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Evaluation of ber (*Ziziphus mauritiana*) genotypes under semi-arid region of Haryana

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ABSTRACT

Present study was carried out during 2020–21 and 2022–23 at Regional Research Station (CCS Haryana Agricultural University, Hisar, Haryana), Bawal, Haryana for characterizing 35 distinct ber (*Ziziphus mauritiana* Lamk.) genotypes by evaluating their 16 morphological attributes as growth habits, foliage and thorn characteristics. The experiment was laid out in randomized block design (RBD) with three replications. Among selected genotypes, an upright growth pattern was reported in five genotypes, whereas, the most of the genotypes displayed a semi-erect growth habit. All the genotypes showed tomentose shoot surface. Further, four distinct leaf shapes were documented. Ovate leaf shape was exhibited by 15 genotypes, while 8 genotypes displayed oval and 6 genotypes showed cordate and obovate type leaf each. The maximum leaf blade length (10.63 cm) and width (7.31 cm) was recorded in Thar Sevika, while, the minimum size of leaf blade length was noticed in Sanori (6.95 cm) and width was found in Katha Bombay (3.86 cm). In response to branch thorniness, the less branch thorniness was found in Illaichi, Naki, Umran and Kaithali, while two genotypes revealed high branch thorniness (Tasbtso, Narkali). Only two types of thorn shape were noticed, as out of 35 genotypes, 21 had alternate curved thorn. Based on anthocyanin blush of immature fruit, genotypes Kathaphal, Sanori and Narkali had reddish blush on fruit. Further, theses genotypes were categorized into early, mid and late on the basis of fruit maturity. Six genotypes showed early maturing fruits, while 21 genotypes were mid-season and 8 were late maturing genotypes. The bunch bearing of fruit was noticed only in two genotypes (Jhajjar Selection and BS 2). It is worth highlighting that all these genotypes under study exhibited substantial variability across various morphological traits, which can potentially be attributed to genetic disparities stemming from the diverse ancestral species from which these cultivated genotypes originated.

Keywords: Ber, DUS, Genotypes, *Ziziphus mauritiana*

Indian jujube or ber (*Ziziphus mauritiana* Lamk.), commonly referred to as a time-honoured and native fruit indigenous to India, classified within the Rhamnaceae family having chromosome no. 2n=48 (Srinivasan 1952). In India, the ber crop is cultivated in 53000 ha area, yielding a production of 570 thousand tonnes (Anonymous 2022). The ber is known for remarkable resilience to drought conditions, thriving in arid regions as well as degraded, eroded, gravelly, saline and sodic wastelands. The Indian jujube tree assumes significant commercial value due to the multifaceted utility of virtually all its constituent parts. Berries from this tree surpass apples in their protein content, phosphorus, calcium, carotene, and vitamin C (Azam-Ali *et al*. 2006 and Krishna *et al*. 2014) and outstrip oranges in phosphorus, iron, vitamin C and carbohydrate content. Additionally, it stands as a notable source of antioxidants (Krishna and Parashar 2013).

The *Ziziphus* genus encompasses 135–170 species, as noted by Islam and Simmons (2006). Among these species, 17 are indigenous to India (Watt 1883, Bailey 1947 and Singh *et al*. 2000). Furthermore, there are more than 180 named cultivars of ber documented in literature (Bal 1992 and Reddy *et al*. 1995). Due to cross-pollination nature of ber, the cultivation of this crop has resulted in a diverse population of seedlings, leading to the accumulation of a valuable gene pool. Most of the genotypes presently cultivated as commercial, evolved through a process of selective breeding. In this context, seedlings occurring in the wild were chosen by agriculturalists based on their economically advantageous traits and subsequently propagated vegetatively to preserve their genetic identity. Predominant efforts in ber breeding have concentrated on clonal selection to foster early maturing clones. The

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Table 1 Characterization of ber genotypes based on DUS descriptor

