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MORPHOLOGICAL CHARACTERIZATION OF LONGAN (*DIMOCARPOUS LONGAN* LOUR.) GENOTYPES BASED ON QUALITATIVE CHARACTERISTICS

Ajay Kumar[1,2]*, A.K. Gupta[3], and Neeharika Kanth[1]
[1]Department of Horticulture, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar (848 125), India
[2]ICAR-Indian Institute of Horticultural Research, Bengaluru (560 089), India
[3]ICAR-Central Institute for Subtropical Horticulture, Lucknow (226 101), India
*Corresponding author E-mail: ajayaadihorti@gmail.com
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ABSTRACT

Longan (*Dimocarpus longan* Lour.) is an important underutilized fruit in India. It is a very rich source of vitamins, nutritional compounds, and flavonoids. The present investigation was carried out at the ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar. The aim of the investigation was to characterize 20 longan genotypes based on qualitative morphological characteristics. In this experiment, we investigated tree, leaf, flowering, and fruiting characteristics. The results showed that the smooth trunk surface, spreading growth habit, medium tree vigor and branching density, and semicircular crown shape were observed as dominant over others. An irregular branching pattern was observed in all the studied longan genotypes. Leaf characteristics also showed great variability among studied genotypes. The panicle initiation was observed in February, and the duration ranged from 8 to 13 days. The duration of hermaphrodite functional male and functional female flower was observed from 11 to 15 days and 10 to 13 days, respectively. LGC-6 and LGC-18 genotypes exhibited early fruiting, high fruit intensity, and sweet aril. The observed variability within studied traits might be due to their genetic constitution as well as to the climatic condition of the particular area. Therefore, based on this study, these morphological characteristics can be utilized as an effective tool for identification of various longan genotypes or varieties.
Keywords: Longan; Qualitative traits; Morphological; Characterization

Introduction

Longan (*Dimocarpus longan* Lour.) is an underutilized subtropical and tropical fruit crop. It belongs to the litchi family Sapindaceae and has chromosome number 2n=2X=20. It is believed to be a be a native of Southern China and was introduced into India in 1798 (Leenhouts 1971). It is a significant economic crop of China, Thailand, Vietnam, Malaysia, the Philippines, and India (Yonemoto *et al*., 2006; Riangwong *et al*., 2023). The leading producer of longan is China in the world, followed by Thailand, Vietnam, India, and South Africa. These five countries account for 90% of global production (Huang *et al*., 2021). Longan production in India is still in its early stages and is restricted to a few states, including Assam, West Bengal, Bihar, Kerala, and Karnataka. It may be grown across the nation, from the south to the north, with the exception of desert and temperate zones (Tripathi 2021). Most of the native cultivars that are cultivated in India are referred to by their regional names.

Longan is an evergreen tree and has spreading to erect growth habit, which can grow up to 20 meters high. It has 6–9 leaflets, which are arranged opposite or alternate. Young leaves are red-brown, becoming dark green as they mature (Subhadrabandhu and Stern, 2005; Shi *et al*., 2005). It has complex dichasia with duodichogamy inflorescences that are terminal, leafless, upright, and branched panicles. The inflorescence or panicle vary from 8 to 60 cm long (Davenport and Stern, 2005; Subhadrabandhu and Stern, 2005). Flowers are unisexual and cross-pollinated and bloom in three phases or waves, varying on genotype and climate (Pham *et al.*, 2015; Paull and Duarte, 2011). Longan is a single-seeded fruit, and fruits are produced in clusters, and the way that litchi and longan fruit develop is similar. The edible part of longan fruit is the translucent fleshy white aril (Subhadrabandhu and Stern, 2005; Stern and Gazit, 2010).

Fruits are sweet, have a pleasant flavor, are typically consumed fresh, and are abundant in nutrients and bioactive compounds such as flavonoids and phenolics. It is also higher in vitamins and minerals than Litchi fruit (Wall, 2006). Longan can be considered a potential choice in India's fruit basket to combat nutritional insecurity. Longan fruits contain moisture (82.4 g), carbohydrates (15.8 g), fat (0.1 g), protein (1.0 g), ash (0.7 g), nicotinic acid (1.3 mg), thiamine (0.01 mg), fiber (0.4 g), calcium (10 mg), phosphorus (42 mg), and iron (1.2 mg) per 100 g of fresh fruits (Park *et al.*, 2010; Wall 2006; Cheng 2014). It has more ascorbic acid (60.1–74.0 mg/100 g) than litchi and rambutan fruits (Wall 2006). It is also rich in sugar with high TSS (18.00 Brix) and low acidity (0.18%), which provide energy of 458 kJ/100 g of fresh fruits (Suiubon *et al.*, 2017).

