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Research Article

# Diversity Analysis in Finger Millet (*Eleusine coracana* L.) Germplasm for Agro-Morphological and Grain Yield Attributing Traits

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## Abstract

**Finger millet (*Eleusine coracana* L.) is an important millet crop grown at large scale in Asia and Africa. Germplasm is the basic source of variation in the crop improvement. An experiment on characterization of 2000 germplasm accessions was conducted in augmented design at ICAR-Indian Institute of Millets Research (IIMR), Hyderabad during Kharif 2017. The multivariate analysis is an important statistical tool which can easily asses the polygenic traits important for breeding program. The PCA analysis showed 14 Principle Components (PCs) to total variability. The first six principal components explained a total of 63.99% of variability with Egan's value of >1. The first two PCs played important role in diversity contribution than other PCs. A total of nine clusters were formed on the bases of Euclidian distance of 14.67% and 85, 63% variation observed within and between clusters. The selection of genotypes from the different clusters will help the breeders to increase variability in their breeding programme**

**Key words:** Genetic diversity, *Eleusine coracana*, Principle Component Analysis, Clusters and Egan's value

## 1. Introduction

Finger millet (*Eleusine coracana* L.) is popularly known as '*Ragi*' in India. It is an annual millet crop grown mainly in arid and semi-arid region of the world covering Africa and South Asia. Finger millet is tetraploid, self-pollinated and believed to be evolved from wild relative *Eleusine africana* (Sood *et al.* 2017). It is native to Ethiopia and Uganda's highlands (D'Andrea *et al.,* 1999). It is known to with stand 3000 m mean sea level latitude (Bisht and Singh, 2009), contains high level of micronutrients (Iron and Methionine). Finger millet is known to have high drought tolerance and long storability (Keerthana *et al.* 2019).

Variability in the genetic material is the prerequisite for any crop improvement programme. Germplasm is the basic source of natural variation maintained in the gene banks globally. In India, ICAR-National Bureau of Plant Genetic Resource (NBPGR), New Delhi, ICAR-Indian Institute of Millets Research (IIMR), Hyderabad and International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru are the nodal organisations to maintain Indigenous and Exotic finger millet germplasm. Along with the creation of genetic diversity, it is essential to characterize the germplasm for effective utilization for crop improvement (Upadhyaya *et al.* 2007).

Finger millet is commonly known as nutritious millet as the grains are rich in protein, vitamins, minerals and exceptionally superior in calcium content. It serves as a staple food for rural people in developing countries wherein calcium and anaemia are rampant (Owere *et al.* 2015).

Phenotyping characterization of germplasm accessions and knowing the association between the traits helps in development of high yielding cultivars through crop improvement. Simultaneous improvement of traits depends upon the nature and degree of correlation that exists between traits (Mnyenyembe and Gupta 1998). Many researchers have reported on association and variability of finger millet traits. Mehra (1962) reported that existence of diversity for rachis and raceme width, spikelet and glume length by Metroglyph analysis. There were wide genotypic and phenotypic variations for tiller number, ear numbers and grain weight of 33 cultivars (Goud and Laxmi, 1977). Rao *et al.* (1986) reported the variability of traits, heritability and genetic advance for grain yield among $F_2$ generations of three crosses.

Core sub sets (minicore) have been developed by (Upadhyaya *et al.* 2006, 2007) in finger millet of 5949 germplasm accessions using geographic origin and collected data on 14 quantitative traits. Upadhyaya *et al.* (2007) observed large variability for days to 50 % flowering, plant height and inflorescence length of 909 finger millet germplasm accessions introduced from Southern and Eastern Africa.

Multivariate analysis methods are most useful for characterization, evaluation and classification of large number of accessions assessed for several agronomically important trait (Peeters and Martinelli 1989). Multivariate analysis has been demonstrated to be useful in drawing meaningful information out of large-scale phenotypic characterization of germplasm accessions. Outcome of this analysis can be utilized for identifying accession in the group of desirable traits for crossing, planning efficient germplasm collecting expedition, for establishing of core collection and crop evolution studies. The objective of this study was to phenotypically characterize a set of finger millet germplasm accessions and to estimate the genetic variability.

