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A study on characterization of morphological diversity among different mango (*Mangifera indica* L.) varieties with respect to tree attributes under Raipur's agro-climatic condition

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Abstract
Mango (*Mangifera indica* L.), known as the "king of fruits" is a vital crop in India, which leads global production with over 40% of the world's output. In 2021-22, India produced 20,772 thousand metric tons, contributing significantly. Mango exhibits high genetic diversity, making characterization essential for breeding and conservation. Chhattisgarh, with 7,753 hectares under mango cultivation, produces 473,333 metric tons, reflecting both economic and cultural importance. This study evaluated 15 mango varieties at the Government Horticultural Nursery, Paragaon, Raipur, under local Agro-climatic conditions using a Randomized Block Design. Key morphological traits such as tree height, trunk girth, crown diameter, crown shape, branching and foliage density were measured following IPGRI descriptors. Results showed considerable diversity among varieties. Growth habits were categorized as erect, drooping, and spreading, with spreading predominant (80%). Crown shapes were mainly semi-circular and broadly pyramidal. Branching and foliage densities varied, with most varieties exhibiting dense growth. Tree heights ranged from 4.37 m (Gaddemaar) to 18.43 m (Dashehari), with diverse height classes supporting varied orchard designs. Trunk diameters ranged from 0.41 m (Alphonso) to 1.08 m (Dashehari), indicating differences in structural strength. Crown diameters varied widely, with large-crowned varieties suited for traditional orchards and compact types ideal for high-density planting. In summary, the study highlights significant morphological variation among mango varieties in Chhattisgarh, influenced by genetics and environment. This diversity is crucial for selecting varieties adapted to local conditions, optimizing orchard management and enhancing productivity, thereby supporting sustainable mango cultivation in the region.

Keywords: Randomized block design, morphology, crown, breeding, varieties and foliage etc.

Introduction
Mango (*Mangifera indica* L.), often hailed as the "king of fruits" is a cornerstone of India's horticultural landscape and a major contributor to the country's agricultural economy. India is the world's leading producer of mangoes, accounting for over 40 percent of global production, with a remarkable output of 20,772 thousand metric tons in 2021-22. Andhra Pradesh and Telangana together contributed 28.37 percent of this total, yielding 5,892.45 thousand metric tons, underscoring their significance in national mango cultivation (Balaganesh, 2023) [5]. Botanically, mango belongs to the order Sapindales and the family Anacardiaceae. Its origins trace back to the Indo-Burma region, believed to be its center of origin due to the high genetic diversity observed there (Vavilov, 1926) [15]. Mukherjee (1951) [13] further suggested that while the genus Mangifera may have originated in Southeast Asia, the cultivated mango specifically arose in the Assam-Burma region. Characterization of mango varieties is essential for breeding and conservation, and can be achieved using morphological (visible traits) and non-morphological (molecular) markers (Beckman and Soller, 1986) [6]. Mango trees thrive from sea level up to 1400 meters in altitude, with ideal temperatures ranging from 24-27 °C. (Bal, 1997) [4]. The crop performs well in areas receiving 25 to 250 cm of annual rainfall, but high humidity, rain, or frost during flowering can adversely affect yields. India boasts a vast mango germplasm, with around 1,000 varieties cultivated across the country.

Chhattisgarh, in particular, stands out for its unique mango heritage, covering 7,753 hectares and producing 473,333 metric tons at a productivity rate of 6.09 MT/hectare (Anon., 2023-24). Here, mango cultivation is not only an agricultural activity but also a cultural hallmark, reflecting the region's harmony between nature and human ingenuity.

2. Materials and methods

This study evaluated 15 mango varieties, both commercial and local, using a Randomized Block Design with three replications at the Government Horticultural Nursery, Paragaon, Raipur. The research aimed to assess tree morphological traits under local agro-climatic conditions, following standard agronomic practices and IPGRI (2006) descriptors. Tree height was measured from the ground to the highest point using a measuring tape and with the help of bamboo recorded in meters. According to mango descriptors, height is classified into four categories: short (<6 m), medium (6.1-9 m), tall (9-12 m) and very tall (>12 m). Trunk girth, measured at 15 cm above ground level using a measuring tape, represents the collar section of the main stem. The measurements are recorded in centimeters, and the average values are used to assess the trunk thickness of each mango tree variety. Crown diameter was determined by measuring the tree's crown in both North-South and East-West directions, then calculating the mean of these two measurements, with results expressed in meters. Data on morphological characteristics were analyzed to identify mango varieties most suitable for commercial cultivation in Raipur and surrounding areas. analysis of morphological traits helped identify mango varieties best suited for commercial cultivation in Raipur. Favorable tree morphology improves adaptability, orchard management and canopy health, leading to better yields and fruit quality. These benefits ultimately enhance productivity and profitability for mango growers in the region.

