



Morphological characterization of *ber* germplasm

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ABSTRACT

The twelve accessions of germplasm of *ber*, maintained in the field gene bank of Regional Station of ICAR-National Bureau of Plant Genetic Resources at Jodhpur were characterized and compared on the basis of morphological and fruits characters *viz.*, growth habit, foliage, thorn, fruits and presence or absence of stone in the fruits for the four subsequent years (2013-14 to 2016-17). A landrace collected from Maharashtra state was recorded with a unique trait *i.e.*, the stone part of the fruit was merely absent and small, soft and shriveled edible seeds were present, thus this landrace is named as stoneless *ber*, whereas, in all other land races and cultivars the large sized stone is present. It is observed that 97-99 % part of the fruit of the stoneless *ber* is made up of edible fleshy pulp. While in other landraces of *ber* only 10 to 40 % part of the fruit was made up of edible pulp and rest of the part (60-90 %) of the fruit is made up of stone that is inedible. The germplasm revealed wide range of diversity for different morphological characters as they have been collected from different parts of the country.

Key words: *Ziziphus mauritiana*, stoneless *ber*, land races, variability.

INTRODUCTION

Indian jujube (*Ziziphus mauritiana* L.) commonly known as *ber*, belongs to the family *Rhamnaceae*, is mainly distributed in the tropic zone of southern Asia, Australia, and Africa including Taiwan and China (Pasternak *et al.*, 12). Due to a high degree of climatic adaptability, it is an important multipurpose fruit tree of arid and semi-arid regions and plays a major role in preventing soil erosion and desertification (Pareek, 11). *Z. mauritiana* is tolerant to drought, flood, salinity and withering (Grice, 6). *Ber* provides food (fruit), fodder, and fuel for desert dwellers as it bears nutritious fruits, excellent as agro forestry species, makes good fodder and has good medicinal properties. One idealist describes this species as "a gift of mother nature which symbolizes the productive capacity of the seemingly infertile ecosystem". *Ber* tree is used for fencing, hedges, and wind breaks. Leaves are readily eaten by camels, cattle, sheep and goats. The Indian jujube is one of the hosts for the lac insect *Kerria Lacca* and the leaves are also used to feed tasar silkworms. It is well known for its nutritional and medicinal properties. *Ber* fruits are rich source of protein, phosphorus, calcium, carotene, vitamin C than apple (Krishna *et al.*, 8) and phosphorus, iron, vitamin C and carbohydrates than oranges (Krishna and Parashar, 7). The fruits are used as sedative, flavonoids, anti-cancer, tonic, wound healer and against asthma (Ashraf *et al.*, 3). Hence, Indian jujube is also known desert apple or Indian plum or

poor man's apple, and popularly called as the king of arid zone fruits (Shoba and Bharathi, 15). These miracle characters of Indian jujube are making this fruit as "*Famine Reserve Fruits*". The extract from fruits, leaves and seeds have been reported to exhibit antioxidant activity (Okala *et al.*, 10; Dahiru and Obidoa, 5). Sadeghi (13) demonstrated antibacterial activity and synthesis of gold nanoparticles from extracts of *Z. mauritiana*.

But as the time passed, the *ber* fruit lost its importance and *ber* fruits are replaced by expensive fruits like apple, grapes, strawberries *etc.* and remained underutilized due to lack of awareness and popularization of technologies for utilization and largely due to too little attention given to it by the world scientific community. Hence, *ber* is commonly known as orphan or neglected or underutilized fruit crop. Thus, there is an urgent need to give attention to *ber* improvement by augmenting, characterizing, evaluating germplasm and utilizing it in breeding programmes for the enhancement of productivity and development of better fruit quality.

The characterization and evaluation of *Z. mauritiana* germplasm are primarily based on morpho-physiological traits. Researchers use morphological descriptors, *i.e.*, growth habit, leaf, shoot, flower and fruit morphology to classify and discriminate different varieties of *Z. mauritiana* (Vashishtha, 16 and Saran *et al.*, 14). The choice of suitable cultivars is of paramount importance for its success. Thus there is need for improvement of *Z. mauritiana* for its fruit quality under different agro-ecological environments.

