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Morphological characterization and evaluation of barnyard millet varieties, cultivars and mutants for varietal identification

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Abstract
The present study was undertaken to characterize barnyard millet (*Echinochloa frumentacaea* L.) varieties, cultivars and mutants on the basis of morphological descriptors with the objective to identify the key diagnostic characters of the genotypes. A set of 11 barnyard millet genotypes were evaluated in randomized block design with three replications. A total of 12 morphological characters were observed. All the genotypes were classified into different groups based on each character. Among the 12 characters, nine qualitatitive characters *viz*., pigmentation, inflorescence colour, inflorescence shape, stamen colour, stigma colour, panicle compactness, spikelet arrangement, lower raceme shape, seed colour and three quantitative characters *viz*., plant height (cm), 50% of flowering (days) and panicle length (cm) were studied. These differences in morphological traits were useful in identification of individual barnyard millet genotypes.

Keywords: Barnyard millet, DUS, varietal identification, morphological characterization

1. Introduction
Barnyard millet (*Echinochloa frumentacaea* L.) is native of Eurasia, the area of cultivation ranges from 50°N to 40°S latitude in both temperate and tropical habitats. It is the quickest growing of all millets in all condition. In India, the crop is confined to states like Tamil Nadu, Andhra Pradesh, Karnataka and Uttar Pradesh. In Tamil Nadu, it is cultivated in dry lands and hilly areas of Ramanathapuram, Madurai, Salem, Namakkal, Vilupuram, Dindugal, Coimbatore and Erode districts (Channappagoudar, Hiremath *et al*. (2010). Excellent source of nutrient content, antioxidants, dietary fibre and protein things make it to be measured as a serviceable food and fodder crop.

The varietal identification and parietal purity assessment is a significant parameter for the released cultivars. Cultivars are usually identified on the basis of morphological differences of seed, seedling and mature plant. In general, quality of seed is estimated by varietal purity including physical and genetical. A variety/cultivar is a collection of cultivated plant which is clearly distinguished by any character (morphological, physiological, cytological, chemical or others) and which when reproduced (sexually or asexually) retains its distinguishing characters. Practically, a variety must prove, Distinct, Uniform and Stable (DUS) variations in the characters that are adopted for use in varietal identification. Morphological evaluation of pepper germplasm accessions have been considered for most of the plant and fruit traits. It has been reported that the variations in cotyledon color, number of stems, stem color, stem pubescence, leaf properties, number of flowers, flower color, anthocyanin in fruit, anther color, stigma position, immature fruit color and number of fruit in chilli (Wang and Bosland, 2006). With the foreword of Indian legislation Protection of Plant Varieties and Farmers Rights Act (PPV and FRA, 2001), the release of new crop varieties is possible only if it is distinct (D) from other varieties, uniform (U) in their characteristics and generally stable (S) over the years (DUS). Importance on characterization, varietal identification and genetic purity assessment of barnyard millet cultivars are significant to the field functionaries, certification officers, seed production officers and seed growers for regulating quality of the seed. Farmers and seed growers need an assurance that they are being given with correct seed material with known identity of a specific variety and assured quality. Thus, there is an essential need to look for rapid and reliable methods of varietal identification. For identification of varieties through morphological characters and conduct of GOT, the plant and seed characters need to be studied and documented.

2. Materials and methods

Plant materials: A total of 11 barnyard millet genotypes (MDU 1, CO (KV) 2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, M 38, PRJ1, PRB 903) were obtained from Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai and the research was carried out in the Department of seed science and technology at B block, AC&RI, Madurai during August 2019.

Field experiments: Different genotypes were evaluated in three replications using Randomized Block Design (RBD) with the plot size of 3× 3 m and in view of inter and intra row spacing as 30× 15 cm respectively. The suggested agronomical and plant protection packages were followed. The observations were recorded on 5 randomly selected plants for each character in each replication at different crop growth stages. The morphological characters such as plant height (cm), pigmentation, 50% of flowering (days), inflorescence colour, inflorescence shape, stamen colour, stigma colour, panicle compactness, panicle length (cm), spikelet arrangement, lower raceme shape and seed colour were observed.