Genotype	Growth habit	Shoot surface	Leaf apex	Leaf base	Leaf shape	Leaf curving	Leaf pubescence on lower surface	Branch thorniness	Thorn shape	Thorns persistence: Caducous	Fruit maturity group	Bearing habit: Bunching	Immature fruit: Anthocyanin blush	Fruit cracking
Dandan	5	5	3	2	1	9	1	5	5	9	3	1	1	1
Gola	3	5	3	2	1	9	5	5	5	9	3	1	1	9
Govindgarh Sel. 3	3	5	3	1	1	1	1	5	5	1	5	1	1	1
Kathaphal	3	5	3	2	3	9	5	5	3	1	7	1	9	1
Katha Rajasthan	5	5	5	2	5	9	3	5	5	1	7	1	1	1
Katha Bombay	1	5	3	4	1	9	3	5	5	1	7	1	1	1
Katha Gurgaon	5	5	3	1	1	9	1	5	5	1	7	1	1	1
Gola GGN	5	5	3	2	5	9	1	5	5	1	3	1	1	1
Jhajjar Selection	3	5	5	4	5	9	3	5	3	1	5	9	1	1
Seo	3	5	3	2	5	1	5	5	5	9	5	1	1	1
Illaichi	3	5	3	4	3	9	3	3	3	1	5	1	1	1
Jhajjar Special	3	5	3	1	1	9	1	5	3	1	5	1	1	1
Hsaianaul	5	5	3	2	1	9	1	5	5	9	5	1	1	1
Bhadurgarhia	3	5	3	4	1	9	1	5	3	1	5	1	1	1
Sanori	3	5	3	1	1	1	3	5	5	9	7	1	9	1
Safeda Rohtak	5	5	3	1	1	1	5	5	5	1	7	1	1	1
Safeda Selection	3	5	3	1	1	9	5	5	5	1	5	1	1	1
Tasbtso	1	5	3	1	1	1	1	7	5	1	5	1	1	1
Thornless	1	5	3	1	7	9	1	5	5	1	5	1	1	1
Bawal Selection (BS 1)	3	5	5	2	3	9	1	5	3	1	5	1	1	1
Bawal Selection (BS 2)	3	5	5	2	3	9	3	5	3	9	5	9	1	1
Narkali	5	5	3	2	1	9	1	7	5	1	5	1	9	1
Narua	1	5	3	4	5	9	3	5	3	1	5	1	1	1
Naki	3	5	3	4	5	9	3	3	5	1	5	1	1	1
Lakhan	3	5	5	2	3	1	3	5	3	1	7	1	1	1
Vilati	3	5	3	4	7	9	1	5	3	1	5	1	1	1
S. Narnaul	3	5	5	4	7	1	1	5	3	9	5	1	1	1
Umran	3	5	5	2	3	9	3	3	3	1	7	1	1	1
Kaithali	3	5	5	4	3	9	5	3	5	1	5	1	1	1
Chuharra	3	5	5	2	3	9	5	5	5	1	5	1	1	1
Goma Kirti	1	5	5	1	7	9	1	5	5	9	3	1	1	1
Thar sevika	3	5	5	4	7	9	1	5	5	9	3	1	1	1
Thar Bhubharaj	3	5	5	3	7	9	1	5	5	9	3	1	1	1
Narendra Ber Sel. 1	5	5	3	3	1	9	1	5	3	9	5	1	1	9
Narendra Ber Sel. 2	3	5	5	3	1	9	1	5	3	9	5	1	1	1

majority of the commonly grown cultivars have emerged as outcomes of selection practices in various regions. In India, a broad spectrum of variability exists among ber genotypes with respect to essential traits, suggesting considerable potential for improvement. However, it is noteworthy that the morphological descriptions of many cultivars remain indistinct. Henceforth, this current study was initiated with the aim of characterizing 35 distinct ber genotypes by evaluating their morphological attributes and to affirm the uniqueness of the candidate variety in comparison to all other ber genotypes accessible within India.

