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Morphological evaluation of tree, leaf and branch characteristics in indigenous ber (*Ziziphus mauritiana* Lamk.) at Bemetara district of Chhattisgarh

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Abstract
The investigation was conducted over the years 2022-23 and 2023-24 to study the morphological characteristics of indigenous ber (*Ziziphus mauritiana* Lamk.) from the different villages in Bemetara district of Chhattisgarh. The survey and evaluation involved 40 indigenous ber trees selected from various locations within the Bemetara district and was designed using a linear mixed effect model with forty trees with four random branches. The morphological characterization focused on tree characteristics and leaf characteristics recording observations on growth habit, shoot surface, leaf apex leaf base, leaf shape, leaf length leaf width and branch thorniness.
The study focused on observing and characterizing the indigenous ber trees in their wild forms, noting significant variations in their morphological attributes. The primary objectives was to thoroughly document and analyze these indigenous ber trees to understand their potential and variability better.
Results revealed that in tree character on growth habit (spreading- 16 trees semi- erect- 15 trees and erect- 9) and shoot surface (tomentose- 24 and smooth- 16) leaf character on leaf apex (obutus- 29 and acute- 11), leaf base (round- 21, cordate-13, oblique-5 and acute-1), leaf shape (oval-15, obavate- 11, ovate- 7 and cordate-7), leaf length (short-38 and medium-2) and leaf blade width all shorts type are present in all indigenous ber trees and branch characters, branch thorniness (medium- 25, high- 9 and less-6) These observations highlight the diversity within the indigenous ber tree population, with variations in tree growth habit, shoot surface, leaf characteristics, and branch thorniness.

Keywords: Ber, characterization, morphological and *Ziziphus mauritiana*

Introduction
The Indian jujube commonly known as ber (*Ziziphus mauritiana* Lamk.) is one of the ancient and indigenous fruit of India. It belongs to the Family Rhamnaceae. The tree is an example of extremely drought hardy species, which can be grown in dry land areas and on degraded, eroded, gravely, saline and sodic wasteland. It is a dominant component of the natural vegetation in the Indian “Thar desert” and thrives well under a maximum annual temperature of 35-42 °C and the minimum temperature of 4-12 °C. The plant can tolerate temperatures as high as 49-50 °C and as low as -2 °C. However, growth and development of the plant is affected at both the extremes (Awasthi *et al*., 2007) [3].
The plant species exhibits a broad variety of morphologies, ranging from small to medium-sized shrubs to spreading, semi-erect or erect trees. Although trees 20 metres or more are relatively rare, heights range from 3–4 to 10–16 metres or more. Trees have many branches and are semi deciduous. The bark is either red dish-brown or greyish-brown in colour, with deep longitudinal furrows.
Usually, the shrub or tree is spinous, but occasionally unarmed. Branch letsare densely white pubescent, especially when young and tend to be *zig-zag*. Branches erect and spreading, becoming flexuous and dull brown grey. Fruiting branches are not deciduous. Leaf laminae are elliptic to ovate or nearly orbicular, 3-8 cm long and 1.5-5 cm at the widest point. The apex is rounded, obtuse or subacute to emarginated, the base rounded, sometimes cuneate, mostly symmetri calor nearly so. Margins are minutely serrulate. There are three marked nerves almost to the apex, the nerves being depressed in the upper, light or dark green, glabrous surface. Lower surface is whitish due to persistent dense hairs but may be buff coloured. Occasionally the lower surface is glabrous.

Evaluation of the germplasm is primarily first step to collect basic information of respective germplasm before initiating any breeding programme for crop improvement. Knowledge of the inter relationship of quantitative traits of economic importance with yield and among themselves is very important for the improvement in a complex character like yield and quality through selection (Meena *et al*., 2019) [6]. There is a need to improve the crop for commercial cultivation in different agro-ecological environments. The idea is to combine maximum desirable traits in a cultivar. Various techniques of breeding can be grouped into broad headings *viz.*, introduction, selection, hybridization, polyploidy, mutation, breeding, biotechnological methods and genetic engineering.