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Hence the objectives of this study were to estimate morphological characters of the collected germplasm and identification of unique character that can be used for the improvement of *ber* quality and to establish distinctness of the available accessions at field gene bank using National Test Guidelines (Anonymous, 2).

MATERIALS AND METHODS

The morphological data were recorded on the three shrubs of 12 different accessions of *ber* viz., Gola, Gola (Kakwan), Gola (Delhi), Umran, Aliganj, Illaichi, Seb (Hard), Seb (Soft), Pemily, Mundia, Stoneless *ber* (only two shrub are available) and Tikadi (only two shrubs are available) of available germplasm in the field gene bank at the Regional Station of National Bureau of Plant genetic Resources at Jodhpur. The germplasm were evaluated for 20 characters at specified stage of crop growth

when character had full expression. To establish distinctiveness among cultivars, the descriptor of essential characters (Table 1) were used in sequential manner as per the National Test Guideline for the conduct of test for distinctiveness, uniformity and stability on *ber* (Anonymous, 2). Accordingly, observations were recorded on 10 leaves of each replication (with three replications) and ten fruits from each replication (with three replications) in each case for four years *i.e.*, year 2013-14 to 2016-17. Observations on growth habit, shoot surface, thorn and leaf characters were recorded four months after pruning, when canopy attained its characteristic shape specific to a variety. Fully developed leaves which were not showing the sign of active growth, in the middle of tertiary branches were selected for the observations. Similarly, observations on thorns were recorded in the middle of tertiary branches. Observation on immature fruits were recorded

Table 1. Character wise grouping of accessions of *ber* germplasm following national descriptors of *ber*.

	Plant descriptor	Range in expression	No. of germplasm	Germplasm
1.	Plant growth habit	1. Erect	1	Tikadi
		3. Semi-erect	9	Stoneless, Seb (Hard), Umran, Gola, Gola (Kakwan), Gola (Delhi), Illaichi, Seb (Soft), Mundia,
		5. Spreading	2	Aliganj, Pemily
2.	Shoot surface	3. Smooth	2	Tikadi, Pemily
		5. Tomentose	10	Stoneless, Gola, Gola (Kakwan), Gola (Delhi), Illaichi, Mundia, Umran, Aliganj, Seb (Hard), Seb (Soft)
3.	Thorn Shape	3. All curved	1	Pemily
		5. Alternate curved	11	Stoneless, Gola, Gola (Delhi), Illaichi, Umran, Tikadi, Mundia, Aliganj, Gola (Kakwan), Seb (Hard), Seb (Soft)
4.	Leaf: Apex	3. Acute	3	Stoneless, Tikadi, Aliganj
		5. Obtuse	9	Gola (Kakwan), Gola, Illaichi, Pemily, Mundia, Seb (Hard), Gola (Delhi), Umran, Seb (Soft)
5.	Leaf: Base	1. Acute	2	Stoneless, Gola (Delhi)
		2. Cordate	6	Gola, Gola (Kakwan), Tikadi, Umran, Seb (Hard), Seb (Soft)
		3. Round	2	Mundia, Aliganj
		4. Oblique	2	Illaichi, Pemily
6.	Leaf: Shape	1. Ovate	2	Stoneless, Aliganj
		2. Oval	5	Umran, Mundia, Illaichi, Gola, Gola (Kakwan), Gola (Delhi) Tikadi, Seb (Hard), Seb (Soft)
		3. Cordate	3	Pemily
		4. Obovate	1	
7.	Leaf: Curving	1. Absent	7	Stoneless, Gola (Delhi), Gola (Kakwan), Tikadi, Pemily, Seb (Hard), Seb (Soft)
		9. Present	5	Gola, Illaichi, Aliganj, Umran, Mundia,
8.	Leaf: Pubescence on lower surface	1. Smooth	2	Stoneless, Tikadi
		3. Sparsely tomentose	6	Pemily, Umran, Gola (Kakwan), Illaichi, Aliganj, Gola (Delhi)
		5. Densely tomentose	4	Gola, Mundia, Seb (Hard), Seb (Soft)