In India, little research has been conducted on longan. Several studies have been done on production, phenological stages, floral induction, fruit composition, and genetic diversity based on molecular markers (Nakasone and Paull, 1998; Paull and Duarte, 2011; Kumar *et al.*, 2024a). The first stages in fruit production and breeding enhancement programs are the identification and characterization of cultivars. There is a lack of information on the characterization of longan germplasm. So, the present study was aimed at morphological characterization of longan germplasm, which will help in the identification of cultivars.

Materials and Methods

The present experiment was conducted on 10 years old 20 longan genotypes (LGC-6, LGC-12, LGC-18, LGC-22, LGC-24, LGC-25, LGC-26, LGC-27, LGC-34, LGC-37, LGC-40, LGC-47, LGC-49, LGC-50, LGC-52, LGC-54, LGC-59, LGC-60, and LGC-61) that were surveyed and collected from different locations of India and conserved in a Field Gene Bank of ICAR-National Research Centre on Litchi, Muzaffarpur, Bihar. The cultural practices were provided uniformly in a similar manner during the experiment (Singh *et al.*, 2011). Bihar state has a humid subtropical climate with hot, dry summers and an annual rainfall of about 1150 mm. The temperature of this place varies from 8°C to 43°C.

In this experiment, a total of 28 qualitative morphological traits were recorded in 20 longan genotypes as per the descriptor of "International Plant Genetic Resources Institute, Rome, Italy" (IPGRI, 2002). The following qualitative tree, leaf, flowering, and fruit traits were observed: trunk surface, tree growth habit, tree vigour, branching density, branching pattern, crown shape, young leaf colour, mature leaf colour, leaflet arrangement, leaflet blade shape, leaflet apex shape, leaflet base shape, leaflet curvature, leaflet margin, petiole colour, leaflet midrib colour, leaflet venation, protuberances, abundance of flower, date of first and last panicle initiation, date of opening of first and last hermaphrodite male flower, date of opening of first and last functional female flower, date of initiation and end of fruit set, fruit maturity group, fruit intensity, and aril quality.

Results and Discussion

Tree characteristics

The qualitative tree characteristics were highly diversified within twenty longan genotypes (Table 1). The trunk surface of different genotypes was noticed to be smooth, rough, and very rough among the germplasm, and the predominant was smooth trunk surface in twelve genotypes, followed by very rough in five genotypes, while rough trunk surface was only reported in three genotypes. Four tree growth habits (erect, semi-erect, drooping, and spreading) were observed, which were highly diverse, and the predominant growth habit was spreading in twelve genotypes, followed by drooping in three genotypes, semi-erect in three genotypes, and erect in two genotypes. Tree vigour was observed as low, medium, and high, and medium tree vigour was most dominant, which was recorded in thirteen genotypes, followed by high and low each in three genotypes.

Table 1: Morphological qualitative tree characteristics of 20 longan genotypes

Genotypes	Trunk Surface	Tree growth habit	Tree Vigour	Branching density	Branching pattern	Crown shape
LGC- 1	Rough	Spreading	Medium	Medium	Irregular	Semicircular
LGC-6	Smooth	Spreading or Erect	High	Dense	Irregular	Spherical