Materials and Methods

The experimental material consists of 40 indigenous ber trees, that were identified from different locations of the Bemetara, Berala, Navagaon and Saja blocks in Bemetara district of Chhattisgarh under study. The experiment was conducted in Linear mixed effect model design with inclusion of four different soil types. These indigenous ber trees were morphologically characterized for their tree and leaf parameters which involves the observations of growth habit, shoot surface, leaf apex, leaf base, leaf shape, leaf length, leaf width and branch thorniness as per the key descriptor of *Ziziphus mauritiana*, Food and Agriculture Organization of the United Nations.

Results and Discussions

Tree characters

Growth habit

Growth habit for forty indigenous ber was classified into four categories *viz.*, erect, semi-erect, spreading and drooping (Table 1.1). Among the forty indigenous ber, 9 indigenous ber observed erect growth habit (Tree-4, Tree-5, Tree-14, Tree-25, Tree-26, Tree29, Tree-30, Tree-32, and Tree-33) whereas, 15 indigenous ber, had recorded semi-erect (Tree-1, Tree-2, Tree-3, Tree-9, Tree-10, Tree-11, Tree-12, Tree-15, Tree-16, Tree-19, Tree-20, Tree-21, Tree-27, Tree-36 and Tree-37) and the remaining 16 indigenous ber recorded spreading growth habit (Tree-6, Tree-7, Tree-8, Tree-13, Tree-17, Tree-18, Tree-22, Tree-23, Tree-24, Tree-28, Tree-31, Tree-34, Tree-35, Tree-38,Tree-39 and Tree-40).

Singh, (2019) observed that 12 different accessions of ber showed erect growth habit was present only 1accession, 9 accessions had semi-erect type of growth habit and rest 2 accession showed spreading growth habit. Similar results were also observed by Akter and Rahman (2020) [1] in ber and Vikalp *et al.* (2023) [11] in ber.

Shoot surface

Shoot surface for forty indigenous ber was classified into two categories *viz.*, smooth and tomentose (Table 1.1). Among the forty indigenous ber, 16 type of ber tree had smooth shoot surface (Tree-3, Tree-4, Tree-5, Tree-8, Tree-13, Tree-15, Tree-19,Tree-20, Tree-24, Tree-28, Tree-31, Tree-35, Tree-37, Tree-38, Tree-39 and Tree-40) whereas, 24 indigenous ber recorded tomentose type shoot surface (Tree-1, Tree-2,Tree-6, Tree-7, Tree-9, Tree-10, Tree-11, Tree-12, Tree-14, Tree-16, Tree-17, Tree-18,Tree-21, Tree-22, Tree-23, Tree-25, Tree-26, Tree-27, Tree-29, Tree-30, Tree-32.Tree-33, Tree-34 and Tree-36).

Kumar, *et al*. (2022) [5] found the similar results on ber. They noticed among the 8 different varieties of ber, seven varieties are smooth shoot surface and one variety of ber was tomentose shoot surface. Also similar results were also observed Singh *et al*. (2019) [10] in ber and Vikalp, *et al.* (2023) [11] in ber.

Leaf characters

Leaf apex

Leaf apex for forty indigenous ber was classified into two categories *viz.*, acute and obtuse (Table 1.1). Among the forty indigenous ber, 11 tree acute type of leaf apex (Tree-5, Tree-10, Tree-11, Tree-13, Tree-16, Tree-23, Tree-26 Tree-33, Tree-35, Tree-36 and Tree-37) and 29 ber trees recorded obtuse type of leaf apex (Tree-1,Tree-2, Tree-3, Tree-4, Tree-6, Tree-7, Tree-8, Tree-9, Tree-12, Tree-14, Tree-15,Tree-17, Tree-18, Tree-19, Tree-20, Tree-21, Tree-22, Tree-24, Tree-25, Tree-27,Tree-28, Tree-29, Tree-30, Tree-31, Tree-32, Tree-34, Tree-38, Tree-39 and Tree-40).