3. Results and Discussion

The identification of barnyard millet genotypes based on the morphological characteristics. These are highly useful to set up distinctness, uniformity and stability of the cultivars. Based on the variations in physical characteristics, it was attempted to group the 11 barnyard millet genotypes and to identify each and every genotypes. Based on the height of plants, the genotypes were grouped into three categories as semi dwarf, tall and very tall. Based on this variations, the genotypes were grouped in semi dwarf with two (PRJ 1 & PRB 903), three were tall (TNEF 317, IEC 350 and IEC 356) and the other six (MDU 1, CO (KV) 2, ACM 16 343, ACM 16 353, TNEF 318 and M 38) grouped under very tall category. Variations in the pigmentation grouped as present or absent (Figure 1). Only 3 genotypes (CO (KV)2, IEC 350 and IEC 356) showed the presence of pigmentation on both leaf sheath and internodes and the remaining 8 genotypes (MDU 1, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, M 38, PRJ 1 and PRB 903) showed absence of pigmentation. Based on the days to 50% flowering, the cultivars were grouped as early (< 40), medium (40-50) and late (>50). But there is no variation was found among these genotypes and it falls under late category. Similarly, genotypes identification based on distinguishable morphological characters were reported by Lalitha (2007) [6], Singh *et al.,* (2015) in pearl millet, Gediya *et al.,* (2018) [7] in chickpea and Bhoot *et al.,* (2019) [2] in sesame.

Based on the variations in the inflorescence colour one genotype (IEC 350) exhibited light purple, one (IEC 356) showed dark purple and the other nine genotypes (MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, M 38, PRJ 1 and PRB 903) exhibited green colour (Figure 2). With reference to the inflorescence shape, 9 genotypes (MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, M 38, IEC 350 and IEC 356) showed pyramidal and the other 2 (PRJ 1 and PRB 903) were globose elliptical in nature (Figure 3). Based on the stamen colour, no difference was found and all the 11 genotypes possess straw white colour stamen. The difference was found in colour of stigma (Figure 4) as white and dark purple. Among the 11 genotypes, 3 (MDU 1, ACM 16 353 and M 38) were white, 6 ((CO (KV) 2, ACM 16 343, TNEF 317, TNEF 318, IEC 350 and IEC 356) were dark purple and the other 2 (PRJ 1 and PRB 903) stamen and stigma colour was not visible. Similar characterization and grouping of genotypes based on plant morphological characters were made by Kumar, Varier *et al.* (2005) [1], Arunkumar *et al.,* (2005), Singh *et al.,* (2015) in pearl millet, Gediya *et al.,* (2018) [7] in chickpea and Bhoot *et al.,* (2019) [2] in sesame.

Barnyard millet genotypes exhibited variability in the compactness of the panicle (Figure 5). Based on this variation 11 genotypes under study were grouped into open with 5 (CO (KV) 2, TNEF 318, IEC 350, PRJ 1 and PRB 903), intermediate with 3 (ACM 16 343, M 38 and IEC 356) and compact with 3 genotypes (MDU 1, ACM 16 353 and TNEF 317). The study of the length of the panicle (Figure 6) revealed that barnyard genotypes were grouped into three categories. The 2 genotypes (PRJ 1 and PRB 903) comes under short (< 15.0), 6 (ACM 16 353, TNEF 317, TNEF 318, M 38, IEC 350 and IEC 356) under medium (15.0-25.0) and 3 genotypes (MDU 1, CO (KV)2 and ACM 16 343) under long (>25.0).

