International Journal of Advanced Biochemistry Research 2025; 9(6): 113-120

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(6): 113-120
www.biochemjournal.com
Received: 02-04-2025
Accepted: 06-05-2025

Paramanand Prajapati
Ph.D. Research Scholar, Department of Fruit Sciences College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Om Prakash
Assistant Professor, Department of Fruit Sciences, College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Akhilesh Kumar Srivastava
Professor, Department of Fruit Sciences, College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Subhash Chandra Singh
Associate Professor, Department of Fruit Sciences, College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Vaishali Gangwar
Assistant Professor, Department of Crop Physiology, College of Agriculture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Vishvajeet Singh
Ph.D. Research Scholar, Department of Fruit Sciences College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Shivam Chaurasia
Ph.D. Research Scholar, Department of Fruit Sciences College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Dhananjay kumar
Ph.D. Research Scholar, Department of Fruit Sciences College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Corresponding Author:
Om Prakash
Assistant Professor, Department of Fruit Sciences, College of Horticulture. Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India

Morphological characterization of tree and leaf parameters in bael (*Aegle marmelos* Correa) genotypes

Paramanand Prajapati, Om Prakash, Akhilesh Kumar Srivastava, Subhash Chandra Singh, Vaishali Gangwar, Vishvajeet Singh, Shivam Chaurasia and Dhananjay Kumar

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i6b.4538

Abstract
Bael (*Aegle marmelos* Correa), a native fruit of the Indian subcontinent, reveals its hidden diversity in this study of 55 genotypes (BUAT-B-01 to BUAT-B-55) across nine bael-growing districts of Uttar Pradesh—Kushinagar, Gorakhpur, Sultanpur, Ayodhya, Mau, Ballia, Gazipur, Bhadohi, and Banda. Surveyed from 2022-23 to 2023-24, these 10- to 30-year-old trees exhibited remarkable morphological variation. Semi-spreading growth dominated (24 genotypes), dense foliage prevailed (33), and all presented thorny bases. Leaf colors ranged from dark green (22) to light green (18) and green (15), with lanceolate shapes prevailing. Trunks displayed a yellowish-grey hue (24), while bark split irregularly in all genotypes. This rich tapestry of tree and leaf traits, assessed using DUS guidelines, highlights bael's genetic potential and paves the way for selecting superior genotypes in breeding programs.

Keywords: Bael, genetic diversity, genotypes, morphological, growth habit

Introduction
Bael (*Aegle marmelos* Correa) is a significant fruit crop in the Indian subcontinent, valued for its nutritional, medicinal and religious importance. It belongs to the Rutaceae family and known by various local names across different regions, including Bengal quince, bilva, Indian quince, golden apple, holy fruit, bel belwa, shirphal, stone apple (Singh *et al.*, 2019) [10]. Its widespread in India, Bangladesh, China, Cambodia, Fiji, Indonesia, Laos, Myanmar, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Tibet and Vietnam, etc., and other southeastern Asian countries (Neeraj and Johar 2017 [4], Sarkar *et al*. 2020) [9].
In India, it mainly occurs in Indo-Gangetic plains of northern states, Sub-Himalayan tracts, North-Eastern states, arid and deciduous forests of the southern and central peninsular regions up to 1300 msl (Pradheep *et al*. 2021; Debbarma and Hazarika 2023) [8, 2].
Morphological characterization is a fundamental step in evaluating genetic diversity and identifying elite genotype. Tree and leaf traits relatively stable and easily observable, serve as primary descriptors for genotype differentiation and selection in perennial crops like bael. These traits not only reflect the plants adaption to environmental condition but als offer valuable insight into growth habits and canopy architecture. In bael, tree traits such as plant height canopy spread, and growth habit along with leaf shape, size texture, colour, vary significantly among genotypes (Singh *et al* 2014) [15]. Such variation offers a valuable resource for selecting genotypes suited for specific agro-climatic conditions or cultivation purposes. Characterizing this diversity can aid in conservation strategies, genetic improvement, and developing superior cultivars tailored for higher productivity, climate resilience, and commercial viability. (Singh *et al* 2023) [16]
Keeping in view the above facts, this study entitled: "Morphological characterization of tree and leaf parameters in bael (*Aegle marmelos* Correa) genotypes" genotypes aim to assess the morphological diversity among 55 bael seedling genotypes under different growing conditions of Uttar Pradesh