3. Results and Discussions

All the data recorded regarding all the parameters were displayed in the Table 1 and illustrated in Figure 1 below.

3.1 Tree growth habit

The assessment of tree growth habit among 15 mango (*Mangifera indica* L.) varieties under the Agro-climatic conditions of Raipur revealed notable differences, as summarized in Table 1 The varieties were categorized into three distinct growth habits: erect, drooping and spreading. Specifically, Gaddemaar and Kalepad exhibited an erect growth habit, Sundari displayed a drooping habit, while the remaining 12 varieties including Alphonso, Banarasi Langra, Banganpalli, Baramasi, Chausa, Chhattisgarh Nandiraj, Dashehari, Kishanbhog, Mallika, Neeleshan, Neelum and Totapari demonstrated a spreading growth habit. The spreading type was predominant, accounting for 80% of the varieties, followed by erect (13%) and drooping (7%). These variations in growth habit, canopy area and tree height can be attributed to several interrelated factors. Genetic makeup is a primary determinant, as each mango variety possesses unique genetic traits influencing its vigor, stature and overall architecture. Environmental factors such as soil type, climate and water availability also play significant roles, with different varieties exhibiting varied adaptability to local conditions. Moreover, cultural practices including pruning, fertilization, irrigation and pest management can further modify tree growth, with well-managed trees often developing more desirable growth habits and larger canopies. The findings of this study are consistent with previous research by Bhamini *et al.* (2018) [7], Majumdar *et al.* (2011) [12], Uddin *et al.* (2011) [14], Bakshi *et al.* (2012) [3], who also reported significant diversity in tree growth habits and related morphological attributes among mango germplasm.

3.2 Crown shape

The crown shape of 15 mango varieties was classified into four groups: oblong, broadly pyramidal, semi-circular, and spherical. Most varieties (53%) exhibited a semi-circular crown, while the remaining 47% had a broadly pyramidal shape. These variations are attributed to differences in genotype age, agronomic practices, growing environments and root distribution patterns, all affecting water and nutrient absorption. Such diversity in crown shape influences overall tree growth and adaptability. The findings align with previous studies by Bhamini *et al.* (2018) [7], Khadivi *et al.* (2022) [11], Igbari *et al.* (2022) [8], Jnapika *et al.* (2023) [10].

3.3 Branching density and foliage density

The study classified the branching density of 15 mango varieties into three groups: dense, intermediate, and sparse. Dense branching was observed in 60% of varieties, including Alphonso, Banganpalli and others, while 20% had intermediate and 20% had sparse branching. Variations in branching and foliage density are influenced by genetic factors, environmental conditions, soil quality, water availability, pruning, tree age, light exposure and pest resistance. These factors collectively affect tree health and growth patterns. The study assessed foliage density in 15 mango varieties, classifying them into dense, intermediate, and sparse categories. Dense foliage was observed in 54% of varieties, including Banarasi Langra, Banganpalli, and others, while 33% exhibited intermediate density and 13% had sparse foliage. These variations are likely due to differences in genotype age, agronomic practices, growing environments, and soil conditions. Such diversity in foliage density impacts tree health, productivity, and adaptability. The findings are consistent with previous research Jnapika *et al.* (2023) [10], supporting similar trends observed in mango germplasm.

3.4 Tree height

The study categorized 15 mango varieties into four height classes: short (<6 m), medium (6.1-9.0 m), tall (9.1-12.0 m), and very tall (>12.0 m). Heights ranged from 4.37 m (Gaddemaar) to 18.43 m (Dashehari). Short and tall varieties each comprised 13%, medium 27% and very tall 47%. This variation reflects differences in genotype, agronomic practices, environment and root distribution, influencing water and nutrient uptake. Understanding these height differences aids in selecting suitable varieties for specific agricultural needs. The findings align with previous research by Uddin *et al.* (2011) [14], Bakshi *et al.* (2012) [3], Jamil *et al.* (2015) [9], Bhamini *et al.* (2018) [7] on mango genotypes, confirming significant diversity in tree height and growth habits.