LGC-12	Smooth	Spreading	High	Medium	Irregular	Semicircular
LGC-18	Smooth	Spreading	High	Dense	Irregular	Semicircular
LGC-22	Very rough	Semi-erect	Medium	Medium	Irregular	Semicircular
LGC-24	Very rough	Drooping	Medium	Medium	Irregular	Semicircular
LGC-25	Very rough	Spreading	Medium	Sparse	Irregular	Semicircular
LGC-26	Smooth	Spreading	Low	Sparse	Irregular	Semicircular
LGC-27	Smooth	Spreading	Medium	Medium	Irregular	Semicircular
LGC-34	Smooth	Drooping	Medium	Sparse	Irregular	Semicircular
LGC-37	Rough	Drooping	Low	Sparse	Irregular	Oblong
LGC-40	Smooth	Spreading	Medium	Dense	Irregular	Semicircular
LGC-47	Smooth	Spreading	Low	Sparse	Irregular	Irregular
LGC-49	Very rough	Spreading	Medium	Dense	Irregular	Semicircular
LGC-50	Rough	Spreading	Medium	Medium	Irregular	Semicircular
LGC-52	Smooth	Spreading	Low	Dense	Irregular	Semicircular
LGC-54	Smooth	Semi-erect	Medium	Medium	Irregular	Semicircular
LGC-59	Smooth	Erect	Medium	Dense	Irregular	Semicircular
LGC- 60	Smooth	Semi-erect	Medium	Medium	Irregular	Spherical
LGC-61	Very rough	Erect	Medium	Dense	Irregular	Semicircular

The branching density was varied from sparse to dense, and the most dominant was medium in eight genotypes, followed by dense in seven genotypes, while the lowest was sparse in five genotypes. However, an irregular branching pattern was predominant in all the genotypes. Furthermore, crown shape was (spherical, semicircular, oblong, and irregular) observed, and the predominant was semicircular in sixteen genotypes, followed by spherical in two genotypes, whereas irregular and oblong were each observed in one genotype. The morphological tree characteristics like trunk surface, growth habit, vigour, and crown shape were used to identify the genotypes of litchi as earlier reported by several researchers (Khurshid *et al*., 2004; Madhou *et al*., 2010; Lal *et al*., 2023; Hossain *et al*., 2017). In Litchi, some researchers found that the morphological traits could be affected by climatic and soil conditions (Khurshid *et al*., 2004; and Madhou *et al*., 2010). The identification results based on morphological traits might be a little bit different from that based on molecular markers (Pathak *et al*., 2014).

Leaf characteristics

The recorded leaf characteristics were highly diverse among the studied genotypes (Table 2.1 and Table 2.2). The genotypes exhibited four young leaf colours (reddish brown, light green, pinkish green, and yellowish green), and the predominant colour was reddish brown in nine genotypes, followed by light green in six genotypes, yellowish green in three genotypes, and pinkish green in two genotypes. Three colours were observed in mature leaf colour, and the predominant was green in eight genotypes, followed by dark green in seven genotypes and light green in five genotypes. The arrangement of leaflets was observed in genotypes as opposite and alternate types, and opposite leaflet arrangement (12 genotypes) was predominant among genotypes. However, elliptic leaflet blade shape and acute leaflet apex shape were dominant in all the studied genotypes. The leaflet base shapes were observed in genotypes as ovate, lanceolate, and obovate. The ovate leaflet base was predominant in thirteen genotypes, followed by lanceolate in four genotypes and obovate in three genotypes. Leaflet curvature was highly diverse among the studied genotypes, and five types of leaflet curvature were observed as flat, upward, upward from the midrib, slightly downward from the top, and downward along with the margin. The predominant leaflet curvature was flat in eleven genotypes, followed by downward along with margin and slightly downward from the top each in three genotypes, whereas upward from the midrib was recorded in one genotype. Leaflet margin was observed as entire and slightly wavy, and the predominant was entire in 13 genotypes among 20 genotypes. The five colours of petiole were observed in the studied genotypes (green, greenish brown, brown, pale green, and greenish yellow), and the predominant colour was greenish brown in eleven genotypes. However, leaflet midrib colour in different genotypes showed four colours (yellowish green, pale yellow, greenish yellow, and pale green), and the predominant colour was yellowish green in twelve genotypes. However, leaflet midrib was prominent and protuberance was present in all the studied genotypes, whereas leaflet venation was observed as prominent and slightly prominent, and the predominant leaflet venation was prominent in sixteen genotypes.

Table 2.1: Morphological qualitative leaf characteristics of 20 longan genotypes.