Razi *et al.* (2013) [9] examined the leaf qualitative characteristics of eleven commercial varieties along with two unidentified strains at the University of Agriculture, Faisalabad. They observed that the leaf apex was obtuse in varieties Desi, Karela, Annonymous I, Gola, Khati Mithi and Kernal Local. In contrast, leaf apex of the other varieties was noted to be cuspidate, acute or sub-acute.

Similar results were also recorded Singh *et al.* (2019) [10], Mishra, *et al*. (2023) [7] and Kumar and Tripathi (2024) [4] found the similar inference in ber.

Leaf base

Leaf base of forty indigenous ber was classified into four categories *viz.*, acute, cordate, round and oblique (Table 4.1). Among the forty indigenous ber, one acute type (Tree-30), 13 indigenous ber trees cordate (Tree-4, Tree-5, Tree-7, Tree-10, Tree-12, Tree-19, Tree-20, Tree-25, Tree-28, Tree-31, Tree-34, Tree-38 and Tree-39) 21 ber round type leaf base (Tree-2, Tree-3, Tree-6, Tree-8, Tree-11, Tree-14, Tree-15, Tree-16, Tree-17, Tree-18, Tree-21, Tree-22, Tree-23, Tree-24, Tree-26, Tree-27, Tree-32,Tree-33, Tree-35, Tree-37 and Tree-40) and 5 ber oblique type leaf base (Tree-1, Tree-9, Tree-13, Tree-29 and Tree-36).

The largest proportion of leaf base was recorded round leaf base with 55 percent followed by cordate 32.50 percent, oblique 10percent while smallest proportion leaf base was noticed in acute 2.50 percent.

Singh *et al.* (2019) [10], Mishra, *et al.* (2023) [7] and Vikalp *et al.* (2023) [11] found similar results in ber.

Leaf shape

Leaf shape for forty indigenous ber was classified into six categories *viz.*, ovate, oblong, elliptic, oval, cordate and obovate (Table 1.1). Among the forty indigenous ber, 7 indigenous ber recorded ovate of leaf shape (Tree-2, Tree-5, Tree-10, Tree-11,Tree-13, Tree-16 and Tree-22), 15 indigenous ber recorded oval of leaf shape (Tree-3,Tree-4, Tree-6, Tree-7, Tree-9, Tree-12, Tree-17, Tree-20, Tree-21, Tree-24, Tree-26,Tree-27, Tree-35, Tree-37 and Tree-39), whereas, 7 indigenous ber observed cordate of leaf shape (Tree-14, Tree-18, Tree-25, Tree-28, Tree-31, Tree-34 and Tree-38) and 11 indigenous ber trees was recorded obovate of leaf shape (Tree-1, Tree-8, Tree-15, Tree-19,Tree-23, Tree-29, Tree-30, Tree-32, Tree-33, Tree-36 and Tree-40).

The largest proportions of tree growth habit was recorded in spreading type of tree with 40 percent followed by semi-erect 37.50 percent and erect type with 22.50 percent.
Similar result was recorded Singh *et al.* (2019) [10], Mishra *et al.* (2023) [7] and Vikalp *et al.* (2023) [11] found similar results in ber.

Leaf blade length (cm)
Leaf blade: length (cm) forty indigenous ber tree was divide into three categories *viz.*, short (<7) medium (7-9) and long (>9) (Table 4.2). Among the 40 indigenous ber recorded 38 indigenous ber short (<7) (Tree-1, Tree-2, Tree-3, Tree-4,Tree-5, Tree-6, Tree-7, Tree-8 Tree-9 Tree-11, Tree-12, Tree-13, Tree-14, Tree-16,Tree-17, Tree-18, Tree-19, Tree-20, Tree-21, Tree-22, Tree-23, Tree-24, Tree-25,Tree-26, Tree-27, Tree-28, Tree-29, Tree-30, Tree-31, Tree-32, Tree-33, Tree-34,Tree-35, Tree-36, Tree-37, Tree-38, Tree-39 and Tree-40) and followed by medium(7-9) type rest two indigenous ber tree (Tree-10 and Tree-15).
The shoot surface was noticed maximum tomentose type with the 60 percent and minimum smooth type with the 40 percent.
The maximum type of Leaf length (cm) of indigenous ber was short (<7) type with 95 percent and followed by medium (7-9) with 5percent. Similar result were also noticed Mishra *et al.* (2023) [7] and Vikalp *et al.* (2023) [11] in ber.