MATERIALS AND METHODS

The study was carried out during 2020–21 and 2022–23 at Regional Research Station (CCS Haryana Agricultural University, Hisar, Haryana), Bawal, Haryana, which has typical semi-arid climate distinguished by scorching, dry summers and cold winters. The experiment was laid out randomized block design (RBD) with three replications examining 35 ber genotypes (viz. Dandan, Gola, Govindgarh Sel. 3, Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Jhajjar Selection, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, Bawal Selection 1 (BS 1), Bawal Selection 2 (BS 2), Narkali, Narua, Naki, Lakhan, Vilati, S Narnaul, Umran, Kaithali, Chuharra, Goma Kirti, Thar sevika, Thar Bhubharaj, Narendra Ber Sel. 1, Narendra Ber Sel. 2. The study was comprised of 16 different characters, which were noticed at specified stage of crop growth when a particular character showed its full expression as per Distinctiveness, Uniformity and Stability (DUS) guidelines (Anonymous 2013). The observations related to growth parameter, shoot surface, thorn and leaf characteristics were documented at the three-month mark following pruning, coinciding with the establishment of the distinctive canopy structure unique to each genotype. The observation of leaf parameters involved the selection of fully mature leaves located at the central regions of tertiary branches, characterized by the absence of visible signs of active growth. Likewise, thorn-related observations were noticed at the midpoints of tertiary branches. Furthermore, observation on immature fruit were recorded when the fruit had not yet achieved its maximum size, displayed predominantly green coloration and possessed a notably firm texture. The leaf length and leaf width were measured with scale in centimetre from the fully mature leaves.

Statistical analysis: The composed data were subjected to statistical analysis with OP Stat software (http://14.139.232.166/opstat/index.asp), CCS Haryana Agricultural University, Hisar, Haryana (Sheoran *et al*. 1998).

RESULTS AND DISCUSSION

The significant variations were documented among 35 ber genotypes with regard to various morphological traits. The primary attributes of the diverse ber genotypes examined