## 2. Materials and Methods

The initial experimental material consisted of 2000 finger millet accessions out of which only 1487 were considered for final data analysis as some of them failed to germinate while the other few were having missing data either due to poor seed set or high disease susceptibility. The experiment was conducted at ICAR-Indian Institute of Millets Research (17.3207° N latitude, 78.3959° E longitude and 476.5 meters above msl), Hyderabad India in augmented design during Kharif 2017. Two checks viz., KMR 204 (medium duration variety) and DHFM 78-3 (long duration variety) were repeated after every 100 accessions. Each accession was sown in 1 m long row with 60 cm distance between each row and 10 cm distance maintained between plants. Fertilizers were applied at the rate of 60 kg/ha N, 30 kg/ha $P_2O_5$ and 30 kg/ha K during the crop growth period. Full dose of P and K whereas half dose of N were applied as basal dose and remaining half of N applied at 20 days after sowing. All necessary package of practices was followed for good crop stand. Regular irrigation was given to maintain sufficient moisture. The crop was protected from weeds, pest and diseases. The data was analysed for Principle Component Analysis (PCA) and Clustering Analysis using Genlex software 14.0.

## 3. Results and Discussions

### *3.1 Principal Component Analysis (PCA)*

The descriptive statistical (Table 1) analysis reveals the variability within accessions, days to 50 % flowering (0.82) observed with highest variance followed by plant height (0.75) and grain yield (0.70). The yield contributing traits such as number of basal tillers ranged from 1 to 19.33 tillers, plant height (65.00 cm to 185.00 cm), finger length (2.50 cm to 19.57 cm), number of fingers on ear head (3.33 to 17.00), grain yield (1.00 g/plant to 98.00 g/plant) and 100-Seed weight (0.03 g to 3.35 g) also contributed to the overall diversity.

One of the objectives of this study was to use Principal Component Analysis (PCA) to identify representative traits for phenotypic characterization of finger millet. The PCA is a multivariate statistical technique used to simplify and analyse the inter-relationship among a large set of variables in term of a relatively small set of variables or components without losing any essential information of original data set. Total variability can be explained by each component in per cent (%) variation. Thus, it is most useful analysis for genetic improvement of important traits rather than going for all the characters under study. Fenty (2004) reported that PCA depicts the importance of large contributors to total variability at each axis of differentiation and reduce the large set of variables in to smaller sets which summarises the correlations. The total of 14 principle components (PC) contribute to variability of finger millets but cumulative of 63.99 % of variability explained by the first six principle components which were having >1 eigan's values (ranged from 3.17 to 0.18, Figure 1). The first two PCs (22.66 and 10.25%) contribute more towards variability than others. Flag leaf width (cm), Number of leaves and Leaf blade width (cm) were found to be having stronger association with PC1. Patel *et al.,* (2017) reported that first PC contributed 42.81 per cent and second PC was of 18.43 per cent. Each trait has contributed to variability which is explained with cosine value through respective principle components (table 2). The grain yield contributing traits like number of tillers (80.58%) through PC 9, number of fingers on ear head (74.05%) through PC6, finger length (40.59%) through PC 2 and 100-Seed weight (25.66) through PC1 contributed to variability (Table 3). If a single trait associated with a principal component is selected and improved upon will lead to improvement of other traits associated with that PC. The similar trend was supported by Agarwal *et al.,* (2004), Ali *et al.,* (2011), Akatwijuka *et al.,* (2016), Jain and Patel (2016) and Patel *et al.,* (2017).

Table 1: Descriptive statistics of traits studied for characterization of finger millet germplasm during Kharif 2017.

| Traits | Mean | Min | Max | SD | Variance | CV (95.0%) |
|---|---|---|---|---|---|---|
| Days to 50% flowering | 79.56 | 33.00 | 122.00 | 16.15 | 260.82 | 0.82 |
| Number of basal tillers | 5.49 | 1.00 | 19.33 | 2.28 | 5.19 | 0.12 |
| Flag leaf length (cm) | 31.76 | 10.80 | 69.30 | 9.38 | 87.93 | 0.48 |
| Flag leaf width (cm) | 1.27 | 0.30 | 7.50 | 0.36 | 0.13 | 0.02 |
| Number of leaves | 17.30 | 7.00 | 24.00 | 1.74 | 3.03 | 0.09 |
| Leaf blade length (cm) | 56.46 | 1.80 | 84.03 | 7.04 | 49.63 | 0.36 |
| Leaf blade width (cm) | 1.54 | 0.90 | 2.70 | 0.15 | 0.02 | 0.01 |
| Plant height (cm) | 119.34 | 65.00 | 185.00 | 14.66 | 214.92 | 0.75 |
| Finger length (cm) | 8.01 | 2.50 | 19.57 | 2.41 | 5.79 | 0.12 |
| Peduncle length (cm) | 19.27 | 2.50 | 35.10 | 3.93 | 15.45 | 0.20 |
| Number of fingers on ear head | 7.75 | 3.33 | 17.00 | 1.47 | 2.15 | 0.07 |
| Grain yield (g/plant) | 22.88 | 1.00 | 98.00 | 13.67 | 186.95 | 0.70 |
| 100-Seed weight (g) | 0.23 | 0.03 | 3.35 | 0.14 | 0.02 | 0.01 |

