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EFFECTS OF TREE TRUNK, BRANCH AND LEAF TRAITS ON MORPHOLOGICAL DIVERSITY OF *LITCHI CHINENSIS* SONN.

NARAYAN LAL[1]* ABHAY KUMAR AND SD PANDEY

ICAR-National Research Centre on Litchi, Muzaffarpur-842002 (Bihar), India

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Abstract

Twenty five morphological traits of tree trunk, branch and leaf were employed to discriminate 30 Indian Litchi (*Litchi chinensis* Sonn.) genotypes as well as to assess their morphological diversity at ICAR-NRC on Litchi, Muzaffarpur, India. Litchi genotypes were highly diversified. Twelve qualitative and 13 quantitative traits exhibited high degrees of variability. High phenotypic and genotypic coefficients of variation were recorded for tree volume (31.26 and 31.15%), leaf area (22.27 and 21.87%) and thickness of leaf (21.56 and 20.89%). High heritability coupled with high genetic advances was recorded for plant height (97.92%), crown diameter (99.40%), tree volume (99.34%), leaflet number (93.28%), rachis length (91.45%), petiole length (96.45%), petiolule length (95.91%), leaf length (93.07%), leaf area (96.39%) and leaf thickness (93.89%), indicating ample scope of improvement for these traits through selection.

Introduction

Litchi (*Litchi chinensis* Sonn.) is one of the most important members of Sapindaceae associated with mycorrhizae. It is highly specific to its climatic requirements. The emergence of panicle is highly influenced by temperature. Stress as well as phenol content is required for flowering in litchi and fruit set depends on the sources of pollen grains in litchi. Fruit retention, yield and fruit quality are highly affected from temperature. Considerable variations in litchi fruit quality parameters have been found (Lal *et al.* 2018a, b). The genetic diversity of litchi in India is very narrow which tried to widen through hybridization. The same cultivar of litchi is known with different names at different locations and different cultivars have the same name. These affect the germplasm conservation, breeding and fruit production in litchi. Attempts have been made to distinguish and classify litchi germplasm based on morphological traits (Zhu *et al.* 2015, Chavaradar 2016). Molecular markers are being used but it is costly and professional skills for markers screening and data analysis are required and difficult to find the key informative polymorphic loci to discriminate all litchi cultivars (Wu *et al.* 2016). Identification of litchi based on morphological traits is highly acceptable and easily distinguishable. Therefore, the present study was aimed to assess the morphological diversity of trunk, branch and leaf in 30 Indian litchi genotypes. It was expected to establish a simple and perceptual method of distinguishing litchi cultivars based on morphological traits, thus providing theoretical basis for early identification as well as information for developing cultivars and optimum genotypes management.

Materials and Methods

In the present study, 30 Litchi genotypes, collected from different sources and conserved in National Active Germ-plasm Site at ICAR-National Research Centre (NRC) on Litchi, Muzaffarpur, Bihar, were evaluated for genetic diversity. All the trees of 13 years old were subjected to uniform cultural practices. Total of 12 qualitative and 13 quantitative traits of trunk,

*Author for correspondence: <narayanlal.lal7@gmail.com>. [1]ICAR-Indian Institute of Soil Science, Bhopal 462038 (Madhya Pradesh), India.

branch and leaf were measured for two consecutive years (2017 and 2018) based on Litchi Descriptors, IPGRI, Italy. Most statistical analyses were performed using SPSS 16.0 statistical software. The percentage of each quantitative characteristic in litchi genotypes was calculated. Analysis of variance (ANOVA) was performed for morphological variables to find significant differences between studied accessions following randomized block design. Coefficients of variance (CV%) were used as indicators of variability in the studied genotypes. Data recorded on above mentioned traits were statistically analyzed using OPSTAT package program. The genetic estimates, *viz.*, Phenotypic Coefficient Variation (PCV), Genotypic Coefficient Variation (GCV) , Broad Sense Heritability, Genetic Advances (GA) in absolute unit and per cent of the mean.

