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Qualitative characterization and Categorization of Barnyard Millet (*Echinochloa* spp.) Accession, Collected from different Regions of India

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ABSTRACT: This study assesses the critical physical characteristics of barnyard millet (*Echinochloa* spp.) to analyze qualitative morphological traits based on descriptive scoring. For this study, a total of eight barnyard millet species were assessed in field conditions based on their morphological characteristics, *viz.* plant growth habit, plant pigmentation, the colour of inflorescence, inflorescence shape, compactness of inflorescence, shape of a lower raceme, branching of the lower raceme, culm branching, degree of lodging at maturity, grain colour and the grain shape. The qualitative data assessment concluded that the diversified characteristics of lines showed a large amount of variation among barnyard millet. This finding could be used to identify species on field conditions, selection, regulating seed quality, seed production, multiplication, and seed certification process because of the variation in genetic makeup. These differences in morphological traits were helpful in the recognition of individual barnyard millet cultures.

Keywords: Barnyard millet; Morphological characterization; Qualitative traits; *Echinochloa.*

INTRODUCTION

Barnyard millet (*Echinochloa* spp.) is one of Asia's most substantial minor millet crops. Generally, two species of barnyard millet, Indian barnyard millet (*Echinochloa frumentacea*) and Japanese barnyard millet (*Echinochloa utilis*) are cultivated on a large scale in different regions of India. About 8600 barnyard millet germplasm accessions are found across the world, with the most extensive germplasm collection by Japan (~3700 accessions), followed by India (~3200 accessions) (Shingane, 2016). In India, barnyard millet is cultivated in the area of 0.146-m-ha^{-1} and produces 0.147 mt with an average yield of 1034-kg-ha^{-1} (Renganathan *et al.,* 2020; Karthikeyan *et al.,* 2020). Barnyard millet is generally cultivated in tribal or hilly areas where climatic conditions or soil are not suitable to grow major cereals like rice and wheat. The duration of early maturity and its climate-resilient qualities give it an added benefit in supporting agricultural production and the sustenance of farmers in these areas.

It has high nutritional value and is rich in antioxidant components, increasing the demand for the crop. Barnyard millet contains protein ranging from 11.1% to 13.9% (Kuraloviya *et al.,* 2019) and also contain carbohydrate of about 65%, fat of 3.9%, crude fibre of 13.6%, and is an excellent source of iron (Fe), zinc (Zn) and other compounds (Vetriventhan and Upadhyaya 2018). It could cure health-related diseases such as diabetes and cardiovascular diseases. It has enormous potential to provide nutrition and food security, especially in hilly areas where major cereals cannot cultivate due to harsh climatic conditions.

Thus, this study must differentiate all the morphological characteristics of barnyard millet accession with desirable traits so they can be directly selected to further crop improvement breeding programs. The various characteristics of accession indicate that the morphological variations in collected germplasm occur because of differences in genetic makeup. This variation could be better employed for identifying crops under field conditions, certification process, seed multiplication, and regulating the seed quality. Therefore, the present study is based on the qualitative characterization and categorization of barnyard millet germplasm.

MATERIALS AND METHODS

The study used eight accessions of Barnyard millet collected from different areas of India. The field trial was conducted in the poly house of Biotechnology Centre, JNKVV Campus, Jabalpur, India, during the Kharif season (2020-2021). The complete list of the accessions is presented in Table 1.

These eight accessions were evaluated using Randomized Block Design (RBD) in three replications.

The recommended agronomical and plant protection practices were followed during the trial. All the observations were taken on five randomly selected plants for each trait in each replication at different growth stages. The morphological characteristics include plant growth habit, plant pigmentation, the colour of inflorescence, inflorescence shape, compactness of inflorescence, shape of a lower raceme, branching from a lower raceme, culm branching, degree of lodging at maturity, grain colour, and grain shape were observed. All the observations were scored on the basis of *Echinochloa* millet descriptors developed by IBPGR (1893) (Table 2). The data were analyzed using SPSS statistical software. The similarity matrix was prepared with a similarity coefficient using Past software. The Unweighted Pair Group Method with Arithmetic Mean (UPGMA) clustering method of the clustering subroutine SAHN was used to construct the dendrogram.

Table 1: List of Barnyard millet accessions collected from different regions of India.

S. No.	Accession code	Lat-Long	Location	Genotype
1.	BYM-1	12.97° N 77.59° E	Banglore	GECH-619
2.	BYM-2	17.38° N 78.48° E	Hyderabad	ESD-64
3.	BYM-3	17.38° N 78.48° E	Hyderabad	IC426582
4.	BYM-4	24.53° N 81.30° E	Rewa	VL-172
5.	BYM-5	24.53° N 81.30° E	Rewa	RBM-60
6.	BYM-6	17.38° N 78.48° E	Hyderabad	IC426595
7.	BYM-7	17.38° N 78.48° E	Hyderabad	IC426674
8	BYM-8	11.12° N 78.65° E	Tamil Nadu	BYM-8

Table 2: Morphological qualitative characterization of Barnyard millet germplasm collected from a different area of India.