3.5 Trunk and (m)

Table 1 presents the trunk diameter of various mango varieties, revealing considerable variation influenced by genetics and environment. Dashehari exhibited the largest trunk (1.08 m), indicating exceptional structural strength, while Alphonso had the smallest (0.41 m). Other varieties like Banarasi Langra (0.79 m), Chausa (0.84 m), Mallika (0.81 m) and Totapari (0.81 m) also displayed robust trunks. This diversity in trunk girth is crucial for selecting varieties suitable for specific cultivation systems. Thicker trunks support larger canopies and heavier fruit loads, ideal for commercial orchards, while moderate sizes (*e.g.*, Baramasi, 0.53 m) suit smaller setups. Understanding these differences optimizes tree stability, productivity, and long-term orchard success. These findings align with previous studies by Uddin *et al.* (2011) [14], Bakshi *et al.* (2012) [3], Jamil *et al.* (2015) [9], Bhamini *et al.* (2018) [7] on mango genotypes.

3.6 Crown diameter (m)

The present study assessed the crown diameter of fifteen mango varieties, revealing substantial variability in canopy spread, as detailed in Table 1 and Fig. 1. Dashehari exhibited the largest crown diameter (14.56 m), followed closely by Mallika (14.41 m) and Chausa (13.62 m), indicating their suitability for traditional, widely spaced orchards. Banarasi Langra and Banganpalli also showed broad crowns, while varieties like Totapari, Kishanbhog, Kalepad and Sundari had moderately wide canopies. In contrast, Chhattisgarh Nandiraj, Baramasi, Neeleshan and Neelum displayed more compact crowns, with Alphonso and Gaddemaar being the most compact (3.32 m and 3.21 m, respectively). This wide range in crown diameter highlights the importance of selecting varieties based on orchard design, available space and management needs. Larger-crowned varieties are ideal for extensive orchards, while compact types suit high-density or space-limited plantings. These findings align with previous studies by Uddin *et al.* (2011) [14], Bakshi *et al.* (2012) [3], Jamil *et al.* (2015) [9], Bhamini *et al.* (2018) [7] on mango genotypes.