Table 2: Eigen's values and variability explained by principle components for 1489 finger millet accessions characterized during Kharif 2017

| Source | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 | F12 | F13 | F14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eigenvalue | 3.17 | 1.43 | 1.31 | 1.06 | 1.03 | 1.00 | 0.95 | 0.89 | 0.75 | 0.72 | 0.62 | 0.54 | 0.39 | 0.18 |
| Variability (%) | 22.66 | 10.25 | 9.33 | 7.58 | 7.13 | 7.04 | 6.78 | 6.39 | 5.37 | 5.13 | 4.40 | 3.84 | 2.81 | 1.30 |
| Cumulative % | 22.66 | 32.91 | 42.24 | 49.81 | 56.94 | 63.99 | 70.77 | 77.16 | 82.53 | 87.66 | 92.05 | 95.89 | 98.70 | 100.00 |

Table 3: Percent (squared cosines) contribution of variability from each trait through principle components of finger millet accessions

| SN | Traits | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 | F11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days to 50% flowering | 0.21<br>(0.01) | 2.73<br>(0.04) | **44.55**<br>**(0.59)** | 0.04<br>(0.01) | 3.33<br>(0.04) | 0.66<br>(0.01) | 0.15<br>(0.01) | 3.64<br>(0.04) | 0.05<br>(0.01) | 37.07<br>(0.27) | 2.06<br>(0.02) |
| 2 | Number of basal tillers | 10.17<br>(0.33) | 0.17<br>(0.01) | 0.8<br>(0.02) | 1.27<br>(0.02) | 1.17<br>(0.02) | 0.49<br>(0.01) | 0.59<br>(0.01) | 0.38<br>(0.01) | **80.58**<br>**(0.61)** | 0.2<br>(0.01) | 1.2<br>(0.01) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Flag leaf length (cm) | 0.01 (0.01) | 0.01 (0.01) | 23.24 (0.31) | 4.15 (0.05) | 15.4 (0.16) | 5.69 (0.06) | 5.98 (0.06) | **34.85 (0.32)** | 5.09 (0.04) | 1.97 (0.02) | 3.43 (0.03) |
| 4 | Flag leaf width (cm) | **24.28 (0.77)** | 0.5 (0.01) | 0.75 (0.01) | 0.02 (0.01) | 0.01 (0.01) | 0.45 (0.01) | 0.1 (0.01) | 0.17 (0.01) | 0.78 (0.01) | 1.56 (0.02) | 0.47 (0.01) |
| 5 | Number of leaves | **15.81 (0.51)** | 0.57 (0.01) | 1.38 (0.02) | 0.06 (0.01) | 0.02 (0.01) | 0.2 (0.01) | 5.98 (0.06) | 8.02 (0.08) | 4.44 (0.04) | 0.93 (0.01) | 0.56 (0.01) |
| 6 | Leaf blade length (cm) | 3.26 (0.11) | 0.15 (0.01) | 1.29 (0.02) | 0.93 (0.01) | 8.3 (0.09) | 7.77 (0.08) | **68.9 (0.66)** | 2.23 (0.02) | 0.46 (0.01) | 0.58 (0.01) | 1.16 (0.01) |
| 7 | Leaf blade width (cm) | 16.53 (0.53) | 0.89 (0.02) | 0.01 (0.01) | 2.08 (0.03) | 0.81 (0.01) | 0.12 (0.01) | 1.06 (0.01) | 0.52 (0.01) | 6.42 (0.05) | 4.38 (0.04) | 0.89 (0.01) |
| 8 | Plant height (cm) | 0.03 (0.01) | 0.01 (0.01) | 2.21 (0.03) | **46.61 (0.5)** | 37.34 (0.38) | 2.77 (0.03) | 0.46 (0.01) | 0.26 (0.01) | 0.03 (0.01) | 8.07 (0.06) | 0.15 (0.01) |
| 9 | Finger length (cm) | 1.42 (0.05) | **40.59 (0.59)** | 0.01 (0.01) | 0.02 (0.01) | 0.88 (0.01) | 0.01 (0.01) | 2.18 (0.03) | 0.13 (0.01) | 0.19 (0.01) | 7.39 (0.06) | 44.01 (0.28) |
| 10 | Peduncle length (cm) | 0.04 (0.01) | **40.82 (0.59)** | 0.13 (0.01) | 0.23 (0.01) | 1.75 (0.02) | 0.14 (0.01) | 0.69 (0.01) | 13.12 (0.12) | 0.2 (0.01) | 1.39 (0.01) | 41.46 (0.26) |
| 11 | Number of fingers on ear head | 0.99 (0.04) | 0.02 (0.01) | 0.74 (0.01) | 1.11 (0.02) | 7.89 (0.08) | **74.05 (0.74)** | 13.11 (0.13) | 0.17 (0.01) | 0.02 (0.01) | 0.61 (0.01) | 0.73 (0.01) |
| 12 | Grain yield (g/plant) | 0.22 (0.01) | 0.32 (0.01) | 16.19 (0.22) | **40.26 (0.43)** | 7.7 (0.08) | 6.79 (0.07) | 0.68 (0.01) | 0.98 (0.01) | 1.17 (0.01) | 24.1 (0.18) | 1.36 (0.01) |
| 13 | 100-Seed weight (g) | **25.6 (0.82)** | 0.15 (0.01) | 0.24 (0.01) | 0.01 (0.01) | 0.05 (0.01) | 0.39 (0.01) | 0.07 (0.01) | 0.01 (0.01) | 0.59 (0.01) | 0.06 (0.01) | 0.01 (0.01) |


