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Genetic diversity in finger millet [*Eleusine coracana* (L.) Gaertn] using principal component analysis

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Abstract
The easily assessment of the important quantitative traits, principal component analysis is a important statistical tool to study genetic diversity in plant breeding program. The experiment was conducted during *kharif*, 2019 with 35 finger millet genotypes to study genetic diversity for yield, yield attributing traits and quality traits at Hill Millet Research Station, NAU, Waghai, Niger Research Station, NAU, Vanarasi, College Farm, NAU, Navsari, Gujarat in a randomize block design. The observations for eighteen characters were recorded. The multivariate technique, principal component analysis were applied. Principal component analysis indicates that two principal components PC-1 and PC-2 contributed 74.89% and 24.26% respectively of the total variation. The genotypes *viz*., VL-314, Dapoli-1, Dapoli-2, KOPN-235, KOPN-942, Phule Nachni, VR-708, VR-847, PR-202, KMR-204 and GNN-7 were accumulated on positive side of PC1 axis which accounted for days to 50% flowering, days to maturity, plant height, main ear head length, finger length and harvest index contributed maximum towards divergence. On other axis, only two genotypes OEB-532 and Indira Ragi-1 are accumulated on positive side of PC-2 which accounted for chlorophyll content was important traits contributed maximum towards divergence. PC-1 and PC-2 was provide maximum genetic variation. The positive signifying genotypes could be useful in finger millet breeding. Hence, these genotypes can be utilized in hybridization programmes to produce superior recombinants.

Keywords: Principal component analysis, genetic diversity, finger millet

Introduction
Millets are some of the oldest important nutri-cereal crop and cultivated under high rainfall receiving hilly land as well as dry land agriculture. Due to their unique adaptation properties for poor degraded lands and ability to tolerate abiotic stress, millet crops have a long history of cultivation of more than 5000 years (Gowda *et al.*, 2006) [4]. Millets belongs to the grass family Poaceae with small edible seeds which do not shatter readily at maturity and also refers to a group of annual grasses and mainly found in the arid and semi-arid regions (Thurston, 1989) [14]. These grasses family produce small seed and are often cultivated as cereals.

The most important small millet crops of India *viz*., finger millet, barnyard millet, foxtail millet, proso millet, Kodo millet and little millet. Small millets are generally considered as minor crops except in part of Asia, Africa and former USSR. Most of the small millets have their origin in Asia and Africa. The most important domestication areas are East Asia, Indian sub-continent and regions from southern margin of Sahara to the Ethiopian high lands of Africa.

Finger millet [*Eleusine coracana* (L.) Gaertn.] belongs to family Poaceae with species Corocana. The cultivated *E. coracana* is a tetraploid (2n = 4X = 36); has morphological similarities to both *E. indica* (L.) Gaertn. (2n = 18) and *E. africana* (O.) Byrne (2n = 36). It is an important cereal crop amongst the small millets and third in importance among millets in the country in area and production after sorghum and pearl millet. Finger millet is a valued food grain crop and mostly cultivated in rainfed condition in India. Finger millet is more versatile crop due to its adaptability to wide range of geographical areas and agro-ecological diversity.

Finger millet leaves are grass-like, narrow and capable of producing nodal branches and many tillers. The group of digitally arranged spikes on the panicle referred to as fingers. The 4–10 florets arranged serially on the finger is referred to as spikelets. All florets are perfect flowers with the exception of the terminal ones which may sometimes be infertile. The grain is oblong to round and oval, reddish brown in colour with the grains surface finely corrugated. Finger millet is a rainfed crop, tropical and one of the most suitable for dry farming.

The most important tropical cereals among finger millet is very adaptable and thrives at higher elevations. (Vilas *et al.*, 2015) [15].