Results and Discussion

The qualitative characteristics of tree trunk, branch and leaf were highly diversified among 30 Litchi genotypes (Table 1). The trunk in different genotypes showed three types of surface (smooth, rough and very rough), and the predominant surface was rough (70.00%), followed by smooth (23.33%). Furthermore, 76.66% genotypes had broadly pyramidal shape of canopy. The tree growth in different genotypes showed three types of habit (spreading, drooping and semi-erect) and the predominant habit was semi-erect (70.00%). However, 73.33% genotypes showed medium branching density and 16.66% were high branching density. There were only two branching pattern in the studied genotypes (verticillate and irregular) and predominant pattern was irregular (66.66%) and 90% genotypes had young shoot pubescence. There were four colors of young leaf in the studied genotypes (yellowish green, pink, bright pink and dark pink), and the predominant color was yellowish green (43.33%). There were 46.66% genotypes had dark green colour of mature leaf followed by 36.66% genotypes were green leaf colour. The most of the genotypes had opposite arrangement of leaflets (70.00%). The dominant shape of leaflet was elliptic (96.66%). Only one leaflet apex shapes observed in all genotypes was acute. The predominant leaflet base shape was cuneate (73.33%). Morphological traits such as characteristics of fruit, floral, leaf and tree were often used for distinguishing litchi cultivars (Hossain *et al*. 2017, Bhagat *et al*. 2019, Gogoi *et al.* 2020).

The analysis of variance showed that all quantitative parameters significantly differed between genotypes (Table 2). The trait of height was recorded maximum in Coll. 39 (4.60 m) and minimum in IC-0615599 (2.50 m). The maximum trunk girth was found in IC-0615597 (68.00 cm) and lowest in IC-0615587 (35.50 cm). The crown diameter was recorded maximum in IC-0615593(6.565 m) and minimum in IC-0615599 (3.617 m). The volume was found maximum in Coll. 39 (76.37 m^3) and minimum in IC-0615599 (10.44 m^3). The maximum number of leaflets was found in Coll. 35 (7.29) and lowest in IC-0615587 (5.05). The maximum rachis length was recorded in IC-0615608 (15.40 cm) and minimum in IC-0615588 (6.45 cm). The length of petiole was found maximum in IC-0615597 (4.83 cm) and minimum in IC-0615595 (2.54 cm). The maximum leaf length was recorded in IC-0615608 (15.98 cm) and minimum in IC-0615595 (8.10 cm). The width of leaf was found maximum in IC-0615603 (5.05 cm) and minimum in IC-0615599 (2.99 cm). Leaf size and leaf shape are genetic characters and can be used to identify litchi genotypes as also reported by earlier workers (Chavaradar 2016, Saikia and Kotoky 2022).

Assessment of existing variability is a prerequisite in breeding program for selecting desirable genotypes. The average mean performance, standard deviation, range of variation, genotypic and phenotypic coefficients of variation, heritability and genetic advance revealed a wide range of variability for most characters studied (Table 3). Phenotypic and genotypic coefficients of variations were high for tree volume (31.26 and 31.15%), area of leaflet (22.27 and 21.87%),

Table 1. Qualitative Characteristics (twelve) of 30 Litchi genotypes.

