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Morphological Diversity in Litchi Based on Tree and Leaf Characteristics

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

On the basis of tree and leaf characteristics, twenty litchi genotypes were evaluated to select promising genotypes. Numerous differences have been observed between the genotypes. The genotypes KT-1 and GC-2 recorded the highest (5.35 m) and lowest (4.50 m) height, respectively. The girth was greatest for the genotype KD-1 (63.01 cm) and lowest for the genotype GC-2 (49.99 cm). The genotype DP-2 had the smallest canopy diameter (5.29 m) and the genotype KS-1 the greatest (6.40 m) among the ones investigated. In GC-2 and KT-1, the plant volumes ranged from 20.35 m^3 to 26.79 m^3. Leaf exhibited a great deal of variability among them, nine genotypes showed vivid pink in their new leaves, whereas eleven genotypes showed yellowish green. Comparably, the

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colour of the leaves varied among the genotypes; nine had dark green, whereas eleven had green. Nine genotypes showed a downward curve from the midrib, whereas eleven genotypes showed an upward curve. According to an analysis of the number of leaflets on each compound leaf, Shahi had the most (7.24), while GC-1 had the fewest (6.16). The longest rachis measured 11.10 cm in KD-2 and the shortest 9.75 cm in GP-2. The genotype DT-1 exhibited the smallest petiole length, while the genotype KS-1 had the longest. The length of the leaflets varied significantly between genotypes, ranging from 10.86 cm (KD-1) to 13.81 cm (China). The genotype DP-2 had the shortest breadth (3.70 cm), while genotype KD-1 had the widest (4.36 cm). The genotypes GC-2, GP-2 and KD-1 can be promoted in close spacing orchard.

Keywords: Litchi; leaf colour; rachis length; leaflet length.

1. INTRODUCTION

An important member of the Sapindaceae family, litchi (*Litchi chinensis* Sonn.) is an evergreen subtropical fruit tree with significant mycorrhizal associations [1,2,3,4]. Litchi is a fruit crop that is subtropical and evergreen, possessing significant nutritional and therapeutic properties. It is an excellent source of vitamin C [5,6] and phenolics [7]. Its climatic requirements are very particular [8]. Some of the genotypes are susceptible to sun burn and fruit cracking [9,10,11,12]. The genetic base is narrow [13] which needs to be widened through selection or hybridization [14]. The form of the trees and leaves varies significantly amongst litchi cultivars. The names of cultivars have caused a great deal of confusion because they differ in terms of agroclimatic conditions, growth habits, fruit colour, form, and size. Therefore, several names for the same cultivar may be used in different contexts. Due to their introduction as a crop, litchi has limited genetic diversity in India. There is always the possibility that new cultivars will emerge. Different traits are employed to distinguish between cultivars. There are variations in leaf length, shape, size, and colour as well. Litchi identification based on morphological characteristics is quite acceptable and simple to differentiate. Litchi genotypes are distinguished using morphological traits such as leaves, fruits, and flowers [15]. There are very few exotic cultivars that are propagated vegetatively that are available in India. The current project was initiated to investigate genetic variation in various tree and leaf morphological attributes across different litchi genotypes collected from multiple sites. It was anticipated to provide a theoretical foundation for early identification as well as information for generating cultivars and optimal genotype maintenance by establishing a straightforward and perceptive way of differentiating litchi cultivars based on morphological attributes.

2. MATERIALS AND METHODS

Twenty litchi genotypes, ages ranging from 10 to 20 years, were selected for the current study due to their constant size and vigour. These plants were continuously treated with cultural approaches. The three trees for each genotype were considered while documenting the observations. A Randomized Block Design methodology was used in the investigation. Based on the litchi descriptor, IPGRI, Rome, the observations were made for two years in a row (2021 and 2022) in three districts of Uttar Pradesh: Khushinagar, Gorakgpur, and Deoria. Standard techniques were used to measure the canopy diameter, canopy volume, stem girth, and tree height. By visually observing the trees, the colour, arrangement, and curvature of the foliage were noted. Ten randomly selected leaves and flushes from each genotype were used to study the following characteristics: leaf length, width, number of leaflets per leaf, rachis length, and petiole length. Following a randomized block design and homogeneity testing, the mean trait values for both years were combined and put through an analysis of variance (ANOVA) to determine whether genotypes differed significantly from one another [16].