Finger millet is an important cereal because of its excellent storage properties and the nutritive value of the grains. Finger millet is a good source of calcium and dietary fiber and consumed both in native and processed form (Gopalan *et al.*, 1989; Rao and Murlikrishna, 2001) [3, 9]. Finger millet grain can be stored for several years without storage pest infestation which makes it a perfect food grain commodity. The finger millet crop residues are excellent source of dry matter for livestock especially in dry season so, its grains are used for human consumption. Finger millet straw contains up to 61 per cent total digestible nutrients makes good fodder.

Genetic variability and diversity play very important role in any crop improvement program. If we using higher diverse parents they produced higher heterosis in progeny and more chance of getting transgressive segregation. Breeder has to identify diverse parents having high genetic variability for combining desirable characters for develop improved crop variety over existing cultivated variety. Due to multivariate analysis to study morphologically complex, individuals and measuring the degree of divergence between different populations.

Multivariate technique is useful for analyzing multiple measurements on each individual under study. Among the multivariate techniques, principal component analysis (PCA) have been very important in selecting genotypes for breeding program that meet the objective of a plant breeder.

Materials and Methods

The experiment was conducted at three locations (Hill Millet Research Station, NAU, Waghai, Niger Research Station, NAU, Vanarasi and College Farm, NAU, Navsari) and pooled data were used for statistical analysis using 35 finger millets genotypes in randomized block design with three replications during *kharif, 2019*. The data of eighteen different characters *viz.*, Days to 50% flowering (DF), Days to maturity (DM), Plant height (PH), Productive tillers per plant (PT), Fingers per ear (FE), Finger width (FW), Main ear head length (EL), Finger length (FL), 1000 seed weight (SW), Grain yield per plant (GY), Fodder yield per plant (FY), Harvest index (HI), Leaf area (LA), Chlorophyll content (CC), Fiber content (FC), Calcium content (C), Iron content (Fe), Zinc content (Zn) were taken from five randomly selected plants from each replication. PCA was performed using STAR software.

Results and Discussions

Descriptive Statistics

The mean values of the data were subjected to statistical analysis in order to study the descriptive statistics like mean, maximum, minimum and standard deviation. (Table 1).

The genotypes in the collection can flower as early as 62.67 days and late as 86.67 days with a mean of 74.25 days. Days to maturity ranged from 101.33 to 123.33 with a mean of 113.68 days. Plnat height varies from 98 to 133.33 cm with an average of 117.09 cm. productive tillers per plant ranges between 2.88 to 4.86 with an average of 3.79. Fingers per year varies from 5.98 to 9.26 with a mean of 7.35. Finger width varies from 2.64 to 5.86 cm with an average of 3.97 cm. Main ear head length ranges between 8.34 to 14.59 cm with a mean of 11.06 cm. Finger length varies from 4.24 to 9.42 cm with an average of 7.02. 1000 seed weight ranges between 2.10 to 3.72 g with a mean of 2.98 g. Grain yield per plant varies from 3.29 to 4.90 g with an average of 4.23 g. Fodder yield per plant ranges between 8.65 to 12.88 g with a mean of 11.01 g. Harvest index varies from 965.11 to 1388.44 per cent with an average of 1200.93 per cent. Leaf area ranges from 4.81 to 12.60 cm^2 with a mean of 7.43 cm2. Chlorophyll content varies from 15.77 to 29.51 with an average of 22.32. Fiber content ranges between 3.79 to 4.49 per cent with a mean of 4.01 per cent. Calcium content varies from 302.33 to 593 mg/100g with an average of 418.91 mg/100g. Iron content ranges between 2.47 to 4.47 mg/100g with a mean of 3.51 mg/100g. Zinc content varies from 2.37 to 3.31 mg/100g with an average of 2.78 mg/100g. The standard deviation ranges between 0.13 to 105.08.

Correlation studies

The correlation, histogram and bivariate scatter plot of eighteen different finger millet traits represent in pair panels for 18 × 18 matrices (Fig 1). The correlation coefficients represents upper half, the bivariate scatter plot among different variables represents lower half and different variables are normally distributed or not represent diagonally. The highest correlations were observed between days to 50% flowering, finger width and finger length and grain yield contributed in future breeding programme The diagonal represents the type of the distribution of various traits and all the traits are distributed normally in this matrix.