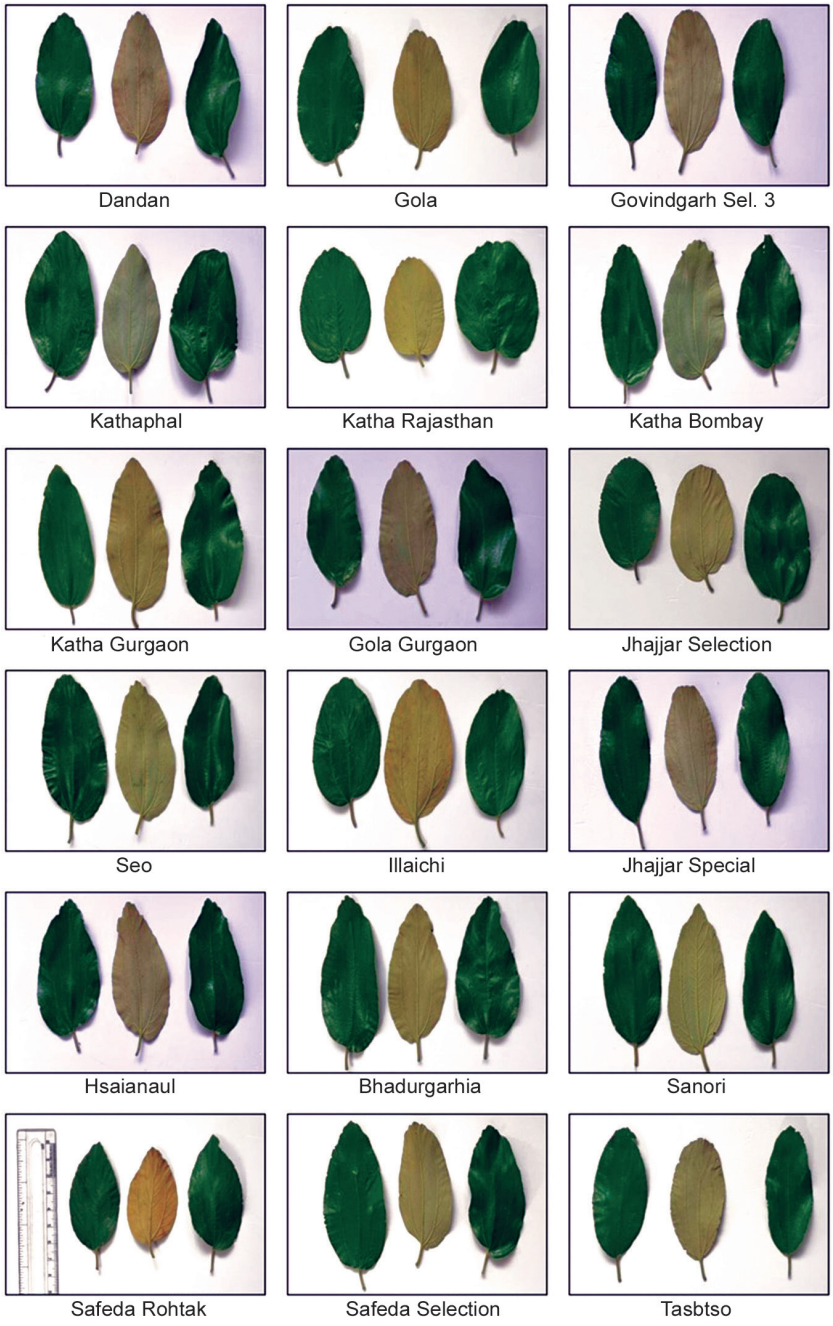

Fig. 1 Mature leaf of different ber genotypes evaluated under semi-arid condition of Haryana. (*Contd.*)

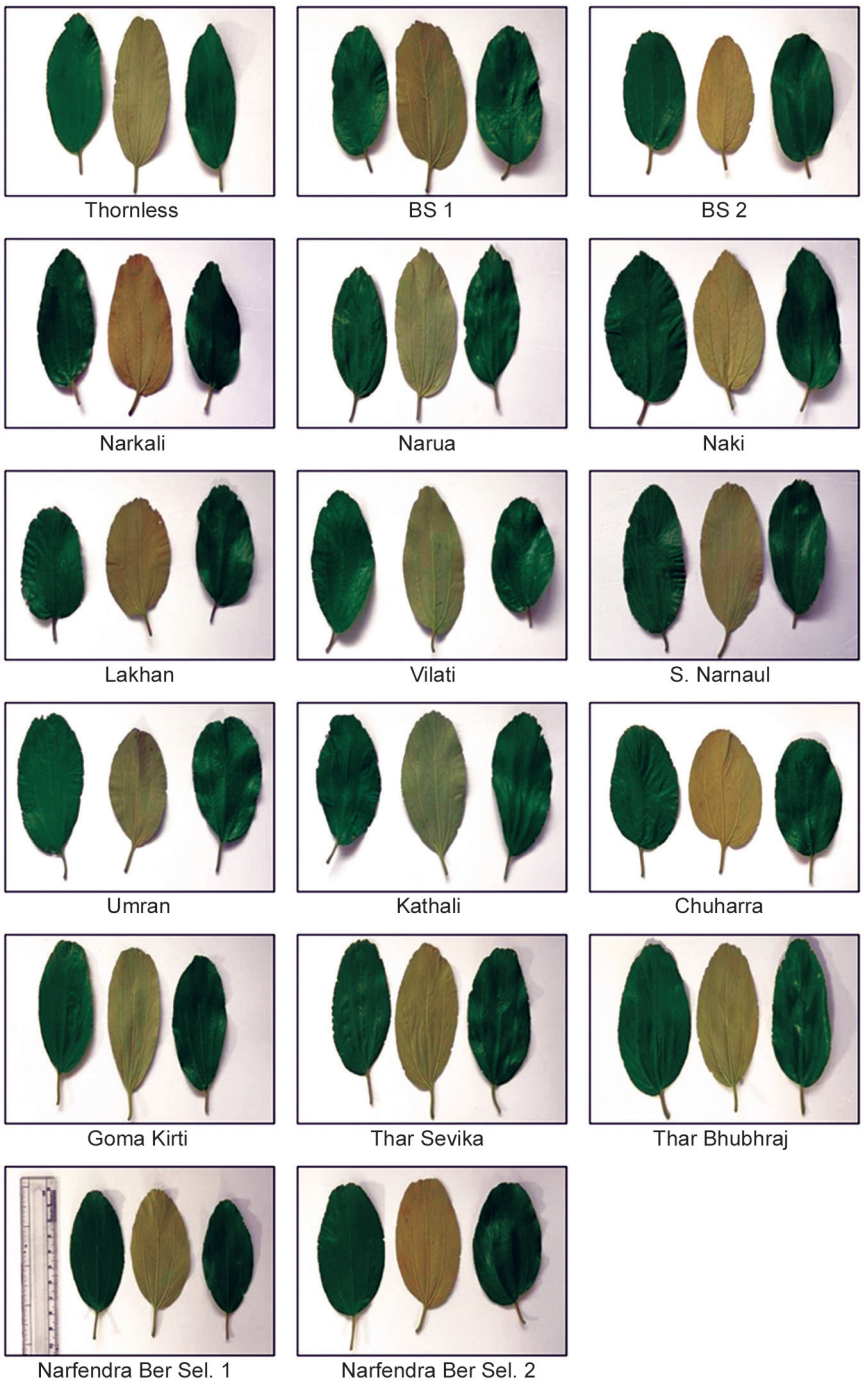

Fig. 1 (*Concluded*)