Materials and Methods
The present experiment was conducted on 10 -30-year-old 55 bael genotypes that were

denoted by (BUAT-B-1, BUAT-B-2…………. BUAT-B-55). The survey was done from major bael growing districts viz., Kushinagar, Gorakhpur, Sultanpur, Ayodhya, Mau, Ballia, Gazipur, Bhadohi, and Banda of Uttar Pradesh, India during the year 2022-23 and 2023-24, to select promising accession among the diverse seeding bael genotypes. These genotypes were morphologically characterized for their tree and leaf, and fruit which includes the observations of tree growth habit, leaf shape, leaf colour, and leaf size as per the DUS guidelines of PPV & FRA descriptor for bael.

Results and Discussion

Tree characteristics

The qualitative tree characteristics were highly diversified within fifty-five bael genotypes (Table 1). Four tree growth habits (drooping, spreading, semi-spreading, and upright) were observed, with the predominant growth habit being semi-spreading in 24 genotypes, followed by upright in 14 genotypes, spreading in 11 genotypes and a drooping growth pattern in only 6 genotypes. Growth habit variation due to genetic diversity, environmental influences and adaption to different agro climatic. A similar result was reported by Singh *et al*. (2024) [17] in their study, which analyzed 213 genotypes. Among these, 5 were drooping, 81 were spreading, 100 were semi-spreading, and 27 were upright."

Thorniness at basal portion of the primary branch of bael according to DUS guidelines of PPV & FRA descriptor for bael. Categorized into two groups, that is thorny and thornless. A thorny portion of the primary branch pattern was predominant in all genotypes of bael. The thorniness particularly at the basal part of the primary branch, may also contribute to the overall hardiness and survivability of the plant under challenging climatic conditions.

The foliage density was varied from spares to dense in 55 genotypes the most dominant foliage density was dence in 33 genotypes of bael and rest genotypes had spare foliage density. And the arrangement of leaves on a plant stem was observed in genotypes as tristichous and pentastichous types. Tristichous phyllotaxy arrangement was observed in 31 genotypes and 24 genotypes were observed as pentastichous phyllotaxy pattern. characteristics such as foliage density phyllotaxy leaf length and width were incorporated, contributing to yield by indirectly participating in photo-assimilating synthesis. Similar results have been reported by Singh *et al*. (2014) [15] in *Aegle marmelos*; Singh *et al*. (2016a) [13] in *Manilkara hexandra* and Singh *et al*. (2016b) [14] in *Feronia limonia*

The trunk colour of different genotypes was noticed to be greyish yellow, yellowish grey, grey and yellow colour among the germplasm, and the predominant colour was yellowish grey in 24 genotypes followed by greyish yellow in 19 genotypes, grey colour in 15 genotypes. while not a single yellow colour in bael genotypes of selected germplasm. The variations in trunk bark color in different cultivars and genotypes observed may be influenced by varietal expression and prevailing environmental conditions (Amulya *et al*. 2022,) [1].

The bark splitting patterns can be classified into three distinct types: rectangular, cylindrical, and irregular. Among the 55 genotypes analyzed, all were found to exhibit an irregular splitting pattern, the predominance of the irregular bark splitting pattern may be most stable and naturally occurring pattern in bael population, particularly under varying agro-climatic condition. Irregular bark splitting may offer an adaptive advantage by providing flexibility to the trunk under environmental stress such as temperature fluctuation and drought (Morris & Jansen 2017) [3]. Similar results have been reported by (Singh *et al* 2024) [17]

Leaf characteristics

The variation in leaf parameter shown in (table 2 and table 3) The genotypes displayed three distinct leaf colours: light green, green, and dark green. The dark green colour was the most prevalent, observed in 22 genotypes, followed by light green in 18 genotypes, and green in 15 genotypes. The leaf colour plays an important role in photosynthetic activity which ultimately decides the growth and development of a tree This variation in leaf colour may indicate underlying genetic diversity or environmental adaptation among the genotypes. Similar leaf colour was observed by (Parihar and Pandey 2019) [6]

The central leaflet shapes observed in the genotypes included broadly ovate, lanceolate ovate, lanceolate, and ovate. The lanceolate shape was predominant in 22 genotypes, followed by a lanceolate to ovate shape in 19 genotypes, and an ovate shape in 14 genotypes. Not a single genotype was found with a broadly ovate shape.