Table 1: Descriptive statistics for different characters in finger millet

Particulars	Maximum	Minimum	Mean	S. D.
Days to 50% flowering	86.67	62.67	74.25	6.17
Days to maturity	123.33	101.33	113.68	6.44
Plant height (cm)	133.33	98	117.09	10.57
Productive tillers per plant	4.86	2.88	3.79	0.60
Fingers per ear	9.26	5.98	7.35	0.96
Finger width (cm)	5.86	2.64	3.97	0.88
Main ear head length (cm)	14.59	8.34	11.06	1.69
Finger length (cm)	9.42	4.24	7.02	1.44
1000 seed weight (g)	3.72	2.10	2.98	0.39
Grain yield per plant (g)	4.90	3.29	4.23	0.43
Fodder yield per plant (g)	12.88	8.65	11.01	1.05
Harvest index (%)	1388.44	965.11	1200.93	105.08
Leaf area (cm^2)	12.60	4.81	7.43	2.09
Chlorophyll content	29.51	15.77	22.32	3.23
Fiber content (%)	4.49	3.79	4.01	0.13
Calcium content (mg/100g)	593	302.33	418.91	60.04
Iron content (mg/100g)	4.47	2.47	3.51	0.53
Zinc content (mg/100g)	2.37	3.31	2.78	0.25

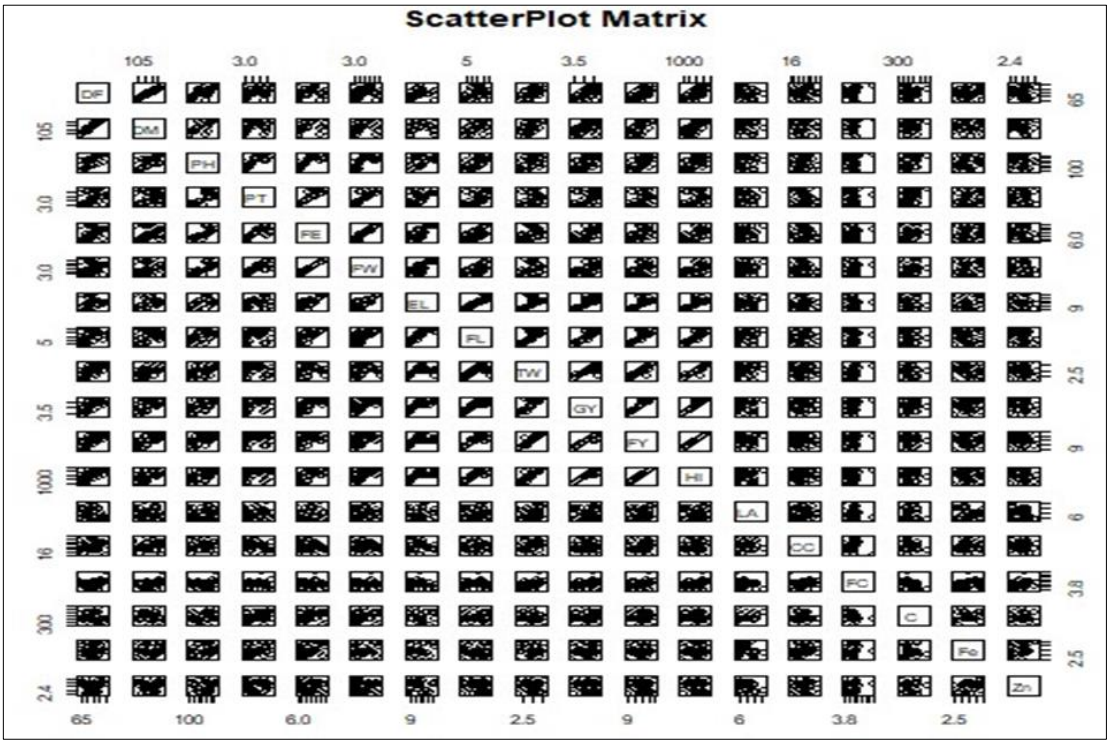

Fig 1: Pair panels for 18 × 18 Matrices represents Pearson correlation, histogram and bivariate scatter plot among the different characters in finger millet