Differences were also found in the spikelet arrangement of barnyard millet, 10 cultures showed unidirectional and the remaining one genotype (TNEF 317) showed surrounded nature (Figure 7). Two groups as straight and curved made based on the variation in the lower raceme shape. Out of 11 genotypes, 3 (ACM 16 343, ACM 16 353 and TNEF 317) were curved and 8 (MDU 1, CO (KV)2, TNEF 318, M 38, IEC 350, IEC 356, PRJ 1 and PRB 903) were straight type (Figure 8). Based on the seed colour, 3 genotypes (CO (KV)2, M 38 and IEC 350) were light grey in colour, 7 genotypes (MDU 1, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, IEC 356 and PRJ 1) were grey and the 1 culture (PRB 903) seed set was not present due to the unfavourable climatic condition.

From this study, it is concluded that a total of 11 barnyard millet genotypes can be effectively distinguished by its morphological characters (Table1). Out of 12 morphological characters, nine qualitatitive characters *viz.,* pigmentation, inflorescence colour, inflorescence shape, stamen colour, stigma colour, panicle compactness, spikelet arrangement, lower raceme shape, seed colour and three quantitative characters *viz.*, plant height (cm), 50% of flowering (days) and panicle length (cm) were found as important for its varietal identification. This study may provide an ideal knowledge to carryout DUS testing in barnyard millet genotypes. A detailed morphological description of plants and seeds should therefore be prepared.

Table 1: Morphological characterization of barnyard millet genotypes

S. No	Characters	States	Varieties	Score
1	Plant height (cm)	Dwarf (< 40) Semi dwarf (41.0-80.0) Tall (80.1-120.0) Very Tall (>120.0)	- PRJ 1 & PRB 903. TNEF 317, IEC 350 and IEC 356. MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 318 and M 38.	3 5 7 9
2	Pigmentation on leaf sheath and internodes	Present Absent	CO (KV)2, IEC 350 and IEC 356. MDU 1, ACM 16 343, ACM 16 353, TNEF 317,	1 9

			TNEF 318, M 38, PRJ 1 and PRB 903.	
3	50% flowering (Days)	Early (<40) Medium (40-50) Late (>50)	- MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, IEC 350, IEC 356, M 38, PRJ 1 and PRB 903.	3 5 7
4	Inflorescence colour	Green (RHS NO 149A) Light purple (RHS NO 58 A) Dar purple (RHS NO 59A)	MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, M 38, PRJ 1 and PRB 903. IEC 350. IEC 356.	1 5 7
5	Inflorescence shape	Cylindrical Pyramidal Globose - Elliptical	- MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, M 38, IEC 350 and IEC 356. PRJ 1 and PRB 903.	3 5 7
6	Stamen colour	White Straw white Purple	- MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, IEC 350, IEC 356, M 38. -	1 2 3
7	Stigma colour	White Purple Dark purple	MDU 1, ACM 16 353 and M 38. - CO (KV)2, ACM 16 343, TNEF 317, TNEF 318, IEC 350 and IEC 356.	1 2 3
8	Panicle compactness	Open Intermediate Compact	CO (KV)2, TNEF 318, IEC 350, PRJ 1 and PRB 903. ACM 16 343, M 38 and IEC 356. MDU 1, ACM 16 353 and TNEF 317.	3 5 7
9	Panicle length (cm)	Short (< 15.0) Medium (15.0-25.0) Long (>25.0)	PRJ 1 and PRB 903. ACM 16 353, TNEF 317, TNEF 318, M 38, IEC 350 and IEC 356. MDU 1, CO (KV)2 and ACM 16 343.	3 5 7
10	Spikelet arrangement	Unidirectional Surrounded	MDU 1, CO (KV)2, ACM 16 343, ACM 16 353, TNEF 318, M 38, IEC 350, IEC 356, PRJ 1 and PRB 903. TNEF 317	3 7
11	Lower raceme shape	Straight Curved	MDU 1, CO (KV)2, TNEF 318, M 38, IEC 350, IEC 356, PRJ 1 and PRB 903. ACM 16 343, ACM 16 353 and TNEF 317.	3 7
12	Seed colour	Straw white (RHS NO 163D) Light grey (RHS NO 156 B) Grey (RHS NO 156 A)	- CO (KV)2, M 38 and IEC 350. MDU 1, ACM 16 343, ACM 16 353, TNEF 317, TNEF 318, IEC 356 and PRJ1.	2 4 5