While lateral leaflet shapes were categorized into two distinct forms: lanceolate and ovate. Among these, the lanceolate shape was predominant, being observed in 29 genotypes, whereas the remaining genotypes exhibited an ovate shape. This distribution highlights the dominance of the lanceolate shape among the genotypes.

The leaf apex of the bael genotypes displayed notable diversity, categorized into three distinct types: acuminate, acute, and aristate. The acuminate apex was the most prevalent, observed in 29 genotypes (52.73%), followed by the aristate apex in 14 genotypes (25.45%), and the acute apex in 12 genotypes (21.82%).

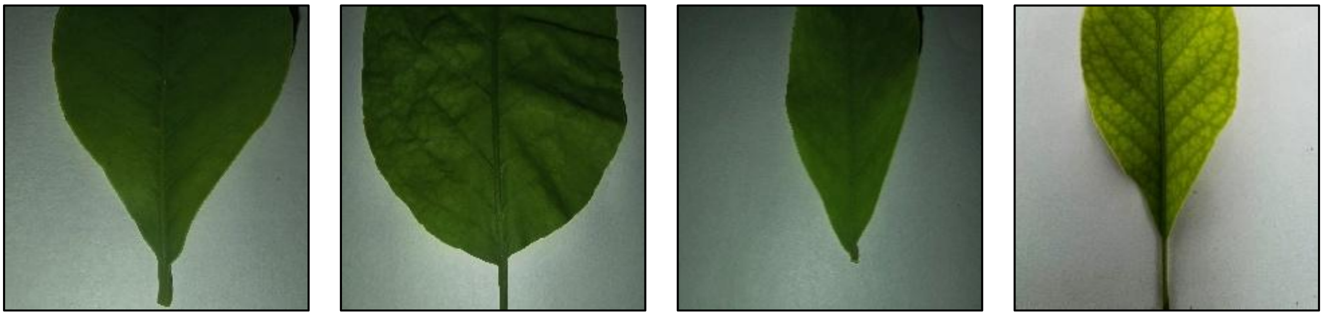
The leaf base was categorized into four types: cuneate, round, attenuate, and tapering. Among these, the cuneate base was the most common, observed in 26 genotypes (47.27%), followed by the round base in 15 genotypes (27.27%), attenuate in 9 genotypes (16.36%), and tapering in 5 genotypes (9.09%). Regarding leaf surface texture, the majority of genotypes (49, 89.09%) exhibited a smooth surface, while a rough surface was noted in only 6 genotypes (10.91%). Leaf margins were grouped into crenate and crenulate types, with the crenate margin being predominant in 37 genotypes (67.27%), and crenulate margins appearing in 18 genotypes (32.73%). For leaf size, medium-sized leaves were most frequently recorded, appearing in 35 genotypes (63.64%), followed by large leaves in 11 genotypes (20.00%), and small leaves in 9 genotypes (16.36%). This broad spectrum of foliar characteristics underscores the rich genetic variability among the bael genotypes and may serve as a valuable resource for selection in breeding programs aimed at specific morphological or adaptive traits.

leaf size plays a crucial role in physiological functions. Larger leaves tend to enhance photosynthetic efficiency, contributing to higher fruit yield by optimizing light absorption. In contrast, smaller leaflets may be an adaptation for drought resistance, reducing transpiration and ensuring survival under arid conditions (Nicotra *et al*. 2011 [5]. Researchers have reported similar results of leaf characteristics in bael, viz, leaf colour (Parihar and pandey

2019) [6]; leaf shape of central and lateral leaflet, leaf apex, leaf base, leaf surface, leaf margin, and leaf size. Similar results were also reported by Amulya (2019) [1], Pavani *et al*. (2017) [7], Singh *et al*. (2015) [11], and Singh *et al*. (2014) [15].