Morphological Characterization of Ber Germplasm

Plant descriptor	Range in expression	No. of germplasm	Germplasm
9. Leaf: Blade length (cm)	3. Short (<7)	10	Illaichi, Gola (Delhi), Gola (Kakwan), Stoneless, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily, Tikadi
	5. Medium (7-9)	2	Gola, Aliganj
	7. Long (>9)	0	-
10. Leaf: Blade width (cm)	3. Narrow (<6)	12	Aliganj, Illaichi, Gola (Delhi), Gola (Kakwan), Gola, Stoneless, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily, Tikadi
	5. Medium (6-7)	0	-
	7. Broad (>7)	0	-
11. Fruit shape: Apex	1. Flat	1	Illaichi
	3. Round	10	Aliganj, Gola (Delhi), Gola (Kakwan), Gola, Stoneless, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily
	5. Pointed	1	Tikadi
12. Mature fruit shape	1. Oblong	1	Umran
	2. Oval	2	Mundia, Pemily
	3. Ovate	2	Tikadi, Aliganj
	4. Oblate	1	Illaichi
	5. Round	6	Gola (Delhi), Gola (Kakwan), Gola, Stoneless, Seb (Hard), Seb (Soft)
	6. Falcate	0	-
13. Mature fruit length (mm)	3. Short (<20)	3	Stoneless, Tikadi, Illaichi
	5. Medium (20-30)	5	Gola, Gola (Kakwan), Gola (Delhi), Seb (Soft), Aliganj
	7. Long (>30)	4	Pemily, Seb (Hard), Mundia, Umran
14. Mature fruit width (mm)	3. Narrow (<15)	1	Tikadi
	5. Medium (15-25)	7	Stoneless, Illaichi, Gola, Gola (Delhi), Seb (Soft), Aliganj, Mundia
	7. Broad (>25)	4	Gola (Kakwan), Pemily, Seb (Hard), Umran
15. Mature fruit color	3. Yellow	6	Stoneless, Gola, Gola (Kakwan), Gola (Delhi), Umran, Illaichi
	5. Green yellow	3	Mundia, Seb (Soft), Seb (Hard)
	7. Chocolate brown	3	Tikadi, Pemily, Aliganj
16. Mature fruit weight (g)	1. Very low (<5)	3	Stoneless, Tikadi, Illaichi
	3. Low (5-10)	6	Gola, Gola (Delhi), Gola (Kakwan), Seb (Soft), Aliganj, Mundia
	5. Medium (11-20)	3	Seb (Hard), Pemily, Umran
	7. High (21-30)	0	-
	9. Very high (>30)	0	-
17. Pulp cavity	1. Absent	2	Stoneless, Tikadi
	9. Present	10	Aliganj, Illaichi, Gola (Delhi), Gola (Kakwan), Gola, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily
18. Pulp cavity: Styler end	1. Absent	12	Aliganj, Illaichi, Gola (Delhi), Gola (Kakwan), Gola, Stoneless, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily, Tikadi
	9. Present	0	-
19. Pulp cavity: Stem end	1. Absent	2	Tikadi, Stoneless
	9. Present	10	Aliganj, Illaichi, Gola (Delhi), Gola (Kakwan), Gola, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily
20. Pulp stone ratio	1. Very low (<5)	1	Tikadi
	3. Low (5-10)	2	Mundia, Illaichi
	5. Medium (11-15)	6	Gola, Gola (Delhi), Gola (Kakwan) Aliganj, Umran, Pemily
	7. High (16-20)	2	Seb (Hard), Seb (Soft)
	9. Very high (>20)	1	Stoneless

when fruits have not attained its full size and were predominantly green and quite hard in texture *i.e.*, 60-70 days after fruit set. On the other hand observation on the ripen fruits and stones were recorded when fruits had attained its full size and were ready for harvesting. All colour characteristics were assessed using the Royal Horticultural Society (RHS) colour chart.