Genotypes	Trunk surface	Crown shape	Tree growth habit	Branching density	Branching pattern	Young shoot pubescence	Young leaf colour	Mature leaf colour	Arrangement of leaflet	Leaflet blade shape	Leaflet apex shape	Leaflet base shape
IC-0615585	Rough	Spherical	Spreading	Medium	Irregular	Glabrous	Deep Pink	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615586	Rough	Spherical	Spreading	High	Verticilate	Glabrous	Yellowish green	Dark green	Opposite	Lanceolate	Acute	Oblique
IC-0615587	Rough	Spherical	Spreading	medium	Verticilate	Pubescent	Bright Pink	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615588	smooth	Broadly pyramid	spreading	medium	irregular	Glabrous	Pink	Green	Opposite	Elliptic	Acute	Cuneate
IC-0615589	Smooth	Broadly pyramid	Semi-erect	medium	Irregular	Glabrous	Yellowish Green	Dark Green	Both	Elliptic	Acute	Cuneate
IC-0615590	Rough	Broadly pyramid	Semi-erect	Medium	Irregular	Glabrous	Pinkish	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615591	Smooth	Broadly pyramid	Semi-erect	Medium	Irregular	Glabrous	Pink	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615592	Rough	Spherical	Semi-erect	Medium	Irregular	Glabrous	Bright Pink	Green	Opposite	Elliptic	Acute	Cuneate
IC-0615593	Smooth	Broadly pyramid	Semi-erect	High	Verticilate	Pubescent	Deep Pink	Dark green	Opposite	Elliptic	Acute	Cuneate
IC-0615594	Rough	Spherical	Semi-erect	High	Irregular	Glabrous	Yellowish Green	Dark Green	Both	Elliptic	Acute	Cuneate
IC-0615595	Smooth	Spherical	Semi-erect	High	Verticilate	Glabrous	Pinkish green	Green	Opposite	Elliptic	Acute	Attenuate
IC-0615596	Rough	Spherical	Spreading	Medium	Verticilate	Pubescent	Deep Pink	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615597	Rough	Spherical	Semi-erect	Medium	Irregular	Glabrous	Greenish yellow	Green	Both	Elliptic	Acute	Cuneate
Coll. 39	Smooth	Broadly pyramid	Spreading	High	Verticillate	Glabrous	Yellowish Green	Green	Opposite	Elliptic	Acute	Attenuate
IC-0615599	Rough	Broadly pyramid	Semi-erect	Low	Irregular	Glabrous	Yellowish Green	Green	Opposite	Elliptic	Acute	Attenuate
IC-0615600	Rough	Broadly pyramid	Semi-erect	Low	Irregular	Glabrous	Greenish yellow	Green	Opposite	Elliptic	Acute	Cuneate
IC-0615601	Rough	Broadly pyramid	Semi-erect	High	Irregular	Glabrous	Yellowish Green	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615602	Rough	Broadly pyramid	Semi-erect	Medium	Verticulate	Glabrous	Yellowish Green	Green	Opposite	Elliptic	Acute	Cuneate
IC-0615603	Smooth	Broadly pyramid	Semi-erect	Medium	Verticillate	Glabrous	Pinkish green	Dark Green	Opposite	Elliptic	Acute	Oblique
IC-0615604	smooth	Broadly pyramid	Drooping	High	Irregular	Glabrous	Deep Pink	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615605	Smooth	Broadly pyramid	Semi erect	Medium	Irregular	Glabrous	Light Pink	Dark Green	Both	Elliptic	Acute	Cuneate
IC-0615606	Rough	Broadly pyramid	Semi-erect	Medium	Irregular	Glabrous	Yellowish Green	Dark Green	Both	Elliptic	Acute	Attenuate
IC-0615608	Rough	Broadly pyramid	Semi-erect	Medium	Verticulate	Glabrous	Yellowish Green	Green	Opposite	Elliptic	Acute	Cuneate
IC-0615610	Rough	Broadly pyramid	Semi-erect	Sparse	Irregular	Glabrous	Yellowish Green	Dark Green	Opposite	Elliptic	Acute	Cuneate
IC-0615611	Very rough	Broadly pyramid	Semi-erect	Medium	Irregular	Glabrous	Bright Pink	Dark Green	Both	Elliptic	Acute	Cuneate
IC-0615613	Very rough	Broadly pyramid	Semi-erect	Medium	Irregular	Glabrous	Bright Pink	Dark Green	Opposite	Elliptic	Acute	Cuneate
Coll. 35	Smooth	Broadly pyramid	Semi-erect	Sparse	Irregular	Glabrous	Yellowish Green	Dark Green	Both	Elliptic	Acute	Cuneate
Coll. 36	Very rough	Broadly pyramid	Semi-erect	medium	Irregular	Glabrous	Pink	Green	Both	Elliptic	Acute	Attenuate
Coll. 37	Rough	Broadly pyramid	Erect	medium	Irregular	Glabrous	Bright Pink	Green	Both	Elliptic	Acute	Cuneate
Coll. 38	Very rough	Broadly pyramid	spreading	High	Verticulate	Glabrous	Light Pink	Green	Opposite	Elliptic	Acute	Cuneate

Table 2. Analysis of variance for quantitative characters in different Litchi genotypes.