Acuminate Aristae Acute

Fig 1: Leaf apex



Attenuate Round Cuneate Tapering

Fig 2: Leaf base

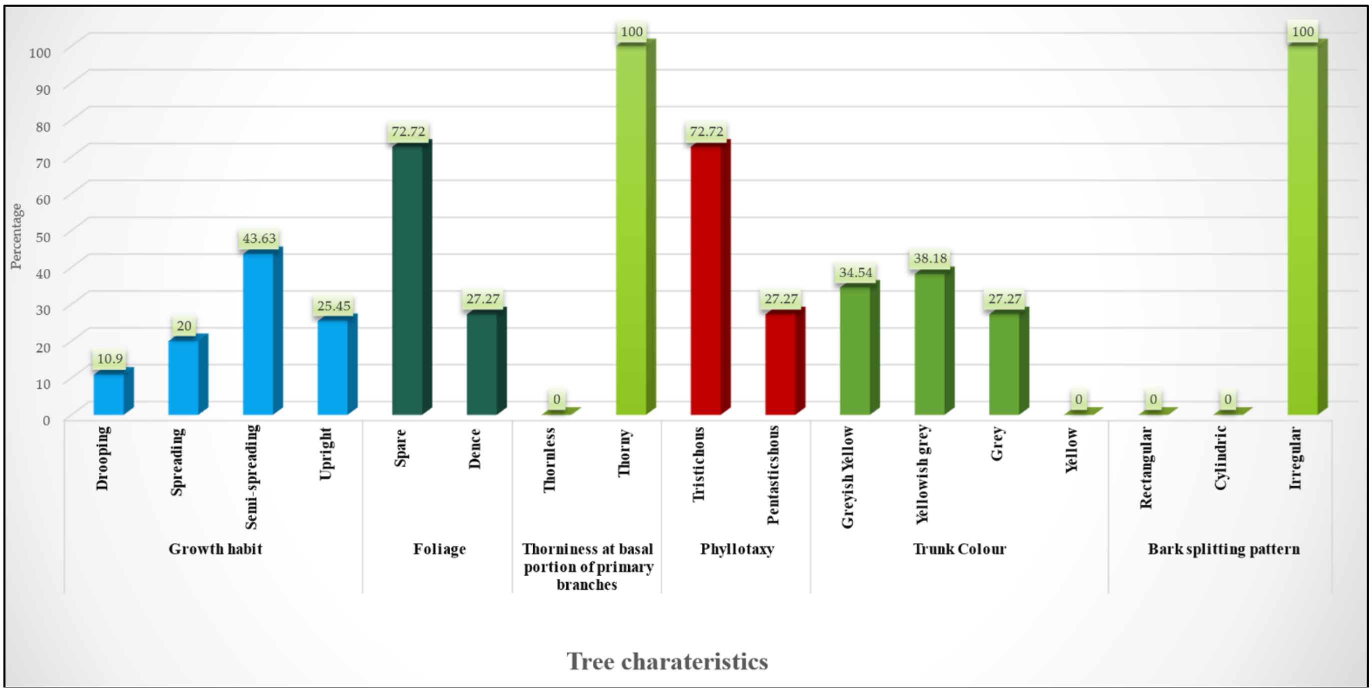


Fig 3: Frequency Percentage of Tree Characteristics

Table 1: Variation in growth habit, foliage, thorniness at basal primary branch, phyllotaxy, trunk colour and bark splitting pattern of bael (*Aegle marmelos* Correa) genotypes.

Genotypes	Growth habit	Foliage	Thorniness at basal portion of primary branch	Phyllotaxy	Trunk Colour	Bark splitting patter
BUAT-B-01	Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-02	Semi-Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-03	Upright	Dense	Thorny	Pentastichous	Yellowish grey	Irregular
BUAT-B-04	Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-05	Semi-Spreading	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-06	Semi-Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-07	Spreading	Dense	Thorny	Pentastichous	Grey	Irregular
BUAT-B-08	Semi- Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-09	Semi- Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-10	Semi- Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-11	Upright	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-12	Semi-Spreading	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-13	Upright	Dense	Thorny	Pentastichous	Grey	Irregular
BUAT-B-14	Upright	Dense	Thorny	Pentastichous	Greyish yellow	Irregular
BUAT-B-15	Upright	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-16	Semi-spreading	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-17	Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-18	Drooping	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-19	Semi-spreading	Dense	Thorny	Pentastichous	Yellowish grey	Irregular
BUAT-B-20	Semi- Spreading	Dense	Thorny	Pentastichous	Greyish yellow	Irregular
BUAT-B-21	Upright	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-22	Drooping	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-23	Upright	Dense	Thorny	Pentastichous	Greyish yellow	Irregular
BUAT-B-24	Upright	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-25	Semi-Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-26	Semi-Spreading	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-27	Upright	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-28	Semi- Spreading	Dense	Thorny	Pentastichous	Yellowish grey	Irregular
BUAT-B-29	Semi- Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-30	Spreading	Dense	Thorny	Pentastichous	Grey	Irregular
BUAT-B-31	Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-32	Semi- Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-33	Dropping	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-34	Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-35	Drooping	Dense	Thorny	Pentastichous	Greyish yellow	Irregular
BUAT-B-36	Spreading	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-37	Semi-spreading	Dense	Thorny	Pentastichous	Grey	Irregular
BUAT-B-38	Upright	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-39	Semi-spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-40	Upright	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-41	Drooping	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-42	Semi-spreading	Dense	Thorny	Pentastichous	Greyish yellow	Irregular
BUAT-B-43	Upright	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-44	Semi-spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-45	Upright	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-46	Semi- Spreading	Dense	Thorny	Pentastichous	Grey	Irregular
BUAT-B-47	Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-48	Semi-Spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-49	Semi- Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-50	Spreading	Dense	Thorny	Pentastichous	Yellowish grey	Irregular
BUAT-B-51	Semi- spreading	Spare	Thorny	Tristichous	Greyish yellow	Irregular
BUAT-B-52	Upright	Dense	Thorny	Pentastichous	Greyish yellow	Irregular
BUAT-B-53	Semi-Spreading	Spare	Thorny	Tristichous	Grey	Irregular
BUAT-B-54	Drooping	Spare	Thorny	Tristichous	Yellowish grey	Irregular
BUAT-B-55	Spreading	Spare	Thorny	Tristichous	Yellowish grey	Irregular