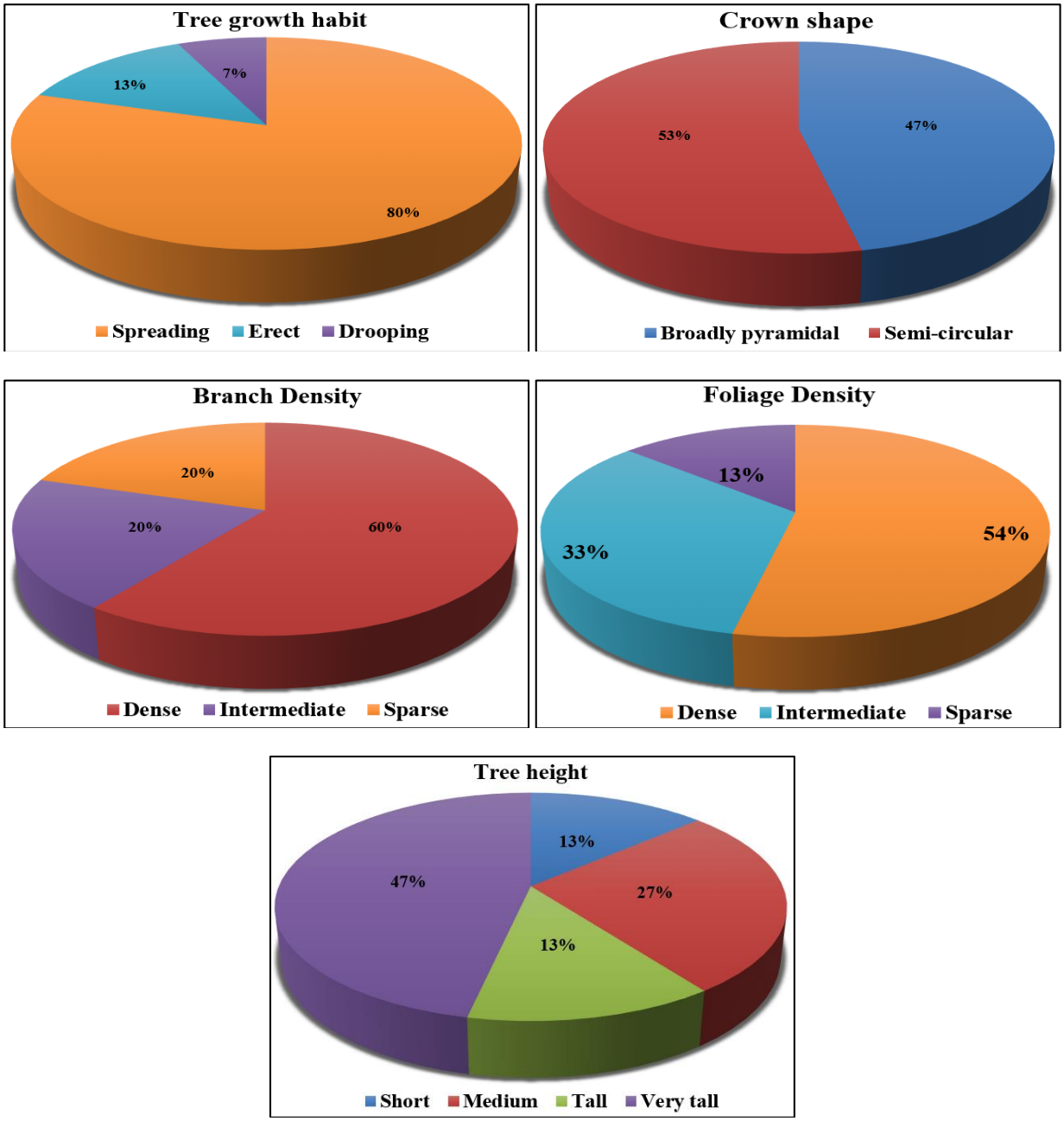

Fig 1: Pie diagram of Tree growth habit, Crown shape and branch and foliage density of different mango varieties

Table 1: Variabilities on morphological tree characteristics like-tree growth habit, canopy shape, branch density, foliage density, tree height, trunk and crown diameter of mango varieties.

Varieties	Tree growth habit	Crown shape	Branch density	Foliage density	Tree height (m)	Trunk Diameter (m)	Crown diameter (m)
Alphonso	Spreading	Semi-circular	Dense	Intermediate	4.98	0.41	3.32
Banarasi Langra	Spreading	Semi-circular	Dense	Dense	16.58	0.79	12.75
Banganpalli	Spreading	Broadly pyramidal	Dense	Dense	15.47	0.57	12.21
Baramasi	Spreading	Broadly pyramidal	Sparse	Sparse	8.26	0.53	6.83
CG Nandiraj	Spreading	Broadly pyramidal	Dense	Dense	8.28	0.65	7.43
Chausa	Spreading	Semi-circular	Intermediate	Intermediate	16.87	0.84	13.62
Dashehari	Spreading	Broadly pyramidal	Dense	Dense	18.43	1.08	14.56
Gaddemaar	Erect	Semi-circular	Sparse	Intermediate	4.37	0.64	3.21
Kalepad	Erect	Broadly pyramidal	Intermediate	Intermediate	14.56	0.71	9.33
Kishanbhog	Spreading	Broadly pyramidal	Dense	Dense	14.79	0.73	9.59
Mallika	Spreading	Broadly pyramidal	Dense	Dense	17.67	0.81	14.41
Neeleshan	Spreading	Semi-circular	Intermediate	Intermediate	7.22	0.69	5.95
Neelum	Spreading	Semi-circular	Sparse	Sparse	7.83	0.66	5.82
Sundari	Drooping	Semi-circular	Dense	Dense	10.23	0.71	8.77
Totapari	Spreading	Semi-circular	Dense	Dense	11.57	0.81	9.34

4. Summary and Conclusions

The evaluation of 15 mango varieties under Raipur's Agro-climatic conditions revealed substantial morphological diversity in traits such as tree growth habit, crown shape, branching and foliage density, tree height, trunk diameter and crown diameter. Growth habits were mainly spreading (80%), with erect and drooping forms less common, reflecting both genetic and environmental adaptability. Crown shapes were predominantly semi-circular or broadly pyramidal, influenced by genotype and environmental conditions that affect nutrient and water uptake. Most varieties exhibited dense branching and foliage, contributing to canopy health and productivity. Tree height ranged from short to very tall and trunk diameters varied significantly, with Dashehari showing the thickest trunk for strong canopy support, while compact varieties like Alphonso had thinner trunks ideal for high-density planting. Crown diameter also ranged widely, with large-crowned types such as Dashehari and Mallika suitable for traditional orchards, and compact-crowned types like Alphonso and Gaddemaar fitting space-limited systems. This diversity, consistent with other mango germplasm studies, underscores the influence of genetics, environment and cultural practices on tree architecture. Understanding these variations is essential for selecting varieties suited to specific Agro-climatic zones and orchard designs, ultimately improving productivity, adaptability and sustainability in mango cultivation.

5. Suggestions for future research work

Future research in Chhattisgarh should focus on evaluating a wider range of mango varieties and hybrids to identify those best suited for local Agro-climatic conditions, especially considering early maturity and export potential. Studies should also investigate the impact of advanced canopy management and high-density planting systems on yield and fruit quality, as well as the integration of intercrops for enhanced orchard productivity and sustainability. Additionally, research on nutrient and water management, pest and disease resistance and the development of predictive models for area, production and productivity will be vital for optimizing mango cultivation and addressing regional challenges.

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