RESULTS AND DISCUSSION

The twelve accessions of *ber* germplasm were characterized as per the national descriptor for 20 characters at specified stage of crop growth when characters had full expression. The main characteristic features of different *ber* accessions under study are presented in Table 1. It was observed that erect growth habit was present only in Tikadi, whereas Aliganj and Pemily showed spreading growth habit and rest of the 9 accessions *viz.*, Stoneless, Gola, Gola (Kakwan), Gola (Delhi), Illaichi, Seb (Soft), Mundia, Umran and Seb (Hard) had semi-erect type of growth habit. For commercial cultivation of *ber*, semi-erect or spreading growth habit is preferred. Since, commercial *ber* cultivars are the result of selection therefore, most of the common germplasm exhibited semi-spreading or spreading growth habit. Branching habit, which determines the growth habit of *ber*, is one of the most appropriate vegetative characters for classification (Azam-Ali *et al.*, 4). Among the studied accessions the shoot surface was observed to be smooth for Tikadi and Pemily; and tomentose for Stoneless, Seb (Hard) and Seb (Soft), Mundia, Umran, Aliganj, Gola, Gola (Kakwan), Gola (Delhi), Illaichi. All curved thorn shape was recorded in Pemily, while alternate curved thorn shape was present in Stoneless, Gola, Gola (Delhi), Illaichi, Umran, Gola (Kakwan), Seb (Hard), Seb (Soft), Mundia, Aliganj and Tikadi.

Based on leaf apex the twelve accessions were fallen in two groups *viz.*, acute (Stoneless, Tikadi, Aliganj) and obtuse [Gola (Kakwan), Gola (Delhi), Gola, Illaichi, Pemily, Mundia, Seb (Hard), Seb (Soft), Umran]. Substantial variation was observed for foliage characters. Four types of leaf bases were observed *viz.*, acute [Stoneless and Gola (Delhi)], cordate [Gola, Gola (Kakwan), Tikadi, Seb (Hard), Seb (Soft), Umran], round (Mundia and Aliganj) and oblique (Illaichi, Pemily). Four types of leaf shapes were recorded on *ber* tree *viz.*, Pemily had obovate leaf shape; Seb (Soft), Seb (Hard) and Tikadi had cordate leaf shape, while Stoneless and Aliganj had ovate leaf shape and rest of the accessions showed oval leaf shape. Leaf curving was absent in Stoneless, Gola (Delhi), Gola (Kakwan), Tikadi, Pemily, Seb (Hard), Seb (Soft), whereas it was

present in Gola, Illaichi, Aliganj, Umran, Mundia. Based on pubescence on lower surface of leaf, the twelve accessions were characterized into 3 groups *i.e.*, smooth (Stoneless, Tikadi), sparsely-tomentose [Pemily, Umran, Gola (Kakwan), Illaichi, Aliganj, Gola (Delhi)] and densely tomentose [Gola, Seb (Soft), Seb (Hard), Mundia]. Leaf blade length was observed to be short in Illaichi, Gola (Delhi), Gola (Kakwan), Stoneless, Umran, Mundia, Seb (Soft), Seb (Hard), Pemily, Tikadi, and medium in Gola, Aliganj and it was not long in any of the accession. Leaf blade width was narrow in all twelve accessions.

Amongst fruit characters, apex type stylar, stem end cavities and fruit shape are the most dependable characters for classification (Azam-Ali *et al.*, 4). Tikadi exhibited pointed fruit apex shape, whereas, Illaichi had flat fruit apex and rest of the ten accessions showed round fruit apex. Large variability was noticed for mature fruit shape. Umran showed oblong, Mundia and Pemily exhibited oval, Tikadi and Aliganj showed ovate, Illaichi exhibited oblate and Gola (Delhi), Gola (Kakwan), Gola, Stoneless, Seb (Hard), Seb (Soft) showed round fruit shapes. Length of matured fruits was recorded to be short (>20 mm) for Stoneless, Tikadi, Illaichi; medium (20-30 mm) for Gola, Gola (Kakwan), Gola (Delhi), Seb (Soft), Aliganj; and long (>30 mm) for Pemily, Seb (Hard), Mundia and Umran fruits. The highest fruit length was observed in Umran (34.90 cm), whereas fruit length of stoneless fruit was (18.20 cm). Fruit width was narrow (<15 mm) for Tikadi; medium (15-25 mm) for Stoneless, Illaichi, Gola, Gola (Delhi), Seb (Soft), Aliganj, Mundia; and broad (>25 mm) for Gola (Kakwan), Pemily, Seb (Hard) and Umran. Variability in fruit colors at horticultural maturity was observed *i.e.*, Stoneless, Gola, Gola (Kakwan), Gola (Delhi), Umran, Illaichi had yellow; Mundia, Seb (Soft), Seb (Hard) exhibited green yellow and Tikadi, Pemily, Aliganj showed chocolate brown matured fruit colours. Matured fruits weight observed to be very low (<5 gm) for Stoneless, Tikadi, Illaichi, low (5-10 gm) for Gola, Gola (Delhi), Gola (Kakwan), Seb (Soft), Aliganj, Mundia and medium (11-20 gm) for Seb (Hard), Pemily and Umran fruits. The highest fruit weight among the accessions studied was recorded for Seb (Hard) (17.48 gm) whereas, for stoneless *ber* it was (2.78 gm). The germplasm exhibited wide variability with respect to the characters of growth habit, shape of thorn, leaf, fruit and stone, leaf and fruit surface, etc. Similarly high variability was recorded by Krishna *et al.* (9) for 24 varieties of *ber* with respect to morphological characters.