3. RESULTS AND DISCUSSION

Tree characters: The genotypes that were selected showed significant variation in plant height; genotype KT-1 recorded the maximum height (5.35 m), while genotype GC-2 recorded the lowest height (4.50 m). The underlying genetic basis of plant growth remains unchanged, despite the fact that agronomic practices may somewhat affect growth rate. The evergreen litchi fruit tree can grow to a height of 15 meters when left unpruned and up to 30 meters under the correct conditions [17]. Lal et al. [18] reported that the genotypes under investigation had plant heights ranging from 2.5

to 4.6 m. Singh et al. [19] state that a well-managed orchard can produce commercial fruit for as long as 50 years. Chavaradar [20] reported that 3.00 m to 19.00 m accounted for 57.87 per cent of the difference in tree height between genotypes. With a girth of 63.01 cm, the genotype KD-1 had the highest girth, while the genotype GC-2 had the smallest (49.99 cm). The biggest increase in the trunk girth of KD-1 is caused by the maximum increases in tree height, which are positively influenced by tree age. According to Chavaradar [20], the girth of a tree trunk can vary greatly, ranging from 28.00 cm to 54.00 cm, with a coefficient of variation of 74.1%. The stem girth of litchi varied, ranging from 35.50 to 68.00 cm [18]. Among the genotypes under investigation, DP-2 had the smallest canopy diameter (5.29 m) and KS-1 the greatest (6.40 m). The KS-1 genotype seems to be expanding horizontally more quickly and strongly by nature. In both North-South and East-West directions, the plant spreads most in Kasba (9.20 m and 9.28 m) and least in Bedana (7.10 m and 7.18 m), according to Sahay [21]. According to Lal et al. [18], the crown diameter of litchi varied from 3.62 to 6.57 m. The plant volume in GC-2 ranged from 20.35 m3 to 26.79 m3 while in KT-1. The result demonstrated that, of the genotypes analyzed, KT-1 exhibited the highest tree volume and the fastest rate of development in both vertical and horizontal directions. The lowest tree volume was connected with the lowest height and canopy diameter. According to Lal et al. [18], there were 6.43 to 33.09 m^3 of trees in Litchi. The variance in tree volume was also noted by Chandola and Mishra [22].

Leaf characters: The colour of the leaves varied greatly between genotypes. Four juvenile leaf colours were identified out of the twenty genotypes that were investigated. Nine genotypes had vivid pink colour, which was a fairly typical form of leaf colour, whereas eleven genotypes had yellowish green colour. The colour of a newly emerging leaf is one of the genetic traits that identify each genotype and aid in type differentiation. The young leaf is also described as vivid pink and yellowish green by Lal et al. [13]. Lal [5] found a new range of leaf colours, from yellowish to deep pink. Chavaradar [20] reported that young flushes exhibit a diversity of leaf colours, including pinkish green (78.12%), greenish yellow (12.5%), and light green (9.37%). Khurshid et al. [15] also observed dark pink flush colours in Bedana cultivars, brownish red in Calcuttia, and reddish brown flush colours in Gola and Bombay. Pereira [23] reported that the colour of the fresh flush varied from light copper to deep copper.