Fig 1: Scree plot of principle components for Eigen's value and cumulative variability of finger millet accessions.

### *3.2 Cluster analysis*

Cluster analysis in germplasm is the grouping of a set of accessions in the same cluster which are more similar to each other than to those in other clusters. In present study,1487 accessions were grouped into four broad clusters. There was 14.67 % of variation within the clusters and 85.33 % of variation observed between the clusters. Which indicates that similar accessions were grouped. Selection of the accessions from the different clusters helps to enhance the genetic diversity. There were nine distinct clusters (Figure 2) formed. The cluster IX contained accessions that better performed for flag leaf length, number of leaves, peduncle length and 100-Seed weight. The cluster VIII better performed for number of basal tillers, leaf blade width and finger length. The cluster V was better for flag leaf width and short plant height which indicates that these accessions in cluster V may be used as genetic resources for lodging tolerance. The cluster III was having accessions which better performed for leaf blade length and number of fingers on ear head whereas cluster VI was better for grain yield (Table 4). The accessions from different clusters for different traits should serve as a pool to select parents with desirable attributes for development of better performing finger millet cultivars. Similar study on clustering of finger millet germplasm has been reported by Patel *et al.*, (2017) who found five clusters while Karad and Patil (2010) reported five clusters from 65 finger millet genotypes. Kumar *et al.*, (2010) studied 140 diverse finger millet genotypes which grouped into 10 clusters.

Table 4: Cluster mean for agro-morphological and yield contributing traits of finger millet accessions characterized during kharif 2017

| Clusters | Days to 50% flowering | Number of basal tillers | Flag leaf length (cm) | Flag leaf width (cm) | Number of Leaves | Leaf blade length (cm) | Leaf blade width (cm) | Plant height (cm) | Finger length (cm) | Peduncle length (cm) | Number of fingers on ear head | Grain yield (g/ plant) | 100-Seed weight (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 72.78 | 5.29 | 35.84 | 1.30 | 16.99 | 57.50 | 1.54 | 116.25 | 7.72 | 18.27 | 7.95 | 39.87 | 0.22 |
| II | 69.51 | 5.54 | 39.40 | 1.37 | 16.95 | 54.79 | 1.54 | 129.71 | 7.95 | 19.16 | 7.81 | 18.15 | 0.24 |
| III | 74.67 | 5.79 | 35.07 | 1.27 | 17.16 | 60.18 | 1.54 | 116.91 | 8.41 | 19.44 | 7.96 | 13.96 | 0.21 |
| IV | 98.89 | 5.34 | 22.70 | 1.13 | 17.66 | 56.45 | 1.53 | 123.74 | 8.14 | 19.94 | 7.66 | 18.74 | 0.22 |
| V | 66.60 | 5.41 | 37.86 | 1.39 | 17.60 | 55.64 | 1.56 | 91.76 | 8.00 | 19.54 | 7.49 | 19.54 | 0.21 |
| VI | 98.98 | 5.48 | 22.57 | 1.11 | 17.50 | 54.67 | 1.55 | 121.86 | 8.04 | 18.07 | 7.72 | 47.47 | 0.24 |
| VII | 60.37 | 5.32 | 32.89 | 1.38 | 17.37 | 57.43 | 1.55 | 118.43 | 7.55 | 18.38 | 7.62 | 18.57 | 0.24 |
| VIII | 100.76 | 5.97 | 24.22 | 1.11 | 17.28 | 55.77 | 1.57 | 100.19 | 8.42 | 20.52 | 7.85 | 26.40 | 0.22 |
| IX | 100.48 | 5.51 | 47.17 | 1.26 | 17.75 | 55.04 | 1.51 | 144.84 | 8.13 | 20.92 | 7.56 | 26.48 | 0.25 |