Pulp character is an important character of *ber* fruit if breeding is aimed for long storage life (Krishna *et al.*, 8). In stoneless and Tikadi accessions, pulp

cavity was found to be absent, whereas in rest of the accessions pulp cavity was present either on stylar end or stem end or both on stylar and stem end of fruits. The pulp:stone ratio is an important character as it indicates towards the edible portion in the fruit (Saran *et al.*, 14). The highest pulp:stone ratio was noted in Stoneless landrace, it was recorded as high as 100 per cent as there was no inedible stone present in that, while the least pulp: stone ratio was recorded in Tikadi in the studied germplasm. The pulp weight was very less in stoneless (2.68 gm) in comparison to Seb-hard (16.20 gm), Umran (14.68 gm), Pemily (11.38 gm) *etc.*

There is a complete absence of stone in stoneless *ber* (Fig. 1) that could be useful inbreeding programme for development of *ber* fruit cultivars with stoneless fruits. Stoneless *ber* was characterized as semi erect in plant habit with bunching bearing habit (Table 2). The fruits characters are like 1-4 fruits/ cluster, plain oblate shaped fruits with shorter fruit length (18.20 mm) and medium fruit width (16.00 mm) (Table 3). Stoneless shrub was recorded to be different in some other characters like absence of pubescence in petioles, green and smooth lower leaf surface (in contrast to tomentose surface in other germplasm) and late in flowering, fruiting and ripening. The descriptor will make access to diversity of a crop by the users of plant genetic resources, who in turn will benefit from their economic and social values (Anonymous, 1).

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Table 2. Characteristic features of stoneless *ber*.

S. No.	Plant descriptor	Features	Note
1.	Plant growth habit	Semi erect	3
2.	Plant height (m)	4.6	-
3.	Plant spread (m)	5.3	-
4.	Type of planting material	Stem cuttings	3
5.	Shoot surface	Tomentose	5
6.	Bearing habit	Bunching present	9
7.	Thorn shape	Alternate curved	5
8.	Thorns	Paired	-
9.	Leaf: Apex	Acute	3
10.	Leaf: Base	Acute	1
11.	Leaf: Shape	Ovate	1
12.	Leaf: Curving	Absent	1
13.	Leaf: Pubescence on lower surface	Smooth	1
14.	Leaf: Blade length (cm)	5.4 (Short)	3
15.	Leaf: Blade width (cm)	3.1 (Narrow)	3
16.	Leaf surface color (upper)	Green	-
17.	Leaf surface (lower)	Smooth	-
18.	Petiole pubescence	Absent	-
19.	Petiole length (cm)	0.9	-
20.	No. of fruits/cluster	1-4	-
21.	Fruit cracking	Absent	1
22.	Fruit surface	Plain	3
23.	Fruit shape: Apex	Flat	1
24.	Mature Fruit shape	Oblate	4
25.	Mature Fruit length (mm)	18.20 Short	3
26.	Mature Fruit width (mm)	16.00 Medium	5
27.	Mature fruit color	Chocolate brown	7
28.	Perimeter of fruit (cm)	6.2	-
29.	Mature Fruit weight (g)	2.7852	Very low
30.	Pulp cavity	Absent	1
31.	Pulp cavity: Stylar end	Absent	1
32.	Pulp cavity: Stem end	Absent	1
33.	Stone	Absent (Edible)	-
34.	Pulp weight (g)	2.6857	-
35.	Seed weight (g)	0.0995	-
36.	Pulp stone ratio	1:0	3