Table 1. Diversity in tree characters in different genotypes of litchi

Genotypes	Plant height (m)	Stem girth (cm)	Canopy diameter (m)	Plant volume (m^3)
Shahi	4.85	56.01	5.89	25.46
KD-1	4.85	63.01	6.04	24.69
KD-2	5.20	59.11	6.24	23.89
KS-1	4.95	57.81	5.99	24.70
KS-2	5.25	56.85	6.40	25.58
KT-1	5.35	57.90	6.04	26.79
KT-2	5.30	56.94	5.91	25.41
China	5.00	51.75	5.58	22.74
GC-1	4.65	52.85	5.48	21.83
GC-2	4.50	49.99	5.58	20.35
GP-1	4.75	56.74	5.56	22.59
GP-2	4.65	50.74	5.75	23.59
GG-1	4.85	52.80	5.96	22.76
GG-2	4.80	53.73	5.78	21.65
DB-1	5.00	56.84	5.89	24.75
DB-2	5.20	58.23	6.34	23.7
DP-1	5.30	59.05	6.00	25.30
DP-2	5.05	52.78	5.29	20.74
DT-1	4.95	50.69	5.41	23.56
DT-2	5.10	51.96	5.55	23.79
SEm ±	0.063	0.710	0.103	0.315
CD at 5%	0.181	2.041	0.297	0.905

Table 2. Diversity in qualitative leaf characters in different genotypes of litchi

Genotypes	Colour of new leaf	Colour of matured leaf	Arrangement of leaflet	Leaflet curvature
Shahi	Yellowish green	Green	Opposite	Curved upward from the midrib
KD-1	Yellowish green	Green	Opposite	Curved upward from the midrib
KD-2	Yellowish green	Green	Opposite	Curved upward from the midrib
KS-1	Yellowish green	Green	Opposite	Curved upward from the midrib
KS-2	Yellowish green	Green	Opposite	Curved upward from the midrib
KT-1	Yellowish green	Green	Opposite	Curved upward from the midrib
KT-2	Yellowish green	Green	Opposite	Curved upward from the midrib
China	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
GC-1	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
GC-2	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
GP-1	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
GP-2	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
GG-1	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
GG-2	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
DB-1	Yellowish green	Green	Opposite	Curved upward from the midrib
DB-2	Yellowish green	Green	Opposite	Curved upward from the midrib
DP-1	Yellowish green	Green	Opposite	Curved upward from the midrib
DP-2	Yellowish green	Green	Opposite	Curved upward from the midrib
DT-1	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin
DT-2	Bright pink	Dark green	Alternate and Opposite	Curved downward along the margin

The morphological leaf descriptors that were analysed also revealed a considerable difference in the colour of the mature leaves. Nine genotypes had dark green colour, whereas eleven genotypes had green colour in the evaluated genotypes, according to the results for mature leaf colour. Depending on the litchi genotypes' phenotypic and morphological evaluations, mature leaf colour varied morphologically. Mature leaf colour ranged from light green to dark green, according to Lal et al. [13]. Mature leaves have three unique colours, according to Chavaradar [20]: pale green, dark green, and green. Mature leaves of the following cultivars were deep green: Bedana, Bombai, Early Large Red, Nafarpal, Piazi, Rose Scented, and Seedless Late [23]. In contrast, the foliage of the other cultivars was relatively light green.

The leaflet arrangement showed a considerable degree of genetic variation. The most opposing leaflet patterns were seen in eleven of the

Table 3. Diversity in leaf characters in different genotypes of litchi

Genotypes	Number of leaflets	Rachis length (cm)	Petiole length (cm)	Length of leaflet blade (cm)	Width of leaflet blade (cm
Shahi	7.24	10.14	3.94	10.86	4.13
KD-1	6.85	10.71	3.86	13.25	4.36
KD-2	6.76	11.10	3.85	12.38	4.13
KS-1	7.11	10.46	4.04	12.49	4.21
KS-2	6.86	10.65	3.99	12.66	4.13
KT-1	6.87	10.76	3.94	11.90	4.20
KT-2	6.89	10.34	3.97	12.45	4.12
China	7.23	9.89	3.92	13.81	3.99
GC-1	6.16	10.13	3.88	13.66	4.03
GC-2	6.84	10.29	3.86	12.89	3.96
GP-1	6.75	9.86	3.88	12.72	3.95
GP-2	6.89	9.75	3.81	12.88	4.04
GG-1	6.91	9.89	3.85	13.25	4.02
GG-2	6.91	10.13	3.83	12.99	4.01
DB-1	6.59	10.58	3.90	10.92	4.04
DB-2	6.91	10.46	3.91	11.74	4.15
DP-1	6.63	10.3	3.93	12.77	4.14
DP-2	6.62	10.12	3.85	10.89	3.70
DT-1	6.31	9.87	3.76	11.76	3.97
DT-2	6.51	9.87	3.79	12.43	3.93
SEm ±	0.106	0.157	0.050	0.191	0.056
CD at 5%	0.304	0.451	NS	0.550	0.161