Table 2: Variation in leaf colour, leaf shape of central and lateral leaflet) and leaf apex of bael (*Aegle marmelos* Correa) genotypes

Genotypes	Leaf Colour	Leaf Shape		Leaf Apex
		Central leaflet shape	Lateral leaflet shape	
BUAT-B-01	Light green	Lanceolate	Lanceolate	Acuminate
BUAT-B-02	Green	Lanceolate	Lanceolate	Acuminate
BUAT-B-03	Dark green	Lanceolate	Lanceolate	Acute
BUAT-B-04	Light green	Lanceolate to ovate	Ovate	Acuminate
BUAT-B-05	Dark green	Lanceolate to ovate	Ovate	Aristate
BUAT-B-06	Light green	Ovate	Lanceolate	Acuminate
BUAT-B-07	Green	Lanceolate to ovate	Ovate	Acuminate
BUAT-B-08	Green	Ovate	Lanceolate	Acute
BUAT-B-09	Light green	Lanceolate	Ovate	Acuminate
BUAT-B-10	Dark green	Lanceolate	Lanceolate	Aristate
BUAT-B-11	Dark green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-12	Dark green	Lanceolate	Ovate	Aristate
BUAT-B-13	Light green	Ovate	Ovate	Acute
BUAT-B-14	Green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-15	Light green	Lanceolate to ovate	Lanceolate	Aristate
BUAT-B-16	Dark green	Ovate	Ovate	Acuminate
BUAT-B-17	Light green	Lanceolate	Ovate	Acute
BUAT-B-18	Light green	Lanceolate	Lanceolate	Acuminate
BUAT-B-19	Dark green	Ovate	Ovate	Acuminate
BUAT-B-20	Light green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-21	Dark green	Ovate	Ovate	Aristate
BUAT-B-22	Light green	Lanceolate	Ovate	Acuminate
BUAT-B-23	Green	Ovate	Lanceolate	Aristate
BUAT-B-24	Dark green	Ovate	Ovate	Acuminate
BUAT-B-25	Dark green	Lanceolate to ovate	Ovate	Acuminate
BUAT-B-26	Green	Ovate	Lanceolate	Acute
BUAT-B-27	Light green	Ovate	Lanceolate	Acuminate
BUAT-B-28	Dark green	Lanceolate	Lanceolate	Acuminate
BUAT-B-29	Dark green	Lanceolate to ovate	Ovate	Acute
BUAT-B-30	Green	Lanceolate to ovate	Ovate	Acuminate
BUAT-B-31	Light green	Lanceolate	Lanceolate	Aristate
BUAT-B-32	Dark green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-33	Light green	Lanceolate	Lanceolate	Aristate
BUAT-B-34	Green	Lanceolate	Lanceolate	Acute
BUAT-B-35	Dark green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-36	Light green	Lanceolate to ovate	Ovate	Aristate
BUAT-B-37	Dark green	Lanceolate to ovate	Ovate	Aristate
BUAT-B-38	Green	Lanceolate	Ovate	Acuminate
BUAT-B-39	Light green	Ovate	Lanceolate	Acuminate
BUAT-B-40	Dark green	Ovate	Lanceolate	Acuminate
BUAT-B-41	Light green	Lanceolate	Ovate	Aristate
BUAT-B-42	Green	Ovate	Lanceolate	Acute
BUAT-B-43	Dark green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-44	Dark green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-45	Green	Lanceolate	Ovate	Aristate
BUAT-B-46	Light green	Lanceolate	Ovate	Acute
BUAT-B-47	Green	Lanceolate	Lanceolate	Acuminate
BUAT-B-48	Green	Lanceolate	Ovate	Acuminate
BUAT-B-49	Green	Ovate	Ovate	Aristate
BUAT-B-50	Dark green	Lanceolate to ovate	Ovate	Acute
BUAT-B-51	Dark green	Lanceolate to ovate	Ovate	Acute
BUAT-B-52	Light green	Lanceolate to ovate	Lanceolate	Acuminate
BUAT-B-53	Dark green	Lanceolate	Lanceolate	Aristate
BUAT-B-54	Green	Lanceolate	Ovate	Acute
BUAT-B-55	Dark green	Lanceolate	Lanceolate	Acuminate