are summarized in Table 1. The frequency distribution of each specific trait, along with illustrative genotype examples, is provided in Table 2. The genotypes displayed substantial variability concerning growth habit, thorn shape, leaf characteristics and leaf surface attributes. Likewise, Krishna *et al*. (2016) documented significant variability in 24 ber varieties with regard to morphological traits. The observed diversity in vegetative and leaf attributes can be attributed to the inherent genetic characteristics of the genotypes.

Growth habit: The outcomes of present study indicate that an upright growth habit was observed in five genotypes, namely, Katha Bombay, Tasbtso, Thornless, Narua and Goma Kirti, while the semi-erect growth habit was noticed in 22 genotypes. Eight genotypes showed spreading growth habit. In general cultivation for commercial purposes, a semi-spreading growth habit is the favoured trait. This preference was attributed to the fact that commercial ber cultivars predominantly originate from selective breeding, resulting in the prevalence of semi-spreading growth habits among the most widely adopted varieties.

Shoot surface: The branching pattern, which decisively influences the growth habit of ber, stands as one of the most suitable vegetative characteristics for classification, as discussed in prior studies (Bal 1992, Azam-Ali *et al*. 2006). All genotypes had tomentose shoot surface.

The considerable variation for various leaf parameters are represented in Fig. 1.

Leaf apex: There were two groups of genotypes based on leaf apex such as acute and obtuse. In the former group, 22 genotypes, while in later thirteen genotypes fell.

Leaf base: In the present study, four types of leaf bases namely acute, cordate, round and oblique were noticed. Nine genotypes exhibited acute leaf base, whereas, 13 genotypes showed cordate. Round and oblique leaf base was noticed in three and ten genotypes, respectively.

Leaf shape: Substantial variation was observed for shape of leaf. Four types of leaf shapes were recorded in ber. Fifteen genotypes, (viz. Dandan, Gola, Govindgarh Sel. 3, Katha Bombay, Katha Gurgaon, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Narkali, Narendra Ber Sel. 1, Narendra Ber Sel. 2) had ovate leaf shape, while eight genotypes, (viz. Kathaphal, Illaichi, BS 1, BS 2, Lakhan, Umran, Kaithali, Chuharra) had oval shape. The cordate leaf shape was found in six genotypes, i.e. Katha Rajasthan, Gola GGN, Jhajjar Selection, Seo, Narua, Naki, while, rest of the genotypes showed obovate leaf shape.

Leaf curving: Among all genotypes, seven genotypes revealed that leaf had no curving whereas, leaf curving was present in 28 genotypes.

Leaf pubescence on lower surface: Ber genotypes could also be categorized based on pubescence on lower surface. These were smooth, sparsely-tomentose and

