	80.0
ASL-76	Green	10.51	3.26	2.80	1.17	12.34	3.09	3.65	3.77	35.75	0.0
ASL-77	Red	21.11	3.64	3.42	1.07	18.40	3.51	4.32	13.28	62.83	0.0
ASL-78	Light red	13.99	3.50	2.92	1.20	16.36	3.08	3.21	7.70	54.82	60.0
ASL-79	Light red	20.54	3.74	3.38	1.11	16.68	3.39	4.06	13.08	63.51	20.0
ASL-80	Red green	14.83	3.52	3.02	1.17	17.60	3.22	3.22	8.39	56.60	0.0
ASL-81	Red	18.95	3.72	3.28	1.13	18.84	3.66	3.07	12.22	63.99	60.0
ASL-82	Red	16.03	3.40	3.12	1.09	19.68	2.84	3.08	10.30	64.35	60.0
ASL-83	Green red	15.97	3.58	3.00	1.19	15.64	2.88	3.96	9.12	57.25	40.0
ASL-84	Red	18.35	3.50	3.24	1.08	17.56	2.45	3.61	12.29	67.06	60.0
ASL-85	Red	21.75	3.88	3.38	1.15	15.96	3.54	4.23	13.98	63.73	40.0
ASL-86	Red	16.44	3.64	3.42	1.06	16.96	4.29	2.81	9.34	56.42	40.0
ASL-87	Green red	16.56	3.76	3.26	1.15	16.28	4.49	2.42	9.59	57.68	60.0
ASL-88	Green red	13.95	3.30	3.10	1.06	16.12	3.19	1.73	9.03	64.50	0.0
ASL-89	Light green	21.21	3.50	3.76	0.93	17.40	4.92	2.09	14.20	66.81	0.0
ASL-90	Dark red	18.59	3.64	3.26	1.12	19.48	3.13	4.03	11.43	61.37	0.0
ASL-91	Dark red	16.69	3.64	3.04	1.20	18.24	2.77	3.53	10.40	62.27	60.0
ASL-92	Dark red	18.22	3.62	3.14	1.15	20.16	2.44	3.48	12.30	67.38	20.0
ASL-93	Dark red	17.95	3.56	3.20	1.11	19.28	2.79	3.47	11.68	65.00	0.0
ASL-94	Red	14.94	3.44	3.08	1.11	18,24	3.50	1.37	10.08	67.43	0.0
ASL-95	Light red	29.92	3.98	4.33	0.92	18.02	4.87	1.18	23.87	79.78	0.0
ASL-96	Light red	20.71	3.38	3.68	0.92	18.40	4.64	1.95	14.12	68.23	0.0
ASL-97	Dark red	21.13	3.70	3.40	1.09	15.40	2.95	0.52	17.76	83.65	0.0

growing conditions. Kumar *et al*. [11] 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 other researchers [12-14]. Fruit weight was maximum in ASL-95 (29.92g) followed by ASL-85 (21.75g) and ASL-89 (21.21g). Fruit size in litchi is a genetic characteristic of the cultivars and is also used for identification of cultivars [15], although affected by cultural practices. Li *et al*. [16] 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 clone ASL-67 produced round fruits, ASL-95 and ASL-96 produced flattened fruits, whereas the fruits in ASL-74 and ASL-65 were elongated. Maximum TSS (20.88^{o}Brix) was recorded in ASL-65 followed by ASL-92 (20.16^{0}Brix) and ASL-82 (19.68^{0}Brix), whereas lowest TSS was recorded in ASL-76 (12.34^{0}Brix), indicating its late maturity. Very large seeds were observed in ASL-77 (4.32g/seed) followed by ASL-85 and ASL-58 (4.23 and 4.22g/seed, respectively). Very small/chicken tongued seeds observed in majority of fruits in ASL-97 (0.52g/seed), ASL-95 (1.18g/seed) and ASL-94 (1.37g/seed). Maximum edible portion was recorded in ASL-97 (83.65%) followed by ASL-94 (79.78%) and ASL-69 (69.83%), but this portion was minimum in ASL-76 (35.75%) and ASL-66 (42.03%). The clones ASL-60, 59, 67, 73, 78, 81, 87 and 91 were having high infestation of the fruit and seed borer (>60%), whereas in many clones, viz., ASL-61, 62, 63, 65, 68, 69, 70, 76, 77, 79, 88, 89, 90, 92, 93, 94, 95, 96 and 97 were free from any infestation of the fruit and seed borer.