Leaf blade width (cm)
Leaf blade width (cm) all forty indigenous ber was into three categories *viz.*, narrow (<6) medium (6-7) and broad (>7) All the forty indigenous ber recorded narrow (<6) with 100.00 percent. No indigenous ber were having medium (6-7) and broad (>7). Nikmatullah *et al.* (2023) [8] and Vikalp *et al.* (2023) [11] found similar inferences in ber.

Branch characters
Branch thorniness
Branch thorniness forty indigenous ber tree was categories in three groups *viz.*, less medium and high (Table 1.1). Among the 40 indigenous ber noted 6 ber tree had less thorny (Tree-4, Tree-13, Tree-18, Tree-22, Tree-33 and Tree-37) 25 medium type (Tree-1, Tree-2, Tree-5, Tree-6, Tree-7, Tree-9, Tree-10, Tree-11, Tree-12, Tree-16, Tree-17, Tree-19, Tree-20, Tree-21, Tree-23, Tree-25, Tree-26, Tree-27, Tree-29,Tree-30, Tree-32, Tree-34, Tree-36, Tree-38 and Tree-39) and 9 high thorny ber trees (Tree-3, Tree-8, Tree-14, Tree-15, Tree-24, Tree-28, Tree-31, Tree-35 and Tree-40).
The largest proportion of branch thorniness was noticed in 25 medium types with 62.50 percent followed by high thorny (22.50 percent) while smallest proportion less thorny was noticed with 15percent. Singh *et al.* (2019) [10] and Vikalp *et al.* (2023) [11] found similar inferences in ber.

Table 1: Morphological characters of indigenous ber trees, leaves and branches.