Table 2 Frequency distribution of different attributes of 35 ber genotypes

Character	Expression and notes	No. of genotypes	Genotypes
Growth habit	Erect (1)	5	Katha Bombay, Tasbtso, Thornless, Narua, Goma Kirti
	Semi-erect (3)	22	Gola, Govindgarh Sel. 3, Kathaphal, Jhajjar Selection, Seo, Illaichi, Jhajjar Special, Bhadurgarhia, Sanori, Safeda Selection, BS 1, BS 2, Naki, Lakhan, Vilati, S. Narnaul, Umran, Kaithali, Chuharra, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 2
	Spreading (5)	8	Dandan, Katha Rajasthan, Katha Gurgaon, Gola GGN, Hsaianaul, Safeda Rohtak, Narkali, Narendra Ber Sel. 1
Shoot surface	Smooth (3)	0	-
	Tomentose (5)	35	All genotypes as mentioned in Table 1
Leaf apex	Acute (3)	22	Dandan, Gola, Govindgarh Sel. 3, Kathaphal, Katha Bombay, Katha Gurgaon, Gola GGN, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, Narkali, Narua, Naki, Vilati, Narendra Ber Sel. 1
	Obtuse (5)	13	Katha Rajasthan, Jhajjar Selection, BS 1, BS 2, Lakhan, S. Narnaul, Umran, Kaithali, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 2
Leaf base	Acute (1)	9	Govindgarh Sel. 3, Katha Gurgaon, Jhajjar Special, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, Goma Kirti
	Cordate (2)	13	Dandan, Gola, Kathaphal, Katha Rajasthan, Gola GGN, Seo, Hsaianaul, BS 1, BS 2, Narkali, Lakhan, Umran, Chuharra,
	Round (3)	3	Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Oblique (4)	10	Katha Bombay, Jhajjar Selection, Illaichi, Bhadurgarhia, Narua, Naki, Vilati, S. Narnaul, Kaithali, Thar Sevika
Leaf shape	Ovate (1)	15	Dandan, Gola, Govindgarh Sel. 3, Katha Bombay, Katha Gurgaon, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Narkali, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Oval (3)	8	Kathaphal, Illaichi, BS 1, BS 2, Lakhan, Umran, Kaithali, Chuharra
	Cordate (5)	6	Katha Rajasthan, Gola GGN, Jhajjar Selection, Seo, Narua, Naki,
	Obovate (7)	6	S. Narnaul, Thornless, Vilati, Goma Kirti, Thar Sevika, Thar Bhubhraj
Leaf curving	Absent (1)	7	Govindgarh Sel. 3, Seo, Sanori, Safeda Rohtak, Tasbtso, Lakhan, S. Narnaul
	Present (9)	28	Dandan, Gola, Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Jhajjar Selection, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Safeda Selection, Thornless, BS 1, BS 2, Narkali, Narua, Naki, Vilati, Umran, Kaithali, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
Leaf pubescence on lower surface	Smooth (1)	18	Dandan, Govindgarh Sel. 3, Katha Gurgaon, Gola GGN, Jhajjar Special, Hsaianaul, Bhadurgarhia, Tasbtso, Thornless, BS 1, Narkali, Vilati, S. Narnaul, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Sparsely tomentose (3)	10	Katha Rajasthan, Katha Bombay, Jhajjar Selection, Illaichi, Sanori, , BS 2, Narua, Naki, Lakhan, Umran
	Densely tomentose (5)	7	Gola, Kathaphal, Seo, Safeda Rohtak, Safeda Selection, Kaithali, Chuharra
Branch thorniness	Less (3)	4	Illaichi, Naki, Umran, Kaithali
	Medium (5)	29	Dandan, Gola, Govindgarh Sel. 3, Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Jhajjar Selection, Seo, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Thornless, BS 1, BS 2, Narua, Lakhan, Vilati, S. Narnaul, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	High (7)	2	Tasbtso, Narkali
Thorn shape	All Curved (3)	14	Kathaphal, Jhajjar Selection, Illaichi, Jhajjar Special, Bhadurgarhia, BS 1, BS 2, Narua, Lakhan, Vilati, S. Narnaul, Umran, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Alternate Curved (5)	21	Dandan, Gola, Govindgarh Sel. 3, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Seo, Hsaianaul, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, Narkali, Naki, Kaithali, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj

Contd.

Table 2 (*Concluded*)