Genotypes	Plant height (m)	Trunk girth (cm)	Crown diameter (m)	Tree volume (m^3)	Number of leaflet	Rachis length (cm)	Petiole length (cm)	Petiolule length (cm)	Leaf length (cm)	Leaf width (cm)	Leaflet interval	Leaf area (cm^2)	Thickness of leaf
IC-0615585	4.30	57.83	5.26	20.69	6.10	8.56	4.13	1.10	12.20	3.91	2.31	22.90	0.32
IC-0615586	4.25	59.00	5.40	21.44	6.97	10.09	3.99	1.00	13.42	3.46	3.12	33.56	0.18
IC-0615587	3.25	35.50	3.84	9.01	5.05	6.52	3.06	1.00	8.67	3.56	1.96	24.82	0.16
IC-0615588	3.50	48.00	4.75	14.26	6.38	6.45	3.40	1.12	11.36	3.79	1.68	31.20	0.25
IC-0615589	3.88	55.25	5.18	21.00	6.56	9.88	4.26	1.00	12.92	3.51	2.62	23.97	0.17
IC-0615590	4.00	61.00	5.11	18.40	6.98	9.54	3.80	1.25	14.03	3.83	2.07	33.76	0.17
IC-0615591	3.60	64.00	4.46	14.17	6.89	9.42	4.02	0.85	11.18	3.90	2.71	32.74	0.22
IC-0615592	3.78	67.50	4.78	17.63	6.21	10.03	3.54	1.10	12.08	4.03	2.13	40.46	0.18
IC-0615593	4.09	60.00	6.57	33.09	6.69	7.72	2.86	0.90	11.38	3.96	1.86	23.71	0.23
IC-0615594	3.90	58.00	5.21	18.33	6.41	8.50	4.00	0.90	14.34	3.95	2.85	31.34	0.21
IC-0615595	3.28	50.50	4.75	13.10	5.52	6.51	2.54	1.00	8.10	3.41	2.24	20.09	0.20
IC-0615596	3.58	67.33	6.29	25.34	6.05	7.60	2.88	0.90	9.40	3.85	1.81	20.85	0.19
IC-0615597	4.10	68.00	5.06	19.66	6.81	11.20	4.83	1.00	12.20	3.88	2.79	46.51	0.16
Coll. 39	4.60	64.15	5.29	22.88	6.72	10.10	3.71	1.20	10.90	3.57	2.28	33.87	0.25
IC-0615599	2.50	36.50	3.62	6.43	6.04	7.78	3.24	0.90	9.85	2.99	2.24	18.43	0.21
IC-0615600	3.88	57.00	5.80	24.29	6.77	9.74	3.73	0.55	13.15	4.16	2.77	26.29	0.19
IC-0615601	4.00	62.25	5.81	24.91	6.34	9.98	3.77	0.56	14.05	4.05	2.66	29.39	0.20
IC-0615602	3.85	67.10	6.16	25.97	6.52	11.25	4.57	0.85	12.25	4.11	3.02	31.09	0.31
IC-0615603	3.78	59.40	4.92	16.58	6.27	9.59	4.16	1.10	13.67	5.05	2.83	31.60	0.21
IC-0615604	3.83	59.50	5.84	23.92	6.20	7.00	2.68	1.20	13.03	4.17	1.76	38.40	0.25
IC-0615605	3.75	53.50	4.77	14.56	6.63	8.71	3.36	0.90	14.05	3.65	2.71	35.68	0.18
IC-0615606	4.00	66.50	6.07	25.40	6.48	10.13	3.85	0.90	12.80	3.46	3.58	41.45	0.21
IC-0615608	3.10	43.00	3.98	9.31	6.94	15.40	4.60	1.10	15.98	4.15	2.79	37.26	0.15
IC-0615610	4.40	62.50	6.20	29.96	7.23	10.97	3.99	0.90	13.33	4.10	3.08	32.68	0.21
IC-0615611	3.90	50.50	5.02	17.40	6.96	10.61	4.05	1.00	13.78	4.00	3.00	37.77	0.19
IC-0615613	3.30	50.00	5.11	14.95	6.07	7.48	2.81	0.60	9.04	3.42	1.95	24.82	0.25
Coll. 35	4.05	53.50	5.55	22.18	7.29	11.37	3.86	0.90	12.30	3.65	2.98	29.44	0.18
Coll. 36	3.48	49.20	5.49	19.64	6.69	10.05	3.97	0.85	11.54	3.74	2.56	37.25	0.29
Coll. 37	4.03	54.90	6.05	26.56	6.63	10.87	3.56	1.30	13.35	3.83	2.32	39.37	0.29
Coll. 38	3.55	50.40	5.80	21.18	6.84	9.50	4.41	1.15	12.76	3.98	2.18	33.97	0.26
SEm ±	0.04	5.95	0.03	0.66	0.07	0.32	0.06	0.02	0.28	0.15	0.20	0.77	0.007
CD (0.05)	0.10	16.88	0.09	0.88	0.21	0.92	0.18	0.06	0.81	0.41	0.59	2.18	0.01