Character	Score	Phenotype	Number of variants	Percentage of variants
Growth habit	1	Erect	3	37.50
	2	Decumbent	5	62.50
	3	Prostrate	0	0.00
Plant pigmentation	1	Absent	5	62.50
	2	Present	3	37.50
Colour of inflorescence	1	Green	5	62.50
	2	Light purple	1	12.50
	3	Dark purple	2	25.00
Inflorescence shape	1	Cylindrical	2	25.00
	2	Pyramidal	5	62.50
	3	Globose to elliptic	1	12.50
Compactness of inflorescence	3	Open	3	37.50
	5	Intermediate	1	12.50
	7	Compact	4	50.00
Shape of lower raceme	1	Straight	2	25.00
	2	Curved	6	75.00
	3	Slender	0	0.00
Branching from lower raceme	1	Absent	8	100.00
	2	Present	0	00.00
Culm branching	1	Absent	4	50.00
	2	Present	4	0.00
Degree of lodging	1	Absent	4	50.00
	2	Present	4	50.00
Grain colour	1	Straw white	2	25.00
	2	Grey+Straw white	4	50.00
	3	Brownish grey	1	12.50
	4	Grey	0	0.00
	5	Light grey	1	12.50
Grain shape	1	Concave	8	100.00
	2	Oval	0	00.00

Table 3: Morphological qualitative characterization of Barnyard millet germplasm collected from a different area of India.

Characters	BYM-1	BYM-2	BYM-3	BYM-4	BYM-5	BYM-6	BYM-7	BYM-8
Growth habit	Decumbent	Erect	Decumbent	Decumbent	Decumbent	Erect	Decumbent	Erect
Plant pigmentation	Absent	Absent	Present	Absent	Absent	Present	Present	Absent
Colour of inflorescence	Green	Dark Purple	Green	Green	Green	Light Purple	Dark Purple	Green
Inflorescence shape	Cylindrical	Pyramidal	Elliptical	Pyramidal	Pyramidal	Pyramidal	Cylindrical	Pyramidal
Compactness of inflorescence	Open	Semi-compact	Open	Compact	Compact	Compact	Open	Compact
Shapeof lower raceme	Straight	Curved	Curved	Curved	Curved	Curved	Straight	Curved
Branching of a lower raceme	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Culm branching	Present	Present	Absent	Present	Present	Absent	Absent	Absent
Degree of lodging	Present	Present	Present	Absent	Absent	Present	Present	Present
Grain colour	Grey + Straw white	Brownish grey	Straw white	Grey+Straw white	Straw white	Grey+Straw white	Grey+Straw white	Light grey
Grain shape	Concave	Concave	Concave	Concave	Concave	Concave	Concave	Concave

RESULTS AND DISCUSSION

Qualitative characterization of the plant showed constant and distinct inheritance, which could be used to distinguish the genotypes. Qualitative analysis generally is less affected by environmental instabilities. An entire of 11 qualitative plant characters was examined for characterization of the barnyard accession (Table 2), and character descriptors were screened and presented in Table 3. The highest frequency of variation of characters was founded in plant growth habit (Fig. 2), plant pigmentation, inflorescence colour, inflorescence shape, compactness of inflorescence (Fig. 3), and the shape of lower raceme and grain colour (Fig. 4). Moderate frequency variants resulted only in culm branching. Among all qualitative traits, no variants were found for traits like the branching of lower raceme and grain shape. Similar results were also obtained for plant growth habits, pigmentation, culm branching, and branching of lower racemes (Joshi *et al.,* 2015). Similar variation for various qualitative traits in barnyard millet (Renganathan *et al.,* 2017; Nilavarasi *et al.,* 2020) and in foxtail millet has been reported by Sapkota *et al.* (2016).

The cluster analysis of the eight accessions for eleven qualitative characters using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) method resulted in the grouping of accessions into 5 clusters while truncating the dendrogram tree similarity coefficient of 0.67 (Fig. 1) (Table 4). Cluster I has accustomed to the most prominent cluster with three accessions, and cluster II consists of 2 genotypes followed by III, IV, and V and with a single genotype. Similar results of solitary clusters were also reported by (Nilavarasi *et al*., 2020) in barnyard millet. The similarity matrix coefficient ranged from 52% to 97%, averaging 67%. Between 82% to 97% similarity, one major cluster formed, further divided into three minor clusters consisting of 7 genotypes, while clusters III, IV, and V include only a single genotype, indicating that wide variation was found among these genotypes.

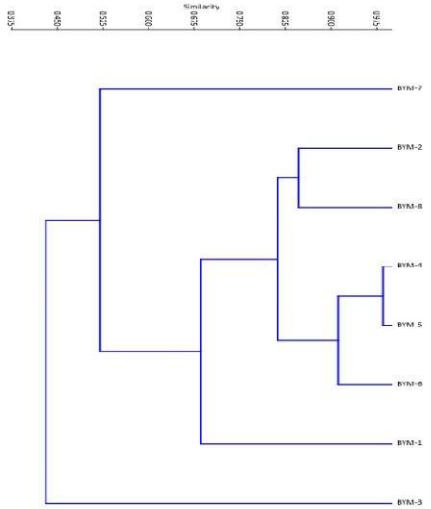

Fig. 1. Dendrogram representing the grouping of eleven barnyard genotypes formed through UPGMA based on different morphological markers.