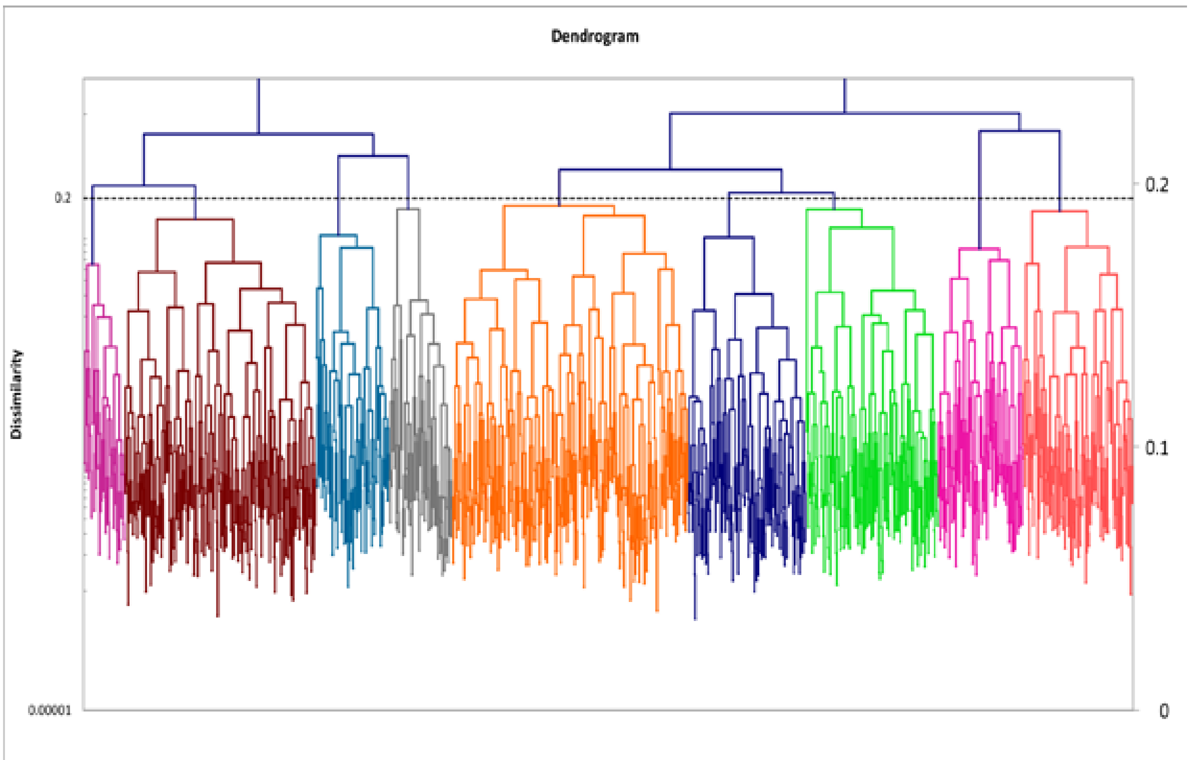


Fig 2: Ward's method of clusters of finger millet accessions characterised during Kharif 2017

## Conclusion

There was sufficient variability in the studied finger millet germplasm. Depending upon the diversity in the germplasm the pool grouped into nine clusters. The breeders can make selection of their desirable trait-specific lines as parents for their breeding program from the studied set of germplasm. The following accessions were identified as the best genotypes traitwise among the germplasm for yield and yield related traits *viz*, IC 0475183, IC 0474893, IC 0476432, IC 0475707 and IC 0476381 for early flowering/short days to 50% flowering (< 53 days); IC 0475740, IC 0475629, IC 0475059, IC 0475658 and IC 0476484 for more number of basal tillers (>15); IC 0474962, IC 0475244, IC 0475374, IC 0475858 and IC 0475473 for number of fingers on ear head (>14); IC 0476095, IC 0475125, IC 0474816, IC 0475407 and IC 0476587 for higher grain yield (>84 g/plant) and IC 0477419, IC 0475620, IC 0477078, IC 0475382 and IC 0475193 for more 100-Seed weight (>1.2 g).

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