Table 3: Variation in leaf base, leaf surface leaf margin, leaf size of bael (*Aegle marmelos* Correa) genotypes.

Genotypes	Leaf base	Leaf surface	Leaf margin	Leaf size
BUAT-B-01	Cuneate	Smooth	Crenate	Medium
BUAT-B-02	Cuneate	Smooth	Crenate	Large
BUAT-B-03	Round	Smooth	Crenate	Medium
BUAT-B-04	Cuneate	Smooth	Crenate	Small
BUAT-B-05	Cuneate	Smooth	Crenate	Medium
BUAT-B-06	Round	Smooth	Crenulate	Medium
BUAT-B-07	Round	Smooth	Crenulate	Medium
BUAT-B-08	Attenuate	Rough	Crenate	Medium
BUAT-B-09	Cuneate	Smooth	Crenate	Medium
BUAT-B-10	Cuneate	Smooth	Crenate	Small
BUAT-B-11	Tapering	Smooth	Crenate	Medium
BUAT-B-12	Cuneate	Smooth	Crenulate	Medium
BUAT-B-13	Round	Rough	Crenulate	Medium
BUAT-B-14	Cuneate	Rough	Crenate	Large
BUAT-B-15	Cuneate	Smooth	Crenulate	Medium
BUAT-B-16	Attenuate	Smooth	Crenate	Small
BUAT-B-17	Cuneate	Smooth	Crenulate	Small
BUAT-B-18	Round	Smooth	Crenate	Medium
BUAT-B-19	Tapering	Smooth	Crenate	Medium
BUAT-B-20	Attenuate	Smooth	Crenate	Medium
BUAT-B-21	Cuneate	Smooth	Crenate	Medium
BUAT-B-22	Round	Smooth	Crenulate	Medium
BUAT-B-23	Cuneate	Rough	Create	Small
BUAT-B-24	Attenuate	Smooth	Crenulate	Medium
BUAT-B-25	Round	Smooth	Crenate	Small
BUAT-B-26	Tapering	Smooth	Crenulate	Small
BUAT-B-27	Attenuate	Smooth	Crenate	Medium
BUAT-B-28	Cuneate	Smooth	Crenate	Medium
BUAT-B-29	Attenuate	Smooth	Crenate	Medium
BUAT-B-30	Cuneate	Smooth	Crenate	Large
BUAT-B-31	Cuneate	Smooth	Crenate	Large
BUAT-B-32	Round	Smooth	Crenate	Large
BUAT-B-33	Tapering	Smooth	Crenulate	Medium
BUAT-B-34	Round	Smooth	Crenate	Small
BUAT-B-35	Cuneate	Rough	Crenulate	Medium
BUAT-B-36	Round	Smooth	Crenate	Large
BUAT-B-37	Cuneate	Smooth	Crenulate	Medium
BUAT-B-38	Round	Smooth	Crenate	Large
BUAT-B-39	Cuneate	Smooth	Crenate	Large
BUAT-B-40	Cuneate	Smooth	Crenate	Medium
BUAT-B-41	Cuneate	Smooth	Crenate	Medium
BUAT-B-42	Round	Rough	Crenulate	Large
BUAT-B-43	Cuneate	Smooth	Crenulate	Large
BUAT-B-44	Round	Smooth	Crenulate	Medium
BUAT-B-45	Tapering	Smooth	Crenate	Large
BUAT-B-46	Attenuate	Smooth	Crenate	Medium
BUAT-B-47	Cuneate	Smooth	Crenate	Medium
BUAT-B-48	Cuneate	Smooth	Crenulate	Medium
BUAT-B-49	Attenuate	Smooth	Crenulate	Medium
BUAT-B-50	Round	Smooth	Crenate	Medium
BUAT-B-51	Attenuate	Smooth	Crenate	Medium
BUAT-B-52	Cuneate	Smooth	Crenate	Small
BUAT-B-53	Cuneate	Smooth	Crenate	Medium
BUAT-B-54	Round	Smooth	Crenate	Medium
BUAT-B-55	Cuneate	Smooth	Crenulate	Medium