genotypes that were examined, whereas the other nine genotypes showed both opposed and alternate leaflet arrangements. Growth habit is a major factor in the characterisation of genotypes. Lal et al. [18] found leaflets arranged in litchi in an opposing and alternating pattern. Out of the twenty genotypes that were observed, the leaflet curvature data revealed that two different forms of curvature were discovered. Nine genotypes displayed a downhill curve, which is a highly typical type of curvature, whereas eleven genotypes showed an upward curve from the midrib. There are curved surfaces in both directions, according to Lal et al. [18]. The morphological diversity of litchi was assessed based on trunk, branch and leaf traits [24]. Shahi had the greatest number of leaflets (7.24), while GC-1 had the fewest leaflets (6.16), according to an examination of the leaflets on each compound leaf. Even though they are essential for producing food material, an excessive number of leaflets with numerous shoots may shade nearby leaflets and reduce the potential output. Although yield potential was significantly influenced by the number of leaflets, yield is also connected with other attributes. The possible difference in leaflet count can be attributed to the innate properties of the germplasm. The leaflet counts in Litchi ranged from 5.05 to 7.29 [18]. According to Pereira [23], the average number of leaflets per leaf in Bedana ranged from 5.9 to 7.5 in Early Muzaffarpur.

During the examination, rachis length was found to vary significantly; in KD-2, the greatest value was recorded at 11.10 cm, while in GP-2, the lowest value was reported at 9.75 cm. The length of the petiole varied from 2.54 cm to 4.83 cm. The rachis of litchi ranged in length from 6.45 to 15.40 cm [18]. Wu et al. [25] also reached a similar conclusion. The genotype with the smallest petiole also contributes to small leaf size. The length of the petiole varied from 3.76 to 4.04 cm. Petiole length measurements showed that the genotype KS-1 had the longest, while the genotype DT-1 had the shortest. The petiole

length of thirty genotypes of litchi varied, ranging from 2.54 to 4.83 cm [18]. Wu et al. [25] also reached a similar finding. The genotype with the smallest petiole also contributes to small leaf size. Between genotypes, leaflet length varied significantly, ranging from 10.86 cm (KD-1) to 13.81 cm (China). According to Lal et al. [18] leaf length in litchi varied from 810 to 15.98 cm. Furthermore, Chavaradar [20] observed a significant variation in leaf length, ranging from 12.0 to 16.8 cm. Kahn et al. [26] and Dorji and Yapwattanphun [27] both reported high levels of leaf size variability. The genotypes KD-1 and DP-2 exhibited the broadest and narrowest widths, at 4.36 cm and 3.70 cm, respectively. According to Lal et al. [18], the leaf breadth of litchi varied from 2.99 to 5.05 cm. Size and shape of the leaves are important varietal traits that are also utilized to distinguish across cultivars [5]. Khurshid et al. [15] observed notable differences in leaf length and leaf width amongst different litchi cultivars. Madhou et al. [28] also noted significant morphological differences in the number and size of leaflets between 34 litchi accessions in Mauritius. Variability in litchi has also been assessed by earlier workers [29,30].

4. CONCLUSION

Significant variation within the species is revealed by the study of morphological diversity in litchi based on tree and leaf features. The genetic diversity among various litchi cultivars is evident in the observed variations in traits such as tree height, canopy structure, leaf size, and leaf colour. This genetic diversity is crucial for breeding initiatives aimed at improving litchi cultivars for specific climatic conditions, pest resistance, and fruit quality. Understanding and preserving this morphological diversity is crucial for cultivating litchi sustainably and for developing new varieties in the future that will ensure the species' adaptability to changing environmental conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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