Genotypes	Young leaf colour	Mature leaf colour	Leaf Arrangement	Leaflet blade shape	Leaflet apex shape	Leaflet Base shape	Leaflet curvature
LGC- 1	Reddish brown	Green	Opposite	Elliptic	Acute	Ovate	Flat
LGC-6	Reddish brown	Dark green	Alternate	Elliptic	Acute	Lanceolate	Flat
LGC-12	Reddish brown	Light green	Opposite	Elliptic	Acute	Ovate	Upward
LGC-18	Light green	Green	Alternate	Elliptic	Acute	Ovate	Upward
LGC-22	Reddish brown	Dark green	Opposite	Elliptic	Acute	Ovate	Downward along with margin
LGC-24	Reddish brown	Green	Alternate	Elliptic	Acute	Ovate	Flat
LGC-25	Light green	Green	Opposite	Elliptic	Acute	Ovate	Flat
LGC-26	Light green	Light green	Alternate	Elliptic	Acute	Ovate	Slightly downward from the top
LGC-27	Light green	Dark green	Opposite	Elliptic	Acute	Ovate	Flat
LGC-34	Light green	Green	Opposite	Elliptic	Acute	Obovate	Flat
LGC-37	Pinkish green	Light green	Opposite	Elliptic	Acute	Lanceolate	Flat
LGC-40	Pinkish green	Light green	Alternate	Elliptic	Acute	Ovate	Flat
LGC-47	Reddish brown	Green	Opposite	Elliptic	Acute	Ovate	Downward along with margin
LGC-49	Reddish brown	Green	Opposite	Elliptic	Acute	Obovate	Slightly downward from the top
LGC-50	Yellowish green	Dark green	Opposite	Elliptic	Acute	Ovate	Flat
LGC-52	Reddish brown	Green	Alternate	Elliptic	Acute	Ovate	Slightly downward from the top
LGC-54	Reddish brown	Dark green	Alternate	Elliptic	Acute	Ovate	Flat
LGC-59	Light green	Dark green	Alternate	Elliptic	Acute	Obovate	Flat
LGC- 60	Yellowish green	Light green	Opposite	Elliptic	Acute	Lanceolate	Upward from the midrib
LGC-61	Yellowish green	Dark green	Opposite	Elliptic	Acute	Lanceolate	Downward along with margin

Table 2.2: Morphological qualitative leaf characteristics of 20 longan genotypes.

Genotypes	Leaflet margin	Petiole colour	Leaflet midrib	Leaflet Midrib colour	Leaflet venation	Protuberance
LGC- 1	Entire	Greenish brown	Prominent	Pale green	Prominent	Present
LGC-6	Slightly wavy	Green	Prominent	Yellowish green	Prominent	Present
LGC-12	Entire	Green	Prominent	Pale yellow	Prominent	Present
LGC-18	Slightly wavy	Greenish brown	Prominent	Yellowish green	Prominent	Present
LGC-22	Entire	Green	Prominent	Yellowish green	Prominent	Present
LGC-24	Entire	Brown	Prominent	Yellowish green	Prominent	Present
LGC-25	Entire	Greenish brown	Prominent	Yellowish green	Prominent	Present
LGC-26	Slightly wavy	Pale green	Prominent	Yellowish green	Prominent	Present
LGC-27	Entire	Greenish brown	Prominent	Yellowish green	Slightly prominent	Present
LGC-34	Entire	Greenish brown	Prominent	Pale yellow	Prominent	Present
LGC-37	Slightly wavy	Greenish brown	Prominent	Yellowish green	Prominent	Present
LGC-40	Entire	Brown	Prominent	Pale yellow	Prominent	Present
LGC-47	Slightly wavy	Pale green	Prominent	Pale green	Slightly prominent	Present
LGC-49	Entire	Greenish brown	Prominent	Greenish yellow	Slightly prominent	Present
LGC-50	Slightly wavy	Greenish yellow	Prominent	Pale yellow	Prominent	Present
LGC-52	Entire	Brown	Prominent	Pale yellow	Prominent	Present
LGC-54	Entire	Greenish brown	Prominent	Yellowish green	Slightly prominent	Present
LGC-59	Entire	Brown	Prominent	Yellowish green	Prominent	Present
LGC- 60	Slightly wavy	Greenish brown	Prominent	Yellowish green	Prominent	Present
LGC-61	Entire	Greenish brown	Prominent	Yellowish green	Prominent	Present