Indigenous Ber	Growth habit	Shoot surface	Leaf apex	Leaf base	Leaf shape	Leaf blade length (cm)	Leaf blade: width (cm)	Branch: Thoriness
Tree-1	Semi-erect	Tomentose	Obtuse	Oblique	Obovate	Short (5.57)	Short (3.25)	Medium
Tree-2	Semi-erect	Tomentose	Obtuse	Round	Ovate	Short (4.20)	Short (3.17)	Medium
Tree-3	Semi-erect	Smooth	Obtuse	Round	Oval	Short (4.85)	Short (3.22)	High
Tree-4	Erect	Smooth	Obtuse	Cordate	Oval	Short (5.00)	Short (4.02)	Less
Tree-5	Erect	Smooth	Acute	Cordate	Ovate	Short (4.60)	Short (3.95)	Medium
Tree-6	Spreading	Tomentose	Obtuse	Round	Oval	Short (4.82)	Short (3.80)	Medium
Tree-7	Spreading	Tomentose	Obtuse	Cordate	Oval	Short (5.37)	Short (3.72)	Medium
Tree-8	Spreading	Smooth	Obtuse	Round	Obovate	Short (5.55)	Short (3.70)	High
Tree-9	Semi-erect	Tomentose	Obtuse	Oblique	Oval	Short (5.55)	Short (3.75)	Medium
Tree-10	Semi-erect	Tomentose	Acute	Cordate	Ovate	Medium (7.68)	Short (5.67)	Medium
Tree-11	Semi-erect	Tomentose	Acute	Round	Ovate	Short (5.50)	Short (3.75)	Medium
Tree-12	Semi-erect	Tomentose	Obtuse	Cordate	Oval	Short (4.90)	Short (3.55)	Medium
Tree-13	Spreading	Smooth	Acute	Oblique	Ovate	Short (4.97)	Short (2.60)	Less
Tree-14	Erect	Tomentose	Obtuse	Round	Cordate	Short (4.60)	Short (4.55)	High
Tree-15	Semi-erect	Smooth	Obtuse	Round	Obovate	Medium (7.10)	Short (4.30)	High
Tree-16	Semi-erect	Tomentose	Acute	Round	Ovate	Short (6.25)	Short (3.57)	Medium
Tree-17	Spreading	Tomentose	Obtuse	Round	Oval	Short (6.47)	Short (4.05)	Medium
Tree-18	Spreading	Tomentose	Obtuse	Round	Cordate	Short (5.55)	Short (4.12)	Less
Tree-19	Semi-erect	Smooth	Obtuse	Cordate	Obovate	Short (6.77)	Short (3.92)	Medium
Tree-20	Semi-erect	Smooth	Obtuse	Cordate	Oval	Short (4.50)	Short (2.92)	Medium
Tree-21	Semi-erect	Tomentose	Obtuse	Round	Oval	Short (3.10)	Short (1.65)	Medium
Tree-22	Spreading	Tomentose	Obtuse	Round	Ovate	Short (1.85)	Short (1.67)	Less
Tree-23	Spreading	Tomentose	Acute	Round	Obovate	Short (2.60)	Short (1.92)	Medium
Tree-24	Spreading	Smooth	Obtuse	Round	Oval	Short (2.02)	Short (1.52)	High
Tree-25	Erect	Tomentose	Obtuse	Cordate	Cordate	Short (1.80)	Short (1.25)	Medium
Tree-26	Erect	Tomentose	Acute	Round	Oval	Short (1.95)	Short (1.70)	Medium
Tree-27	Semi-erect	Tomentose	Obtuse	Round	Oval	Short (2.65)	Short (2.67)	Medium
Tree-28	Spreading	Smooth	Obtuse	Cordate	Cordate	Short (2.45)	Short (1.47)	High
Tree-29	Erect	Tomentose	Obtuse	Oblique	Obovate	Short (2.82)	Short (2.17)	Medium
Tree-30	Erect	Tomentose	Obtuse	Acute	Obovate	Short (3.11)	Short (2.22)	Medium
Tree-31	Spreading	Smooth	Obtuse	Cordate	Cordate	Short (2.65)	Short (1.95)	High
Tree-32	Erect	Tomentose	Obtuse	Round	Obovate	Short (2.15)	Short (1.62)	Medium
Tree-33	Erect	Tomentose	Acute	Round	Obovate	Short (1.80)	Short (1.62)	Less
Tree-34	Spreading	Tomentose	Obtuse	Cordate	Cordate	Short (3.07)	Short (2.05)	Medium
Tree-35	Spreading	Smooth	Acute	Round	Oval	Short (2.35)	Short (2.07)	High

Tree-36	Semi-erect	Tomentose	Acute	Oblique	Obovate	Short (2.67)	Short (2.67)	Medium
Tree-37	Semi-erect	Smooth	Acute	Round	Oval	Short (2.90)	Short (2.00)	Less
Tree-38	Spreading	Smooth	Obtuse	Cordate	Cordate	Short (4.40)	Short (2.54)	Medium
Tree-39	Spreading	Smooth	Obtuse	Cordate	Oval	Short (2.87)	Short (2.00)	Medium
Tree--40	Spreading	Smooth	Obtuse	Round	Obovate	Short (2.67)	Short (2.07)	High

Conclusion

The study evaluated forty indigenous ber trees (*Ziziphus mauritiana* Lamk.) for various characteristics, including tree growth habits and leaf traits. The results revealed significant variability among these trees in both similarities and dissimilarities. Some ber trees exhibited distinct characteristics that could be useful for identification purposes. The findings highlight at Bemetara district of Chhattisgarh possesses a diverse range of *Ziziphus*, which can be utilized for gene pool conservation and the development of improved cultivars for future generations.

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