In general, the fruit characters were better in the litchi clones from Assam as compared to Tripura and are *at par* with the clones from Bihar. The litchi in Assam has exhibited more desirable variation and offers good scope for the selection of superior litchi clones. The clones ASL-85, ASL-89, ASL-94, ASL-95, ASL-96 and ASL-97 need confirmation for the fruit physico-chemical characteristics and are to be propagated vegetatively for their detailed field evaluation in replicated trials.

Selection of litchi clones for processing and value addition

In the selection of superior litchi clones, skin colour and fruit size are external quality criteria, whereas, internal criteria are seed size and flesh sweetness/juiciness. A bright red fruit with no browning, along with freedom from bird, insect and mechanical damage, cracking and decay is preferred for fresh consumption as table fruit [17]. The main fruit physico-chemical characteristics considered for processing and value addition are the fruit weight, edible portion, TSS and seed weight. On the basis of these four characteristics, ten best clones were identified (Table 2) possessing the highest value for these characteristics. The clone possessing maximum of these characteristics was considered better for processing and value addition. The clones ASL-97, ASL-95, ASL-96 and ASL-89 possessed three out of these four characteristics and were considered worth trying for processing and value addition. Earlier, it was reported that clone 90-9 was the most promising of the group, with large fruit (38g), 81% seed abortion, 72% flesh recovery, 18% TSS and fruit maturity one week earlier than the standard Sanyuehong [17]. Most of the present gene pool has been selected on the basis of fruit quality, with a preference for large fruit having bright red skin, a small seed or seed abortion and sweet, crisp

Table 2. Litchi clones with desirable fruit characteristics for processing and value addition

Clone No.	Higher fruit weight (g)	Clone No.	Higher edible portion (%)	Clone No.	Higher TSS (^{0}Brix)	Clone No.	Lower seed weight (g/seed)
ASL-95	29.92	ASL-97	83.65	ASL-65	20.88	ASL-97	0.52
ASL-85	21.75	ASL-95	79.78	ASL-92	20.16	ASL-95	1.18
ASL-89	21.21	ASL-69	69.83	ASL-61	19.88	ASL-94	1.37
ASL-97	21.13	ASL-68	68.63	ASL-82	19.68	ASL-88	1.73
ASL-77	21.11	ASL-96	63.23	ASL-63	19.60	ASL-96	1.95
ASL-96	20.71	ASL-94	67.43	ASL-90	19.48	ASL-89	2.09
ASL-79	20.54	ASL-92	67.38	ASL-62	19.44	ASL-87	2.42
ASL-73	20.08	ASL-72	67.15	ASL-93	19.28	ASL-64	2.80
ASL-69	19.86	ASL-84	67.06	ASL-70	19.20	ASL-86	2.81
ASL-58	18.96	ASL-89	66.81	ASL-67	19.10	ASL-70	2.98

flesh [18]. Selection for these characteristics has been at the expense of productivity [19]. 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 orchards in different litchi growing states. This variation can be exploited in the selection of superior litchi types for extending the maturity period, improving fruit quality and for the purpose of processing and value addition. Diversified fruit processing is necessary to amend the fresh-fruit marketing of upper-grade fruit as regards complete utilization of the whole crop and for this purpose, technological possibilities for processing are available in case of litchi [20]. The identified clones have been propagated vegetatively and will be planted in replicated trials for detailed evaluation.

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