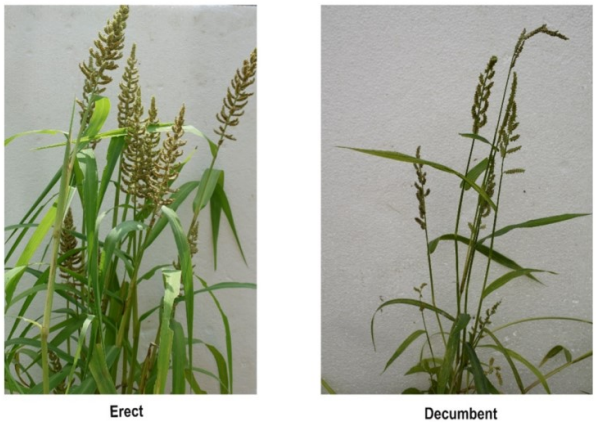

Fig. 2. Plant Growth Habit.

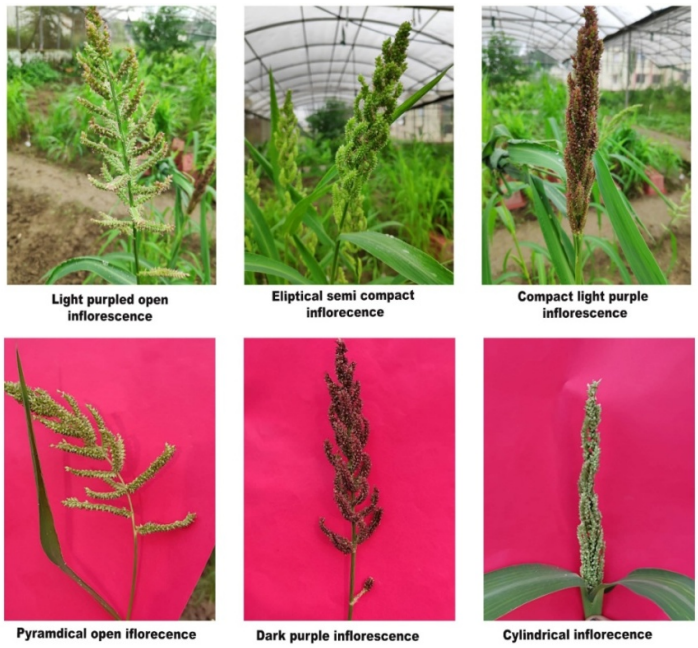

Fig. 3. Inflorescence colour and shape.

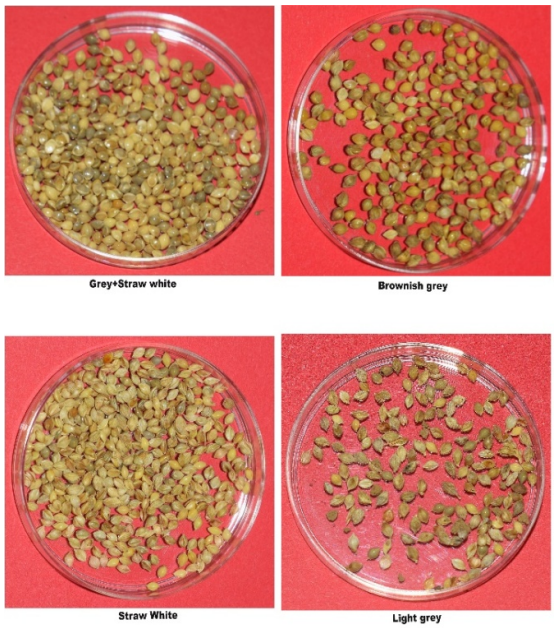

Fig. 4. Seed colour and shape.

Table 4: Constituents of VI clusters in barnyard millet genotypes for 11 qualitative characters truncating the tree 65% similarity level.

Cluster	Number of genotypes	Constituent genotypes
I	3	BYM-4, BYM-5, BYM-6
II	2	BYM-8, BYM-2
III	1	BYM-7
IV	1	BYM-1
V	1	BYM-3,

Hence the diverse genotypes can be easily identified. Similar findings for genetic diversity were also concluded by (Tiwari *et al.,* 2017; Neeru *et al.,* 2017; Mishra *et al.,* 2021) in Indian mustard and soybean.

CONCLUSION

This study revealed sufficient genetic diversity available in the barnyard millet germplasm in accessions BYM-7, BYM-3, and BYM-1 for the following traits *viz*., plant growth habit, plant pigmentation, inflorescence colour, inflorescence shape, compactness of inflorescence, the shape of lower raceme and grain colour showed higher variations. These traits and accession may help identify the genotypes and introgression of novel traits in breeding programmes.

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Conflict of Interest. None.

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