Researchers have reported similar results for leaf characteristics in longan, *viz.,* colour of young and mature leaves (Olesen *et al*., 2002; Shi *et al*., 2015); leaflet arrangement (Shi *et al*., 2015). Jiang *et al*. (2022) also reported similar findings in Longan for leaf characteristics such as leaf colour, leaflet arrangement, leaflet apex and base shape, and leaflet margin. The similar findings reported in litchi for leaf characteristics by several researchers, *viz.,* leaflet shape, leaflet margin, petiole colour, leaflet apex and base shape (Khurshid *et al*., 2004; Wu *et al*., 2016; Hossain *et al*., 2017; Lal *et al*., 2023), young leaf colour, mature leaf colour, leaflet arrangement, and curvature of leaflets (Khurshid *et al*., 2004; Hossain *et al*., 2017; Lal *et al*., 2023; Kumar *et al*., 2024b).

Flowering and fruit characteristics

The flowering and fruit traits were also very diverse in the studied genotypes (Table 3). The abundance of flowering varied from sparse to profuse, and the moderate was predominant in twelve genotypes, followed by sparse and profuse each in four genotypes. The date of panicle initiation ranged from 8th February to 2nd March for the first panicle initiation and 19th February to 12th March for the last panicle initiation. Early first and last panicle initiation was observed in LGC-18, while late first and last panicle initiation was recorded in LGC-27 and LGC-24. The dates of opening of the first and last male flowers ranged from 20th March to 27th March for the opening of the first male flower, while 28th March and 5th April for the last male flower. The duration of the male flower ranged from 7 to 11 days. The dates of opening of the first and last hermaphrodite functional male flowers ranged from 27th March to 15th April, whereas the duration was recorded from 11 to 15 days. The date of opening of the first and last hermaphrodite functional female flowers varied from 10th April to 25th April, and the duration ranged from 10 to 13 days. The initiation of fruit set was observed from 20th April to 26th April, whereas the end of fruit set was ranged from 25th April to 1st May. The fruit maturity groups were observed as early, medium, and late, and the most predominant group was medium in twelve genotypes, followed by early in six genotypes, and the remaining came under the late group. Fruit intensity was recorded as poor, medium, and heavy, while the medium fruit intensity was dominant and observed in twelve genotypes, followed by poor in six genotypes and heavy in two genotypes. The aril quality of fruits was observed as sweet and insipid. Most of the genotypes exhibited sweet aril, followed by insipid aril in only four genotypes. Early fruiting coupled with heavy fruit intensity and sweet aril was observed in LGC-6 and LGC-18 genotypes. Jiang *et al.* (2022) reported similar findings in Longan for flowering and fruit characteristics, *viz.,* panicle initiation, flowering time, fruit maturity group, and aril quality. Phases of flowering in longan are aligning with the findings of Thu *et al.* (2017). The results regarding the opening of male, hermaphrodite, and female flowers agree with the findings of Pham *et al.* (2015). Mong and Razili (2022) reported that characteristics of longan flowers are similar to those of litchi flowers. He *et al.* (2022) reported similar findings on duration of flowering for male, hermaphrodite functional male, and female flowers

Table 3: Morphological qualitative flower and fruit characteristics of 20 longan genotypes.