Principal component analysis

Principal Component Analysis was measure the importance and contribution of each component to total variance when applied as a reductionist approach of the multivariate data. The each principal component is associated, where in each coefficient of eigen vectors indicates the degree of contribution of every original variable on the independent impact of a particular trait to the total variance. PCA analysis revealed that the first seven components in the PCA analysis were with eigen values more than one and contributed to a maximum of 99.99 per cent of the variability among 35 genotypes evaluated for eighteen different traits. These seven principal components were retained based on the scree plot and threshold eigen value greater than 1 (Fig 2 and Table 2). The principal component with eigen values less than one were considered as non significant.

Out of seven principal components only the first four principal component shows 99.89 per cent of the entire variability. The first principal component shows 74.89 per cent of total variability due to all the characters except for calcium content and zinc content. Second principal component accounted for 24.26 per cent of total variability originated primarily due to days to 50% flowering. Third principal component which explains 00.6 per cent of total variability because of days to 50% flowering, days to maturity plant height, productive tillers per plant, fingers per ear and finger width. Fourth principal component accounts 00.1 per cent of gross variability primarly due to plant height, productive tillers per plant, fingers per ear, finger width, main ear head length, finger length, grain yield per plant, leaf area and iron content (Table 2 and 3).

Table 2: Principal components showing the Eigen values, proportion of variance explained and cumulative variance

Principal component	Eigen Value	Variation (%)	Cumulative variance (%)
PC-1	11130.10	74.89	74.89
PC-2	3605.92	24.26	99.15
PC-3	91.38	00.6	99.77
PC-4	18.03	00.1	99.89
PC-5	9.88	00	99.95
PC-6	3.87	00	99.98
PC-7	1.43	00	99.99
PC-8	0.96	00	100
PC-9	0.24	00	100
PC-10	0.13	00	100
PC-11	0.07	00	100
PC-12	0.04	00	100
PC-13	0.03	00	100
PC-14	0.01	00	100
PC-15	0.01	00	100
PC-16	0.005	00	100
PC-17	0.001	00	100
PC-18	0.00	00	100