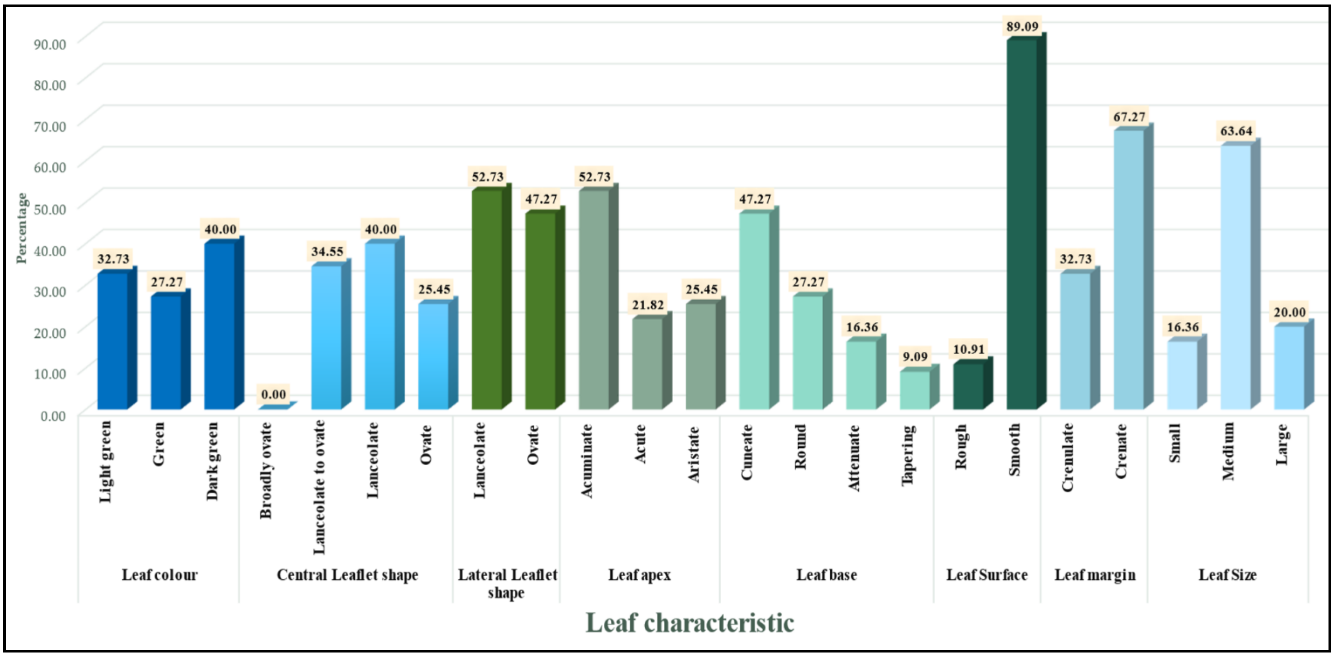


Fig 4: Frequency Percentage of Leaf Characteristics

Conclusion

The present study revealed substantial morphological diversity among the 55 bael genotypes collected from major growing regions of Uttar Pradesh. Variability was observed in key tree traits such as growth habit, foliage density, thorniness, phyllotaxy, trunk colour, and bark splitting patterns. Similarly, a wide range of leaf characteristics—including leaf colour, shape (both central and lateral leaflets), apex, base, surface, margin, and size—further underscored the genetic richness within the evaluated germplasm. Such phenotypic variation indicates significant underlying genetic diversity, soil conditions, and are also influenced by the climatic conditions of all nine districts which can be utilized in selection and breeding programs aimed at crop improvement, stress tolerance, and conservation. The predominance of certain traits, such as semi-spreading growth habit, dense foliage, lanceolate central leaflets, and acuminate apex, provides a potential basis for identifying superior genotypes. Overall, this morphological characterization lays a foundation for future work involving molecular characterization and trait-based selection for enhanced yield and adaptability in bael.