Character	Expression and notes	No. of genotypes	Genotypes
Thorns persistence: Caducous	Non-Persistent (Absent) (1)	23	Govindgarh Sel. 3, Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Jhajjar Selection, Illaichi, Jhajjar Special, Bhadurgarhia, , Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, BS 1, Narkali, Narua, Naki, Lakhan, Vilati, Umran, Kaithali, Chuharra
	Persistent (Present) (9)	12	Dandan, Gola, Seo, Hsaianaul, Sanori, BS 2, S. Narnaul, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
Immature fruit: Anthocyanin blush	Absent (1)	32	Dandan, Gola, Govindgarh Sel. 3, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Jhajjar Selection, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, BS 1, BS 2, Narua, Naki, Lakhan, Vilati, S. Narnaul, Umran, Kaithali, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Present (9)	3	Kathaphal, Sanori, Narkali
Fruit maturity group	Early (3)	6	Dandan, Gola, Gola GGN, Goma Kirti, Thar Sevika, Thar Bhubhraj
	Mid (5)	21	Govindgarh Sel. 3, Jhajjar Selection, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Safeda Selection, Tasbtso, Thornless, BS 1, BS 2, Narkali, Narua, Naki, Vilati, S. Narnaul, Kaithali, Chuharra, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Late (7)	8	Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Sanori, Safeda Rohtak, Lakhan, Umran
Bearing habit: Bunching	Absent (1)	33	Dandan, Gola, Govindgarh Sel. 3, Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, BS 1, Narkali, Narua, Naki, Lakhan, Vilati, S. Narnaul, Umran, Kaithali, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 1, Narendra Ber Sel. 2
	Present (9)	2	Jhajjar Selection, BS 2
Fruit cracking (Absent or Present)	Absent (1)	33	Dandan, Govindgarh Sel. 3, Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Gola GGN, Jhajjar Selection, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Sanori, Safeda Rohtak, Safeda Selection, Tasbtso, Thornless, BS 1, BS 2, Narkali, Narua, Naki, Lakhan, Vilati, S. Narnaul, Umran, Kaithali, Chuharra, Goma Kirti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel. 2
	Present (9)	2	Gola, Narendra Ber Sel. 1

densely-tomentose. Out of 35, 18 genotypes exhibited smooth surface on lower side of leaf, while 10 genotypes exhibited sparsely-tomentose on lower surface and rest of all genotypes (*i.e.,* Gola, Kathaphal, Seo, Safeda Rohtak, Safeda Selection, Kaithali, Chuharra) exhibited densely-tomentose on lower surface.

Branch thorniness: Among 35 ber genotypes, only Tasbtso and Narkali recorded high branch thorniness. The less thorn on branches was found in four genotypes (i.e. Illaichi, Naki, Umran, Kaithali) while, remaining genotypes showed medium branch thorniness.

Thorn shape: There were only two types (Fig. 2) of thorn shape, viz. all curved and alternate curved. Total of 14 genotypes (Kathaphal, Jhajjar Selection, Illaichi, Jhajjar Special, Bhadurgarhia, BS 1, BS 2, Narua, Lakhan, Vilati, S. Narnaul, Umran, Narendra Ber Sel. 1, Narendra Ber Sel. 2) were all curved and remaining twenty-one genotypes had alternate curved.

Thorn persistence: Caducous: Data for thorn persistence: caducous characteristic revealed that it was absent in 23 genotypes and present in twelve genotypes.

Anthocyanin blush on immature fruit: On the basis of anthocyanin blush on immature fruit, genotypes Kathaphal, Sanori and Narkali had reddish blush on fruit, while other 32 genotypes had anthocyanin no blush on developing fruits.

Fruit maturity: These genotypes were categorized into early, mid and late on the basis of fruit maturity. Six genotypes (Dandan, Gola, Gola GGN, Goma Kirti, Thar Sevika, Thar Bhubhraj) were early, while 21 genotypes (viz. Govindgarh Sel. 3, Jhajjar Selection, Seo, Illaichi, Jhajjar Special, Hsaianaul, Bhadurgarhia, Safeda Selection, Tasbtso, Thornless, BS 1, BS 2, Narkali, Narua, Naki, Vilati, S. Narnaul, Kaithali, Chuharra, Narendra Ber Sel. 1, Narendra Ber Sel. 2) were mid-season and eight (Kathaphal, Katha Rajasthan, Katha Bombay, Katha Gurgaon, Sanori, Safeda Rohtak, Lakhan, Umran) were late maturing genotypes.

Bunch bearing: The bunch bearing of fruit was noticed only in two genotypes namely Jhajjar Selection and BS 2 fruits, while absent in rest of the genotypes.

Fruit cracking: Among all studied genotypes, only Gola and Narendra Ber Sel. 1 genotypes showed fruit cracking.