thickness of leaf (21.56 and 20.89%) and moderate to low for other traits. The estimates of GCV were lower in magnitude than PCV and range was nominal which indicates less influence of environment on the traits studied. The higher values of both PCV and GCV for various traits like tree volume, leaf area and leaf thickness indicate that greater improvement can be expected through selection based on these characters. However, the GCV does not offer full scope to estimate the variation that is heritable in nature and therefore, estimation of heritability is very important. Since most of the desired traits are quantitative in nature, complex in their inheritance and highly influenced by environmental conditions, heritability can play a useful role to estimate the scope of improvement by selection. This indicates that selection breeding will be effective for selecting genotypes having high heritability which are useful in predicting the expected progress to be achieved. The heritability in broad sense was more than 80% for plant height (97.92%), crown diameter (99.40%), tree volume (99.34%), number of leaflet (93.28%), rachis length (91.45%), petiole length (96.45%), petioles length (95.91%), leaf blade length (93.07%), area of leaflet (96.39%) and thickness of leaflet (93.89%) while trunk girth had low heritability (26.74%).

Table 3. Estimates of various genetic parameters of Litchi genotypes.

Quantitative traits	Mean	SD	Range	CV (%)	GCV	PCV	Heritability	GA	GA (%)
Plant height (m)	0.43	3.78	2.50-4.60	11.23	11.2	11.31	97.92	0.86	22.82
Trunk girth (cm)	8.61	56.39	35.50-68.00	15.27	11.04	21.34	26.74	6.63	11.76
Crown diameter (m)	0.73	5.27	3.62-6.57	13.81	13.8	13.84	99.4	1.49	28.34
Tree volume (m^3)	19.74	6.16	6.43-33.09	31.19	31.15	31.26	99.34	12.63	63.96
Number of leaflet	0.48	6.51	5.05-8.48	7.39	7.31	7.56	93.28	0.95	14.53
Rachis length (cm)	1.87	9.42	6.45-11.37	19.83	19.54	20.43	91.45	3.62	38.49
Petiole length (cm)	0.59	3.72	2.54-4.83	15.85	15.78	16.06	96.45	1.19	31.92
Petiolule length (cm)	0.18	0.97	0.55-1.30	19.01	18.88	19.28	95.91	0.37	38.08
Leaf blade length (cm)	1.84	12.24	8.10-14.45	15	14.82	15.36	93.07	3.6	29.45
Leaf blade width (cm)	0.36	3.84	2.99-5.05	9.42	8.61	10.86	62.96	0.54	14.08
Leaflet interval (cm)	0.48	2.5	1.68-3.58	19.14	17.22	22.51	58.48	0.68	27.12
Area of leaflet (cm^2)	6.93	31.49	1.68-3.59	22	21.87	22.27	96.39	13.93	44.23

The high heritability indicates that the traits under study had great scope for genetic improvement. Moderate to low estimates indicate a limited scope of improvement through selection. Hence, computation of heritability alone will not be helpful to bring about an efficient improvement in litchi unless there is a higher genetic gain, involving additive gene action which can be achieved through selection. Estimated heritability associated with genetic advance is more reliable than heritability alone for predicting the impact of selection. A high heritability coupled with high genetic advance gives the most effective criteria for selection (Marboh *et al.* 2018). In the present study, higher heritability estimates accompanied with greater genetic advance were observed for plant height, trunk girth, crown diameter, tree volume, number of leaflet, rachis length, petiole length, petiolule length, length and width of leaf, leaf area and thickness of leaf, indicating that these characters are exhibiting additive gene action and phenotypic selection may be more fruitful for all these traits. High values of heritability for the traits clarified that they were least affected by environmental modification and selection based on phenotypic performance would be reliable. Similar findings were also reported by several workers (Srivastava *et al.* 2014, Lal *et al*. 2022) who reported high heritability with high genetic gain for different attributes in other fruits crops. It may be concluded that higher values of both PCV and GCV for various traits such as tree volume, leaf area and leaf thickness indicate that more improvement can be achieved by selection based on these traits. The high heritability estimates associated with the high genetic advances observed for plant height, trunk girth, crown diameter, tree volume, leaf number, spindle length, petiole length, petiole length, leaf length and width, leaf area, and leaf thickness were indicative of additive gene action and selection based on these characters would be more reliable.

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