Fig 1: Pigmentation on leaf sheath and internodes

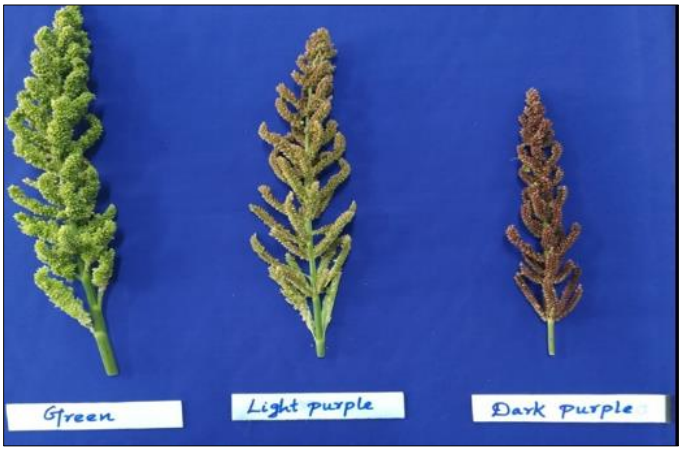

Fig 2: Inflorescence colour

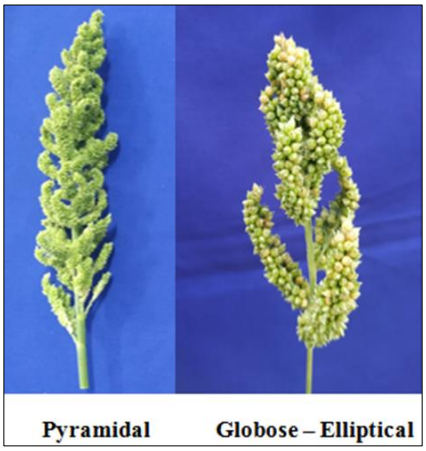

Fig 3: Inflorescence shape

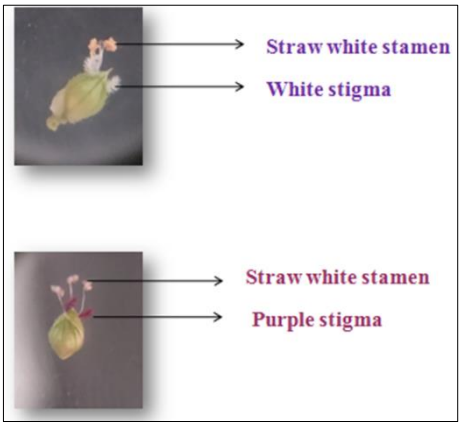

Fig 4: Stamen and stigma colour

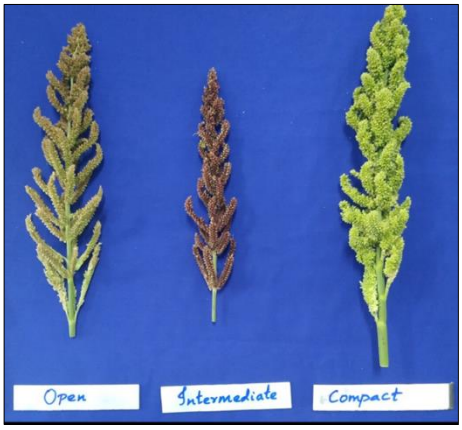

Fig 5: Panicle compactness

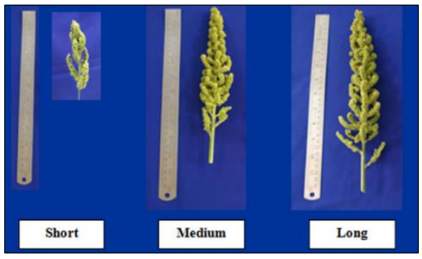

Fig 6: Panicle length

Fig 7: Spikelet arrangement

Fig 8: Lower raceme shape

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