Leaf blade length and width: The maximum leaf blade length (10.63 cm) was recorded in Thar Sevika, which was followed by Umran (10.22 cm) and Narua (10.09 cm) and

Table 3 Mature leaf parameter of different ber genotypes

Genotypes	Leaf blade length (cm)			Leaf blade width (cm)		
	Mean 2020–21	Mean 2022–23	Pooled Mean	Mean 2020–21	Mean 2022–23	Pooled mean
Dandan	9.10	9.45	9.28	4.80	5.12	4.96
Gola	9.20	10.26	9.73	6.10	5.84	5.97
Govindgarh Sel. 3	6.40	8.00	7.20	4.20	5.63	4.92
Kathaphal	8.40	9.56	8.98	5.70	6.02	5.86
Katha Rajasthan	7.40	9.12	8.26	5.70	4.71	5.21
Katha Bombay	7.50	8.98	8.24	3.60	4.12	3.86
Katha Gurgaon	9.00	11.08	10.04	5.50	4.96	5.23
Gola GGN	9.20	8.40	8.80	6.40	5.96	6.18
Jhajjar Selection	8.50	7.51	8.01	5.67	5.42	5.55
Seo	8.40	7.98	8.19	5.30	4.87	5.09
Illaichi	8.40	9.02	8.71	6.10	5.31	5.71
Jhajjar Special	9.20	8.45	8.83	6.10	6.76	6.43
Hsaianaul	10.20	9.65	9.93	6.00	6.51	6.26
Bhadurgarhia	9.00	10.65	9.83	5.20	4.58	4.89
Sanori	7.10	6.79	6.95	4.20	4.91	4.56
Safeda Rohtak	7.50	9.58	8.54	5.40	5.74	5.57
Safeda Selection	8.80	7.87	8.34	5.30	5.86	5.58
Tasbtso	7.60	8.69	8.15	3.90	4.68	4.29
Thornless	8.40	9.32	8.86	4.40	4.86	4.63
Bawal Selection (BS 1)	8.80	9.32	9.06	5.50	4.89	5.20
Bawal Selection (BS 2)	8.40	9.86	9.13	5.90	5.63	5.77
Narkali	7.50	8.61	8.06	4.80	5.18	4.99
Narua	9.40	10.78	10.09	5.50	6.14	5.82
Naki	8.60	9.45	9.03	6.60	6.31	6.46
Lakhan	8.80	7.96	8.38	6.00	5.69	5.85
Vilati	7.70	8.67	8.19	4.70	5.26	4.98
S Narnaul	8.90	7.15	8.03	5.40	5.01	5.21
Umran	9.20	11.23	10.22	7.10	6.72	6.91
Kaithali	9.40	8.84	9.12	5.40	4.84	5.12
Chuharra	8.20	10.21	9.21	6.60	6.14	6.37
Goma Kirti	8.90	7.98	8.44	5.30	4.82	5.06
Thar sevika	10.00	11.26	10.63	7.40	7.21	7.31
Thar Bhubharaj	9.25	8.54	8.90	7.05	6.65	6.85
Narendra Ber Sel. 1	7.60	8.09	7.85	4.80	5.20	5.00
Narendra Ber Sel. 2	9.20	9.78	9.49	6.20	5.49	5.85

the maximum leaf blade width (7.31 cm) was recorded in Thar Sevika, followed by 6.91 cm in Umran and 6.85 cm in Thar Bhubhraj, while the minimum size of leaf blade length was noticed in Sanori (6.95 cm) and leaf blade width was found in Katha Bombay (3.86 cm) (Table 3).

In summary, this investigation has unveiled a broad spectrum of variations within jujube genotypes, encompassing distinct leaf and fruit morphological characteristics, which exhibit genotype specificity. These characteristics, such as leaf area in conjunction with petiole length are not only subject to potential alterations stemming from variations in cultural practices, climatic conditions and various biotic and abiotic factors but also serve as dependable parameters for the identification of jujube cultivars. The outcomes of this study affirm the existence of variations consistent with earlier research conducted by Bisla *et al*. (1988), Pareek (2001), Nanthakumar and Shanmugavelu (2021). So, diverse array of jujube germplasm, which can be further manipulated for gene pool conservation and the enhancement of genotypes

Fig. 2 Stone shape of different ber genotypes evaluated under semi-arid condition of Haryana.

for the benefit of future generations. The examination of DUS characters serves aiding in the assessment of genetic resources and the identification of varieties, facilitating the registration of varieties and compliance with the Plant Variety Protection (PVP) Act, contributing to the varietal information system and the categorization of varieties into distinct groups and establishing a database for plant-related information (Singh *et al*. 2005). The delineation of these characteristics facilitates the accessibility of crop diversity for users of plant genetic resources, ultimately contributing to their economic and social value (Bioversity International 2007).

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