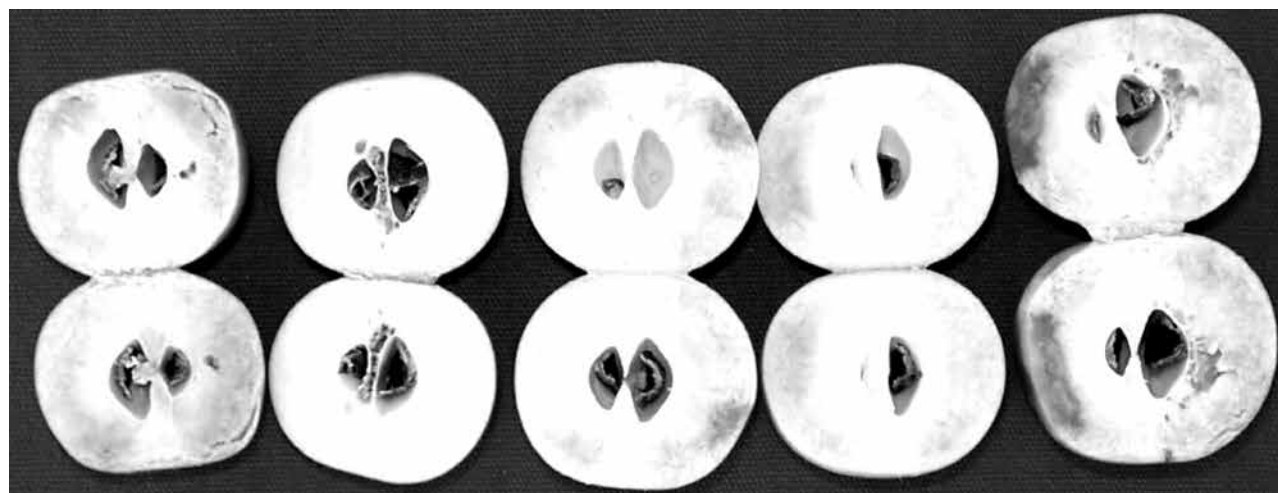


Fig. 1. A view of longitudinal fruit section of stoneless *ber* fruit.

Table 3. Comparison of fruit and stone characters of Stoneless *ber* with selected cultivars (pooled data 2014-2017).

Cultivar	Fruit shape	Fruit Length (mm)	Fruit diameter (mm)	Fruit weight (g)	Stone weight (g)	Stone length (mm)	Stone diameter (mm)	Pulp weight (g)
Stoneless ber	Oblate	18.20	16.0	2.78	0	0	0	2.68
Gola	Round	25.80	24.4	8.18	0.86	18.0	10.6	7.30
Gola (Kakwan)	Round	25.50	25.4	9.98	0.84	17.1	10.3	9.15
Gola (Delhi)	Oblong	24.50	23.3	7.82	0.90	17.5	10.7	6.98
Tikadi	Long	19.60	14.1	1.86	0.33	17.5	0.94	1.51
Illaichi	Round	16.50	16.5	2.88	0.28	12.1	0.64	2.62
Pemily	Oblong	33.40	25.3	12.20	0.90	22.0	0.91	11.38
Seb (Hard)	Oblong	31.30	29.7	17.48	1.38	20.1	1.11	16.20
Seb (Soft)	Round	26.10	23.8	7.65	0.75	17.3	0.99	7.10
Mundia	Long	33.20	23.5	9.75	0.80	22.9	0.90	8.97
Umran	Long	34.90	28.7	15.64	1.00	22.4	0.93	14.68
Aliganj	Round	26.70	21.3	6.71	0.85	17.7	0.99	5.90

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