Genotypes	Abundance of flower	Date of first and last panicle initiation		Date of opening of first and last male flower		Date of opening of first and last hermaphrodite functional male flower		Date of opening of first and last hermaphrodite functional female flower		Date of initiation and end of fruit set		Fruit maturity group	Fruit intensity	Aril Quality
		1st	Last	1st	Last	1st	Last	1st	Last	Initiation	End			
LGC- 1	Profuse	12-Feb	20-Feb	20-Mar	29-Mar	30-Mar	10-Apr	10-Apr	23-Apr	21-Apr	25-Apr	Medium	Medium	Insipid
LGC-6	Profuse	16-Feb	22-Feb	21-Mar	30-Mar	29-Mar	10-Apr	11-Apr	22-Apr	20-Apr	27-Apr	Early	Heavy	Sweet
LGC-12	Moderate	20-Feb	01-Mar	22-Mar	29-Mar	27-Mar	11-Apr	10-Apr	20-Apr	25-Apr	27-Apr	Medium	Medium	Insipid
LGC-18	Profuse	08-Feb	19-Feb	20-Mar	29-Mar	29-Mar	13-Apr	12-Apr	24-Apr	22-Apr	28-Apr	Early	Heavy	Sweet
LGC-22	Sparse	22-Feb	03-Mar	22-Mar	1-Apr	30-Mar	13-Apr	11-Apr	24-Apr	23-Apr	26-Apr	Medium	Poor	Sweet
LGC-24	Sparse	01-Mar	12-Mar	24-Mar	3-Apr	1-Apr	15-Apr	13-Apr	25-Apr	26-Apr	1-May	Medium	Medium	Sweet
LGC-25	Moderate	16-Feb	24-Feb	20-Mar	1-Apr	31-Mar	13-Apr	11-Apr	23-Apr	25-Apr	29-Apr	Late	Medium	Sweet
LGC-26	Moderate	24-Feb	06-Mar	27-Mar	3-Apr	3-Apr	15-Apr	13-Apr	25-Apr	22-Apr	30-Apr	Medium	Medium	Sweet
LGC-27	Moderate	02-Mar	10-Mar	21-Mar	1-Apr	31-Mar	12-Apr	11-Apr	23-Apr	22-Apr	27-Apr	Medium	Poor	Sweet
LGC-34	Moderate	16-Feb	26-Feb	20-Mar	30-Mar	28-Mar	10-Apr	10-Apr	22-Apr	20-Apr	28-Apr	Medium	Medium	Sweet
LGC-37	Moderate	01-Mar	10-Mar	27-Mar	5-Apr	3-Apr	14-Apr	13-Apr	25-Apr	25-Apr	30-Apr	Late	Medium	Insipid
LGC-40	Moderate	14-Feb	26-Feb	20-Mar	29-Mar	31-Mar	14-Apr	12-Apr	23-Apr	24-Apr	1-May	Medium	Medium	Sweet
LGC-47	Moderate	23-Feb	04-Mar	25-Mar	3-Apr	1-Apr	15-Apr	13-Apr	25-Apr	26-Apr	1-May	Medium	Poor	Sweet
LGC-49	Moderate	20-Feb	01-Mar	20-Mar	29-Mar	29-Mar	12-Apr	10-Apr	22-Apr	22-Apr	26-Apr	Early	Poor	Sweet
LGC-50	Moderate	28-Feb	09-Mar	22-Mar	1-Apr	31-Mar	13-Apr	11-Apr	24-Apr	25-Apr	30-Apr	Early	Medium	Sweet
LGC-52	Moderate	17-Feb	26-Feb	20-Mar	28-Mar	29-Mar	12-Apr	11-Apr	23-Apr	24-Apr	27-Apr	Medium	Medium	Sweet
LGC-54	Profuse	24-Feb	07-Mar	21-Mar	30-Mar	30-Mar	12-Apr	10-Apr	22-Apr	23-Apr	29-Apr	Medium	Medium	Sweet
LGC-59	Moderate	28-Feb	09-Mar	23-Mar	2-Apr	31-Mar	11-Apr	10-Apr	22-Apr	22-Apr	27-Apr	Early	Medium	Sweet
LGC-60	Sparse	09-Feb	21-Feb	21-Mar	30-Mar	31-Mar	12-Apr	11-Apr	23-Apr	24-Apr	30-Apr	Medium	Poor	Sweet
LGC-61	Sparse	10-Feb	23-Feb	20-Mar	29-Mar	28-Mar	12-Apr	10-Apr	22-Apr	23-Apr	28-Apr	Early	Poor	Sweet

Conclusion

Based on the results, it can be concluded that there were considerable differences in morphological qualitative traits of tree, leaf, flowering, and fruiting in the studied longan genotypes, which could be effectively utilized for identification of longan genotypes or varieties. This diversity could also be helpful for breeding improvement programs aimed at developing a longan cultivar for particular climatic conditions. Based on the morphological characteristics, genotypes LGC-6 and LGC-18 were found to have potential for high yield coupled with early fruit maturity and sweet aril in this study. These genotypes can be utilized for further breeding improvement programs to develop high-yielding cultivars.

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