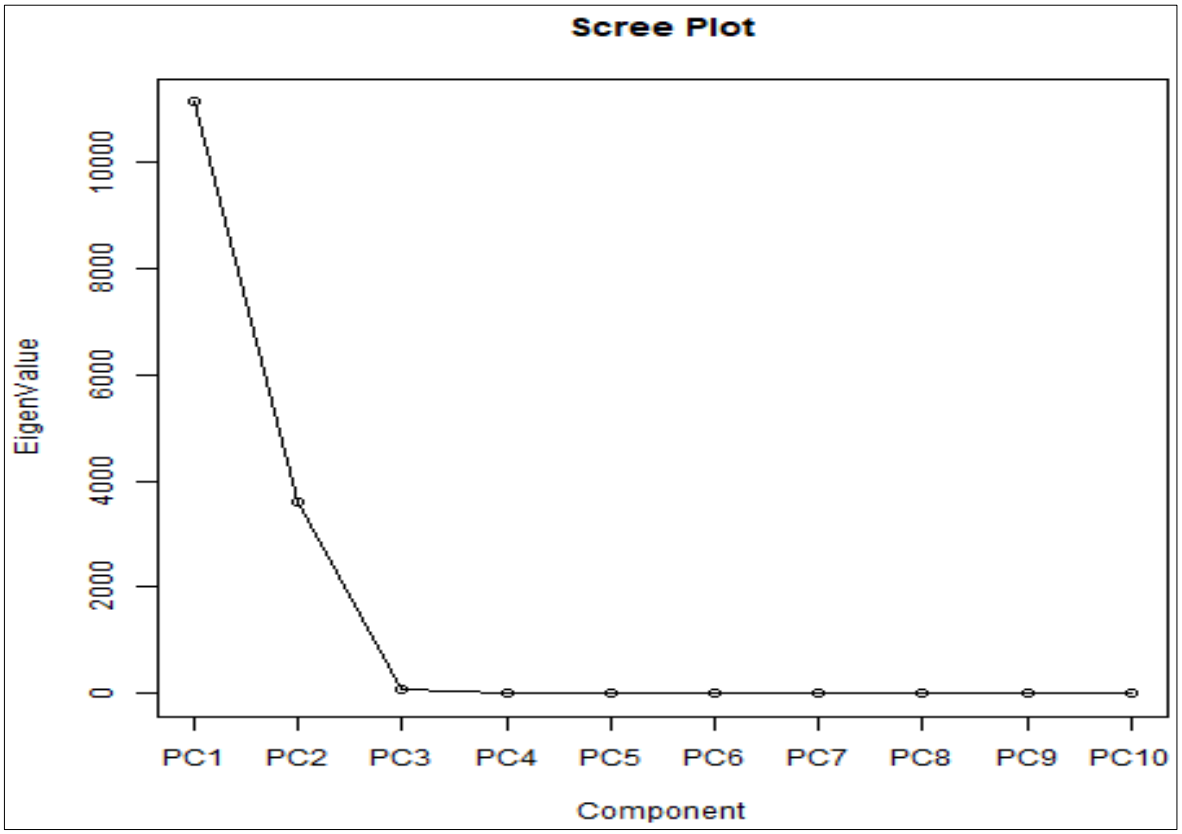

Fig 2: Scree plot formation on basis of eigen values

Table 3: Principal component analysis for 18 different traits in 35 finger millet genotypes non-rotated loadings

Particulars	PC-1	PC-2	PC-3	PC-4
Days to 50% flowering	0.03	0.00	0.41	-0.50
Days to maturity	0.04	-0.00	0.43	-0.55
Plant height (cm)	0.06	-0.05	0.79	0.55
Productive tillers per plant	0.00	-0.00	0.03	0.06
Fingers per ear	0.00	-0.00	0.04	0.13
Finger width (cm)	0.00	-0.00	0.03	0.13
Main ear head length (cm)	0.01	-0.00	-0.00	0.19
Finger length (cm)	0.01	-0.00	-0.00	0.13
1000 seed weight (g)	0.00	0.00	0.00	-0.00
Grain yield per plant (g)	0.00	-0.00	-0.00	0.01
Fodder yield per plant (g)	0.01	-0.00	-0.00	-0.00
Harvest index (%)	0.99	-0.03	-0.08	0.00
Leaf area (cm^2)	0.00	-0.00	-0.05	0.15
Chlorophyll content	0.00	0.01	0.00	-0.13
Fiber content (%)	0.00	0.00	0.00	-0.00
Calcium content(mg/100g)	-0.03	-0.99	-0.04	-0.03
Iron content (mg/100g)	0.00	-0.00	0.000	0.01
Zinc content (mg/100g)	-0.00	0.00	0.00	-0.00