References

1. Amulya RN, Adivappar N, Shivakumar BS, Satish KM. Studies on genetic variability and relationship of bael (*Aegle marmelos* (L.) Correa) using morphological and molecular markers. J Hortic Sci. 2022;17(1):88-94.
2. Debbarma P, Hazarika TK. Genetic diversity of bael [*Aegle marmelos* (L.) Correa] accessions from north-east India based on principal component and cluster analysis. Resour Crop Evol Genet. 2023;1:1-9. *(*Added volume:1 and assumed page range since not given — please update if available)
3. Morris H, Jansen S. Bark: its anatomy, function and diversity. Springer; 2017. *(*Book reference*)*
4. Neeraj BV, Johar V. Bael (*Aegle marmelos*): extraordinary species of India - a review. Int J Curr Microbiol Appl Sci. 2017;6(3):1870-1887.
5. Nicotra AB, Leigh A, Boyce CK, Jones CS, Niklas KJ, Royer DL, *et al*. The evolution and functional significance of leaf shape in the angiosperms. Funct Plant Biol. 2011;38(7):535-552.
6. Parihar N, Pandey CS. Studies on morphological variability in bael (*Aegle marmelos* Correa) gene pool of Kymore Plateau and Satpura hill region. Int J Agric Sci. 2019;11(6):8078-8081.
7. Pavani P, Kiranmayi P, Dash SN. Evaluation of bael (*Aegle marmelos* Correa) genotypes for morphological, quality and yield related characters. Int J Basic Appl Biol. 2017;4(3):164-167.
8. Pradheep K, Joseph John K, Latha M, Suma A. Status of crop plants of agricultural importance in Kerala state, India: an update. Genet Resour Crop Evol. 2021;68:1849-1873.
9. Sarkar T, Salauddin M, Hazra SK, Chakraborty R. A novel data science application approach for classification of nutritional composition, instrumental colour, texture and sensory analysis of bael fruit (*Aegle marmelos* (L.) Correa). Int J Intell Netw. 2020;1:59-66.
10. Singh AK, Singh PD, Singh RS, Misra AK, Singh RK. The bael in India. New Delhi: DKMA, ICAR; 2019. p. 1-130.
11. Singh AK, Singh S, Makwana P. Intervarietal morphological variability in bael (*Aegle marmelos*) under rainfed semi-arid hot ecosystem of western India. Curr Hortic. 2015;3(2):3-9.
12. Singh AK, Singh S, More TA. Preliminary evaluation of bael varieties under rainfed conditions of western India. Indian J Hort. 2014;71(2):264-268.
13. Singh AK, Singh S, Yadav V, Sharma BD. Genetic variability in wood apple (*Feronia limonia*) from Gujarat. Indian J Agric Sci. 2016;86(11):1504-1508.
14. Singh S, Singh AK, Appa Rao VV, Bhargava R. Genetic divergence in khirni (*Manilkara hexandra*) under semi-arid ecosystem of western India. Indian J Agric Sci. 2016;86(3):337-341.
15. Singh AK, Singh S, Singh RS, Joshi HK, Sharma SK. Characterization of bael (*Aegle marmelos*) varieties under rainfed hot semi-arid environment of western India. Indian J Agric Sci. 2014;84(10):1236-1242.

16. Singh P, Sharma A, Jasrotia A, Bakshi P, Salgotra R, Sharma M, *et al*. Variability studies on morphological characteristics of seedling bael genotypes in the north-western plains of India. Indian J Agric Sci. 2023;93(2):245-252. *(*Assumed journal and page details—please verify/update if known*)*
17. Singh P, Sharma A, Tandon V, Salgotra RK, Sharma M, Gupta V, *et al*. Genetic diversity and population structure of bael [*Aegle marmelos* (L.) Correa] genotypes using molecular markers in the north-western plains of India. Sci Rep. 2024;14(1):18032.