Bi-plot represents distribution of accessions on the basis of PC-1 and PC-2 scores and relationship of different traits with PC-1 and PC-2. (Fig 3). From the results it can be concluded that the genotypes *viz*., VL-314, Dapoli-1, Dapoli-2, KOPN-235, KOPN-942, Phule Nachni, VR-708, VR-847, PR-202, KMR-204 and GNN-7 were accumulated on positive side of PC1 axis which accounted for days to 50% flowering, days to maturity, plant height, main ear head length, finger length and harvest index contributed maximum towards divergence. On other axis, only two genotypes OEB-532 and Indira Ragi-1 are accumulated on positive side of PC-2 which accounted for chlorophyll content was important traits contributed maximum towards divergence. PC-1 and PC-2 was maximum provide genetic variation. This type of result reported by Reddy *et al*. (2009) [11], Dagnachew *et al*. (2012) [1], Jadhav *et al*. (2014) [5], Geethanjali and Jagadeeswaran (2016) [2], Patro *et al*. (2016) [8], Patil *et al*. (2017) [6], Savan Kumar *et al*. (2017) [12], Patro *et al*. (2018) [7], Suman *et al*. (2019) [13] and Reddy *et al*. (2020) [10].

The positive signifying genotypes could be useful in finger millet breeding. Hence, these genotypes can be utilized in hybridization programmes to produce superior recombinants.

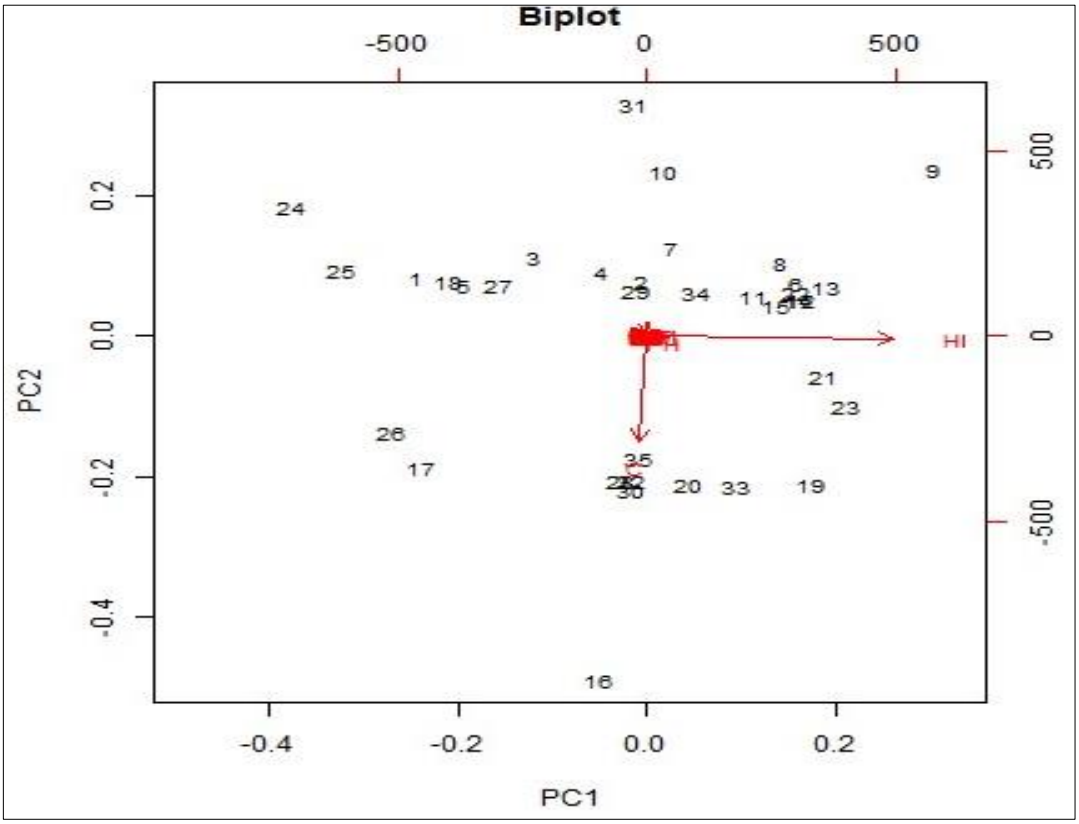

Fig 3: Bi plot formation on basis of PC-1 and PC-2 value

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